MMS-*Lite*
Reference Manual

Revision 15

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Chapter 1

Introduction

What is MMS-EASE *Lite*?

SISCO's **MMS-EASE *Lite*** (**E**mbedded **A**pplication **S**ervice **E**lement) is a C language **A**pplication **P**rogram **I**nterface (API) for the **M**anufacturing **M**essage **S**pecification (MMS) protocol. It consists of source code modules derived from the MMS-EASE product line as well as a set of new files optimized for small system applications. These modules are compiler and operating system independent. For the remainder of the document, it will be referred to a MMS-*Lite.* MMS-*Lite* has been created to minimize code and data space requirements and allows resource-limited devices to embed MMS within the device in a cost effective and resource efficient manner. It provides a mechanism for applications to encode and decode MMS PDUs. It shares the MMS-EASE data structures and a modified subset of the complete MMS-EASE API. In addition, there is an easy to use high-level application framework (MVL) designed to speed the development process. Contact SISCO for more information on available MMS-*Lite* packages.

About This Manual

The MMS-*Lite* Reference Manual explains how to use MMS-*Lite*. It explains how to encode and decode MMS PDUs. This manual is presented in nine sections:

- Chapter 1: Introduction, provides a brief overview of MMS-*Lite*, and this document.
- Chapter 2: Getting Started, describes how to install and configure MMS-*Lite*. It also describes how to use MMS-*Lite* effectively.
- Chapter 3: Building MMS-*Lite*, describes how to compile and link the MMS-*Lite* libraries.
- Chapter 4: MMS-*Lite* Lower Layers, describes the interaction of the MMS-*Lite* Stack components.
- Chapter 5: MVL Application Program Interface, documents MVL (**M**MS **V**irtual **L**ight). It includes an overview, object control structures and functions, as well as MVL Client and Server functionality.
- Chapter 6: Using the UCA features of MVL, describes how to set up and use MVL UCA.
- Chapter 7: Using the IEC 61850 features of MVL, describes the unique functionality provided for IEC 61850 as well as Sampled Value support.
- Chapter 8: Configuring IEC61850 Devices Using SCL, describes how to use SCL with IEC 61850 devices.
- Chapter 9: IEC 61850 GOOSE Support, describes how to configure, send, and receive IEC 61850 GOOSE messages.
- Chapter 10: IEC 61850 GSSE (same as UCA 2.0 GOOSE), describes how to configure, send, and receive IEC 61850 GSSE messages (same as UCA 2.0 GOOSE).
- Chapter 11: IEC 61850 GSE Management, describes GSE Management functionality.
- Chapter 12, MMS Object Foundry, documents the MMS Object Foundry and its function.

In addition, there are the following appendices:

- Appendix A: Subset Creation, provides steps on how to create applications that only use a subset of the supplied services.
- Appendix B: Error Codes, explains error codes useful for troubleshooting and diagnosing problems.
- Appendix C: Logging Tools, provides information regarding the **S**ISCO **Log**ging (**S_LOG**) system, a flexible and useful approach to system logging. It also describes logging masks for diagnosing problems.
- Appendix D: Memory Management Tools, provides a set of memory management tools that include logging and integrity checking.
- Appendix E: Linked List Tools, documents the Linked List Manipulation functions that can be used in your application.
- Appendix F: GLBSEM Subsystem for Multi-threaded Support, addresses the issues related to writing a thread-safe MMS-EASE application.
- Appendix G: Utility Functions, miscellaneous functions.
- Appendix H: Subnetwork API, describes the use of the Subnetwork layer and the rewriting of the API functions.
- Appendix I: MMS-EASE Type Description Language (TDL), provides information on TDL and includes several examples of how to build complex type definitions using the TDL.
- Appendix J: IEC GOOSE Example Application Framework, describes the sample application framework.
- Appendix K: IEC 61850 Product PICS, describes the IEC61850 Conformance Statement.

Conventions Used in this Manual

- Function names, structures, and members of functions and structures are shown in boldface **`Courier New`** type.
- Code fragments are shown in `Courier New`.
- File names are shown in **lowercase, bold Times New Roman**.

Chapter 2

Getting Started

Prerequisites

Because of the technical nature of MMS-*Lite*, and MMS, some level of knowledge is required by the user to fully understand how to use MMS-*Lite*. You need to have familiarity with MMS specifications (particularly MMS: ISO IEC/IS 9506 and ISO DIS 9506). Information about the MMS specifications can be obtained from the following source:

SPECIFICATIONS:
ANSI (American National Standards Institute)
1430 Broadway
New York, NY 10018

ISO (International Organization for Standardization)
1 Rue de Varenbe
Case Pascal 66 CH-1211
Geneva 20 Switzerland

In addition, if using IEC 61850, some level of knowledge is required by the user to fully understand how to use MMS-*Lite*. You need to have familiarity with the following specifications:
IEC 61850 and UCA v 2.0 (IEEE-SA TR 1550-1999).

Installation

The following installation procedures assume that you are familiar with your operating system and your computer.

Notes: *When installing software on a Windows machine, version information giving MMS-Lite part number, location, and the major and minor version numbers are placed in the Windows registry. Also, a file called* ***mmsldefs.h*** *is found in the installation directory containing part number, version, and internal build number information. The definitions in this file may be used by the program, as shown in the sample programs provided. These two locations can be used to determine the version of MMS-Lite installed on your system. Please refer to* ***HKEY_LOCAL_MACHINE\SOFTWARE\SISCO\MMS-EASE Lite\CurrentVersion*** *for related registry information.*

The product installation has been tested on the following Windows Operating Systems:

- *Windows XP Professional Version 2002, Service Pack 3*
- *Windows Server 2008 R2 x64*
- *Windows 7 32 bit*

If the files need to be moved to another computer, it is recommended that FTP be used to transfer the files after installation.

Please note that as of ICCP Lite V5.4000, transferring files to a UNIX or Linux system using a FTP utility does not have to use the "force to lower case" feature because all relevant source files are converted to lower case.

Transfer in ASCII mode is necessary for most of the files, although following directories contain binary files: \mmslite\bin, \mmslite\doc, \mmslite\iccp\doc.

1. Insert the MMS-*Lite* CD into the CD-ROM drive.
2. If the Autorun feature is enabled on your computer, go to Step 4. Otherwise, click on **Start**, select the **Run** option, and type the following command:

   ```
   {d}:\disk1\setup
   ```

   where {d} designates the letter of your CD-ROM drive.
3. When the MMS-*Lite* setup initializes, you will be asked where to install the source code. The installation script will search the Windows Registry and try to find where the product was previously installed and install over the top of any existing installation. To install either MMS-LITE-801-001 or MMS-LITE-802-001, type in the Product Key as found on the label of your CD.
4. Follow the instructions on the screen to complete the MMS-*Lite* installation.

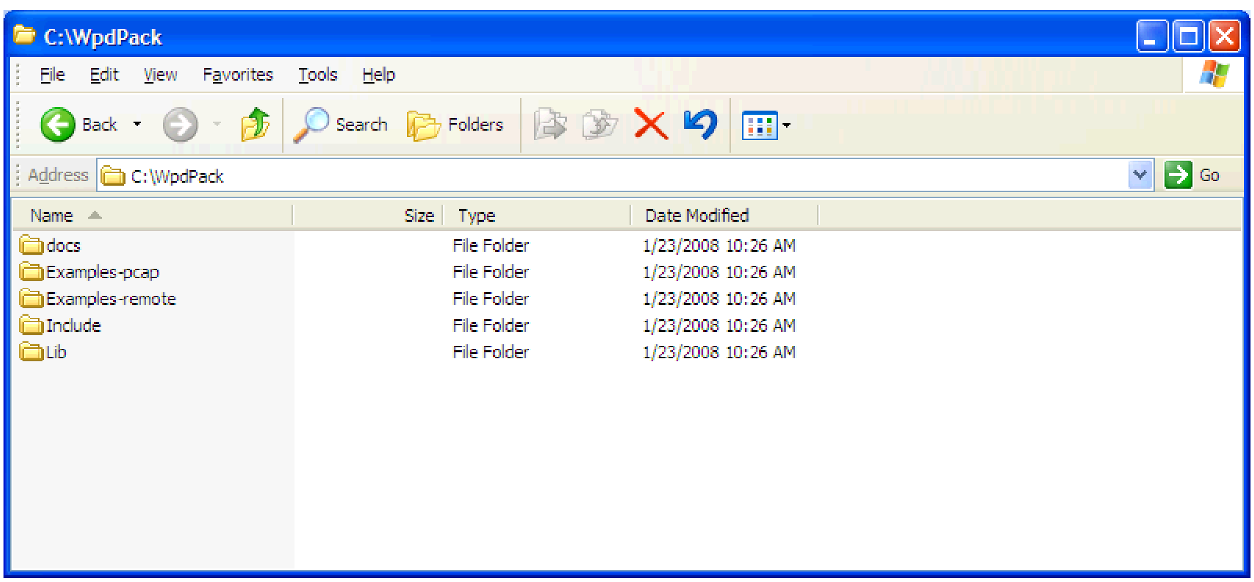
Installing WinPcap Developer's Pack for IEC GOOSE and Sampled Value Support on Windows

The Subnetwork interface has been ported to Windows by using the WinPcap interface which is freely available online. The Subnework interface must be ported to other operating systems (see *Appendix H: Subnetwork API* for more details).

Below are instructions for downloading the WinPcap Developer's Pack for MMS-Lite-802-001. Without WinPcap, the 802 sample solutions for TPX, GOOSE, GSSE and SMPVAL will not build on Windows. Unless these steps are taken only the TCP version of MMS Lite will compile. If you are using MMS-Lite-801-001, it only has support for TCP so WinPcap is not needed.

1. Open up a web browser and go to this website www.winpcap.org
2. Click on the "Development" link - http://www.winpcap.org/devel.htm
3. Please consult the *Release Notes for MMS-Lite* for the proper version of WinPcap supported for each version. Select "Download WinPcap x.x.x Developer's Pack", save the zip file if necessary, and unzip it to the root directory of the drive that MMS-Lite will be installed on. You should end up with a folder named **\WpdPack**.

   Note: If you unzip to any other drive, you must include the drive letter in all instructions related to **WpdPack**.



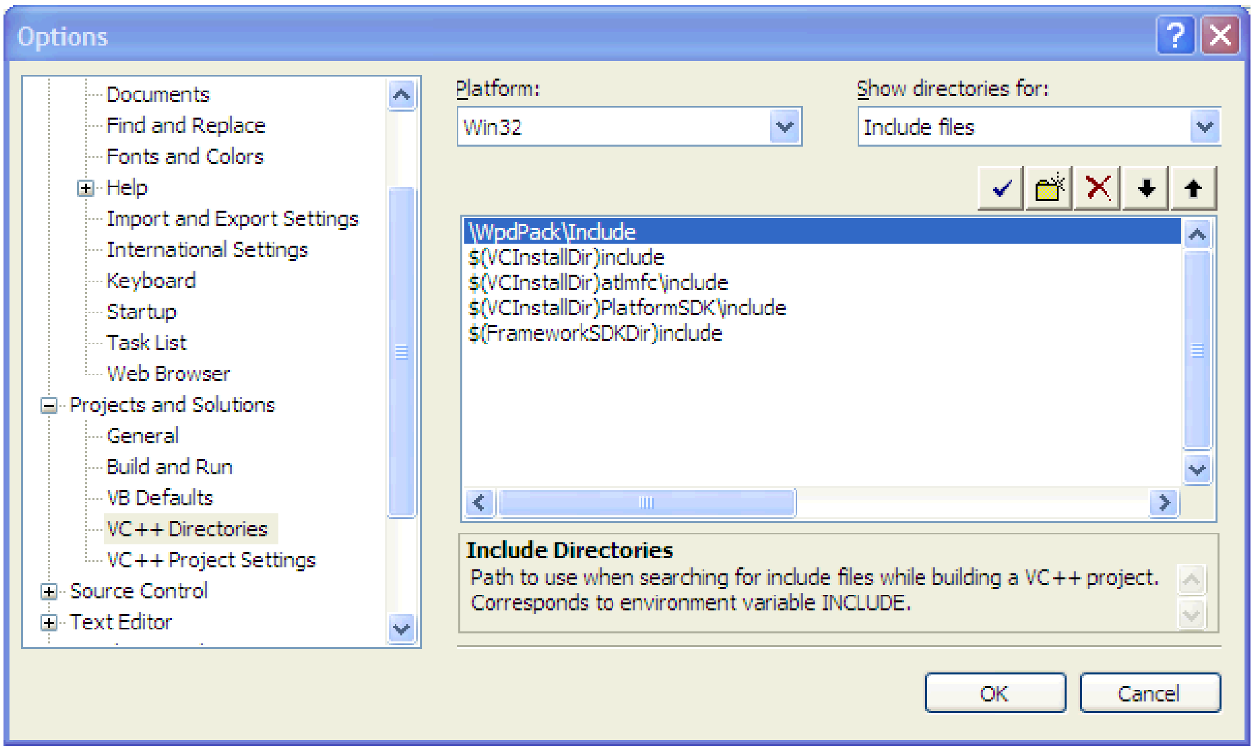
4. See the next section for installing the WinPcap Runtime needed.
5. The Include and Lib folders have to be integrated into the Visual Studio before libraries and applications using IEC GOOSE and Sampled Values will compile and link.

6. Start Visual Studios for Windows.
7. Start the Visual C++ Environment by selecting **Visual C++ Development Setting**.
8. Open the MMS-*Lite* workspace (**\mmslite\cmd\win32\mmslite802.sln**).
9. Libraries with TPX in their name make use of WinPcap include files that reside in the **\WpdPack\Include** folder. To access the header files it is necessary to add the **\WpdPack\Include** directory to the Visual Studio include file path set:

   Tools→Options→Projects and Solutions→VC++ Directories

10. To do this change the *Show directories for:* drop down combo box to *Include files,* click the *new item* icon and type in:

    \WpdPack\Include

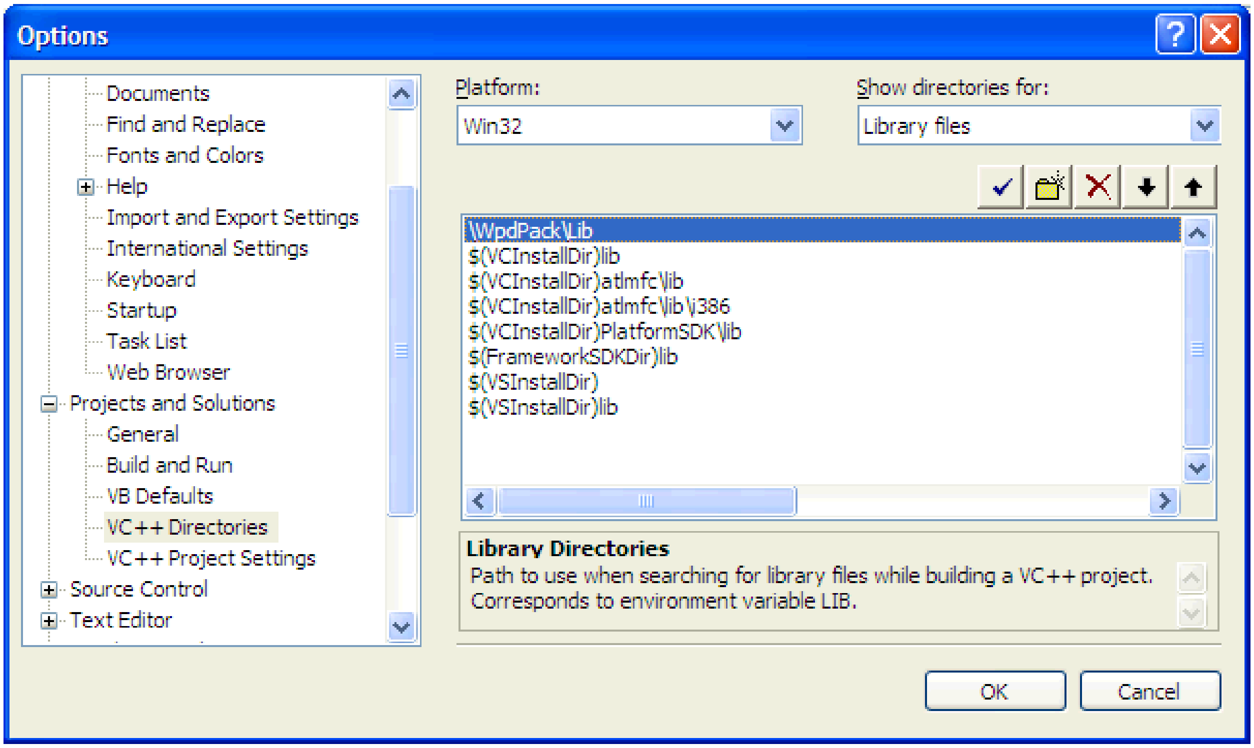


11. Executables with TPX in their name make use of the WinPcap libraries. These reside in the **\WpdPack\Lib** folder. To access the libraries, it is necessary to add the **\WpdPack\Lib** directory to the Visual Studio library path set:

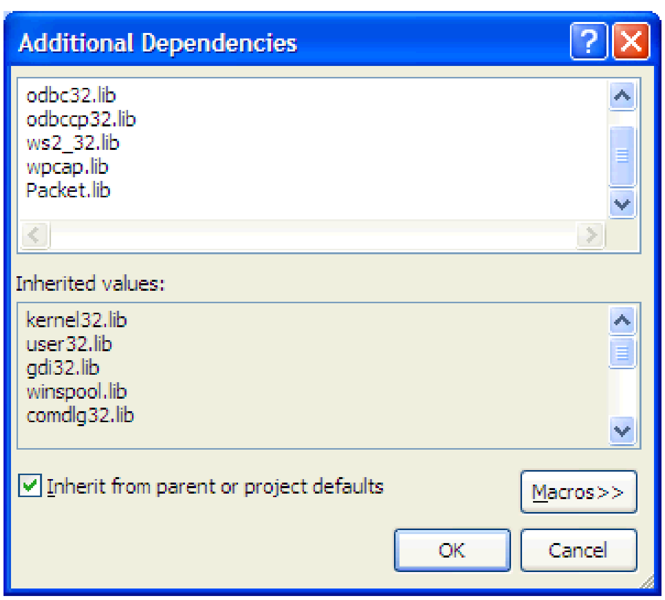
    Tools→Options→Projects and Solutions→VC++ Directories

12. To do this change the *Show directories for:* drop down combo box to *Library files,* click the *new item* icon and type in:

    \WpdPack\Lib



13. Select the desired configuration from the drop-down menu as the active configuration (i.e., Debug, Release, Debug Expat, etc.). **Note:** If the Debug Expat configuration is selected the instructions in the Release Notes for using Expat must be executed first.
14. Use the right click menu on the Solution *mmslite802* node in the Solution Explorer and select **Build Solution** to build the libraries and samples.
15. To port a stack library from the the older not used OSILLC driver to use WinPcap, two files **clnp_w32.c** and **ethsub.c** were removed. The file **clnp_pcap.c** was added in their place.
16. For an application to link with WinPcap, the two libraries **packet.lib** and **wpcap.lib** in the WinPcap library folder need to be added to the project. Right click on the application name, click on **Properties** and then **Linker→ Input** to verify that the following libraries are present:



If they are not added already they will need to be added. They have already been added to our sample executable projects.

Installing WinPcap Runtime Needed to Run Programs

Applications built with WinPcap will need the WinPcap Runtime installed on every machine where they run. The following steps are required to install the WinPcap Runtime:

1. Open up a web browser and go to this website www.winpcap.org
2. Click on the "Get WinPcap" link - http://www.winpcap.org/install/default.htm
3. Please refer to the *Release Notes for MMS-Lite* for the specific version of WinPcap needed for the release. Select "WinPcap auto-installer (driver +DLLs)", download the executable, run it, and follow the instructions to complete the installation.

Directory Structure

\mmslite	(root MMS-*Lite* directory)
\cmd	(command files for creating binaries)
\gnu	(GNU makefiles for Linux, QNX, etc.)
\pharlap	(Pharlap makefiles)
\win32	(Win32 project files)
\src	(source code – all .c files)
\inc	include files – all .h files)
\mmsop_en	(default **mmsop_en.h** file)
\uca	(stack profiles source root)
\acse	(ACSE source)
\goose	(GOOSE source)*
\leant	(TP4, TP0, CLNP, ES-IS, subnet, UCA time sync source)
\sn_test	(subnetwork test tools)
\sn_targt	(subnet server)
\sn_test	(subnet client)
\bin	(utility executables)
\mvl	(MMS Virtual Light)
\src	(MVL source)
\acse	(MVL-ACSE source)
\loop	(loopback LLP files)
\usr	(MVL sample user root)
\client	(MVL sample client)
\server	(MVL sample server)
\iecgoose	(IEC GOOSE framework sample)
\scl_srvr	(IEC_61850 sample server using SCL)
\util	(MVL utility root)
\foundry	(MVL foundry)
\linux	(contains structure alignment configuration file for Linux)
\qnx	(contains structure alignment configuration file for QNX)
\win32	(Win32 makefiles)
\uca09	(GOMSFE Rev 9 UCA model files)
\mbufcalc	MVL buffer init support)
\mmslog	(MMS PDU decoder/analyzer)
\gsemtest	(Global semaphore test code)
\doc	(PDF documentation)
\lib	(libraries)
\win32lib	(Win 32 libraries)

Chapter 3

Building MMS-*Lite*

Many embedded environments require the use of a cross compiler which runs on a "host" computer and the resulting programs are transferred to the "target" system for execution. In this chapter, the term "host" will refer to the environment where the application is compiled and linked, and "target" will refer to the environment where the application is to be executed. See the following chapter for more details.

Development System Preparation

The following items need to be considered before the libraries can be created for MMS-*Lite*.

Conditional Compilation Defines

MMS-*Lite* is a flexible code base that can be used to create a variety of communications profiles and is accomplished by a set of defines that are used for conditional compilation of profile specific code. The defines used for this purpose are listed below.

PRIMARY GENERAL DEFINES	DESCRIPTION
`MMS_LITE`	This define is required in order to compile the MMS-*Lite* MMS source code. This define is used in the standard product makefiles.
`DEBUG_SISCO`	This define is used in most SISCO software components and has two purposes: 1. Compile in logging statements. This adds significantly to the size of the static string space, and slows things down just a bit. SISCO recommends using this define where possible. 2. Compile in some level of debug error level checking. This is a secondary effect of using the **`DEBUG_SISCO`** define. 3. Compile in memory allocation debug calls. These are used to track the file/line number of all allocations This define is used in the standard product makefiles in creating the debug libraries.
`NO_GLB_VAR_INIT`	This define is used when target environments do not support compile time data initializations, which otherwise are used in several places within MMS-*Lite*. This is NOT defined in the standard product makefiles.
`S_MT_SUPPORT`	This define is used to enable multithread support in the various MMS-*Lite* libraries. This is NOT defined in the standard product makefiles except for Windows.
`SD_BYTE_ORDER`	This must be defined in **glbtypes.h** for each platform to indicate the byte order used to store data (big-endian or little-endian). It must be set to **`SD_BIG_ENDIAN`** if the platform is "big-endian". It must be set to **`SD_LITTLE_ENDIAN`** if the platform is "little-endian".
`UNICODE_LOCAL_FORMAT`	This define selects the local format used to store Unicode strings. According to the MMS Specification, Unicode strings must always be encoded in UTF8 format. This is also the format that most UNIX systems use to store Unicode strings. However, some systems (e.g., Windows) store Unicode strings

PRIMARY GENERAL DEFINES	DESCRIPTION

	in UTF16 format. The ASN.1 encoder converts Unicode strings from the local format to UTF8. The ASN.1 decoder converts from UTF8 to the local format. This conversion is controlled by this define. It must be defined as **`UNICODE_UTF8`** or **`UNICODE_UTF16`**. It is currently defined in **asn1r.h** to be **`UNICODE_UTF8`** for all systems except Windows as follows:
	`#if !defined(UNICODE_LOCAL_FORMAT)`
	`#if defined(_WIN32)`
	`#define UNICODE_LOCAL_FORMAT UNICODE_UTF16`
	`#else`
	`#define UNICODE_LOCAL_FORMAT UNICODE_UTF8`
	`/*default format*/`
	`#endif`
	`#endif`

PRIMARY MVL DEFINES	
`MVL_UCA`	This define enables the UCA and IEC 61850 support in MVL. This is used when compiling the mvlu library.
`MVL_AA_SUPP`	This define allows MVL to support alternate access as a variable access server. This is normally defined in **mvl_defs.h** but may be undefined if the user application does not need alternate access support and memory constraints dictate minimum possible size.
`MVL_INFO_RPT_CLIENT`	This define must be used for client applications that will be receiving information reports. For other applications, it will simply increase the size of the Variable Association data structure for no good reason. This is normally defined in **mvl_defs.h**, and may be commented out for server only applications.
`ICCP_LITE_SUPP`	This define is found in **mvl_defs.h** to expose members in MVL structures for use by MMS-*Lite* with TASE.2 Extensions. Comment this define out to build a MVL library optimized for space that is not to be used for ICCP. This define is uncommented by default.
`ICCP_LITE`	This define must be used by all applications using MMS-*Lite* with TASE.2 Extensions. It causes ICCP specific pieces of code to be compiled into **mvl_acse.c**.

SECONDARY MVL DEFINES	
`NEGIOTIATE_INITIATE_PARAM`	This define allows **mvl_acse.c** to negotiate the parameters used to send an initiate response, based on the supplied initiate response parameters. This is normally defined in **mvl_acse.c**, but may be undefined if the user application performs the negotiation process itself.
`CLACSE`	This define allows MVL to make use of connectionless ACSE services. This is normally not defined.
`MVL_XNAME`	Compiling the MVL library with this define causes the *xName* member to be exposed in **`MVLU_RD_VA_CTRL`**, and **`MVLU_WR_VA_CTRL`** typedefs. This define allows the fully qualified UCA variable name to be passed in to UCA variable read and write functions. By default, **`MVL_XNAME`** is commented out in **mvl_defs.h** and the feature is not enabled.
`USE_RT_TYPE_2`	This define allows named components to be added to dynamically created types. It is possible to use both MMS Object Foundry and dynamically created types in an application when **`USE_RT_TYPE_2`** is defined. By default, **`USE_RT_TYPE_2`** is commented out in **mms_vvar.h**. Please refer to the function **`mvl_type_id_create`**.
PRIMARY NETWORK STACK DEFINES	
`MOSI`	This define is used to select the minimal OSI profile when compiling the ACSE & Lean-T software modules. The **`LEAN_T`** define must also be defined when using the MOSI define.
`LEAN_T`	This define is used to enable Transport layer code. It is required if OSI or TCP/IP layers are included in the stack.
`UCA_SMP`	This define is used when compiling the network layer and sample application modules to enable use of the UCA Station Management Protocol (for Time Synchronization). This is defined in the standard product makefiles.
SECONDARY NETWORK STACK DEFINES	
`CLNP_STAT`	This define allows CLNP to record statistics.
`TP0_ENABLED`	This define is used to enable TP0 functionality in the Lean-T software modules. This is required for TCP/IP (via RFC1006) support.
`TP4_ENABLED`	This define is used to enable TP4 functionality in the Lean-T software modules. This is required for OSI support.

PRIMARY MMS DEFINES	
BTOD_DATA_SUPPORT	This define is used to enable support for binary time of day data types This is defined in the standard product makefiles.
TIME_DATA_SUPPORT	This define is used to enable support for generalized time data types. This is defined in the standard product makefiles.
FLOAT_DATA_SUPPORT	This define is used to enable support for floating point data types. This is defined in the standard product makefiles.
INT64_SUPPORT	This define is used to enable support for 64 bit integer data types This is defined in the standard product makefiles for WIN32, and is not defined for DOS. This needs to be examined when porting to other platforms.
SECONDARY MMS DEFINES	
CS_SUPPORT	This define is used to enable support for MMS companion standards. This is NOT defined in the standard product makefiles, and is not supported in MVL in any way.
MOD_SUPPORT	This define is used to enable support for MMS modifiers. This is NOT defined in the standard product makefiles, and is not supported in MVL in any way.
ASN1_ARB_FLOAT	This define is used to enable MMS to decode all forms of floating point data. When it is not defined, only IEEE 754 format floating point data can be decoded. This is defined by default.
GET_CONSTRUCTED_BSTRINGS	This define is used to compile in ASN.1 code for decoding constructed bitstrings. This is not normally required, and is NOT defined in the standard product makefiles.
USE_COMPACT_MMS_STRUCTS	This define controls the makeup of some MMS-EASE data structures and allows a more compact form to be used. This is defined when **MMS_LITE** is defined.
SAMPLE MVL APPLICATION DEFINES	
USE_MANUFACTURED_OBJS	This define is used in **server.c** to compile in code related to using manufactured variables and variable lists. This is done to clearly show the mechanisms required.
HARD_CODED_CFG	This define is used in **server.c** to compile in code related to using hard coded configuration information instead of configuration files. By default, this is not defined.
USE_FRAMEWORK_THREADS	This define is only used in the IEC GOOSE Framework application (in iecgoose directory). It enables multi-threading code.

OTHER DEFINES	
NO_REALLOC_SMALLER	This define can be used when compiling the memory allocation tools to not **realloc** when the new size is less than the old. This can sometimes be helpful in reducing memory fragmentation. This is NOT defined in the standard product makefiles.
MEM_FILL_CONTROL	This define can be used when compiling the memory allocation tools to have **mem_chks.c** overwrite the control header as well as the body of the buffer being freed. This is not defined in the standard product makefiles.
MLOG_ENABLE	This define can be used when compiling **mmsop_en.h** to create the function pointer tables for the MLOG subsystem. By default this is not defined when **MMS_LITE** is defined.

glbtypes.h

To promote portability and reduce name space conflicts, SISCO makes use of a set of defines in place of C data types. For instance, SISCO code uses **ST_INT** in place of the standard “int” keyword. Many of the defines are used to select data types with known precision. These defines can be found in the header file **glbtypes.h**. This file contains the defines for many operating systems and compilers, but it may be necessary to add a section for the target development environment.

This file also includes the **SD_END_STRUCT** define for each target as follows:

SD_END_STRUCT	This define is included at the end of all MMS-EASE data structures that may be embedded within or “attached” to other MMS-EASE data structures. This typically is defined to be nothing, but for some hardware/compiler combinations (especially 64 bit RISC systems) may need to be defined to **ULONG end_of;** to force alignment on a quadword boundary.

sysincs.h

This file is used within MMS-*Lite* to select the system include files to be included. There is a section for each supported target. Review each section to see if one is appropriate for your target. If not, create a new section for your target. Be sure to put **#ifdef/#endif** around your new section, like this:

```
#if defined(SYSTEM_XYZ)
#include <stdio.h>
#include <string.h>
   etc.
#endif /* SYSTEM_XYZ */
```

align.cfg (Data Alignment Rules)

MMS-*Lite* is designed to be able to present arbitrary data types in local C format for ease of use by the application programmer. As different compilers perform different "padding" in data structures, it may be necessary to review and/or create an appropriate data alignment table for each target in a file named **align.cfg**. This file is read by the Foundry Utility to generate code that sets the alignment rules. Each entry in the file indicates the "bits" that must not be set in the address of that object. For example, examine the following line found in **linux/align.cfg**:

```
0x0003,    /* INT32_ALGN 06  */
```

The value of 3 (11 binary) indicates that the 2 lowest order bits must not be set in the address of an INT32 object. This is equivalent to saying that the address must be a multiple of 4.

Unicode porting issues

If the default local format is not correct for your platform, the **`UNICODE_LOCAL_FORMAT`** define must be changed. In this case, it should be defined before including **asn1r.h** (preferably in **glbopt.h**). On systems with a local format of **`UNICODE_UTF16`**, the functions described below must be ported. They are already ported for Windows.

asn1r_utf8_to_local

Usage: On systems where the local format is UTF16, this functions converts from a UTF8 string to UTF16 string. The destination string (**`dst_ptr`**) does NOT need to be NULL terminated (the calling function does that).

Function Prototype:

```
ST_INT asn1r_utf8_to_local (ST_CHAR *dst_ptr,
                            ST_INT dst_len,
                            ST_CHAR *src_ptr,
                            ST_INT src_len);
```

Parameters:

`dst_ptr`	A pointer to the destination UTF16 string.
`dst_len`	The number of bytes in the destination UTF16 string.
`src_ptr`	A pointer to the source UTF8 string.
`src_len`	The number of bytes in the source UTF8 string.

Return Value: Returns the number of bytes in the destination UTF16 string (**`dest_ptr`**) (may include the **`NULL`** terminator).

asn1r_local_to_utf8

Usage: On systems where the local format is UTF16, this function converts from UTF16 string to UTF8 string. The source string (**`src_ptr`**) must be NULL terminated.

Function Prototype:

```
ST_INT asn1r_local_to_utf8 (ST_CHAR *dst_ptr,
                            ST_INT dst_len,
                            ST_CHAR *src_ptr);
```

Parameters:

`dst_ptr` A pointer to the destination UTF8 string.

`dst_len` The number of bytes available in the destination UTF8 string.

`src_ptr` A pointer to the source UTF16 string.

Return Value: Returns the number of bytes in the destination UTF8 string (**`dst_ptr`**) (not including the **`NULL`** terminator).

Floating Point Representation

The ASN.1 floating point handling routines will need to be reviewed. These functions can be found in **ae_float.c** and **ad_float.c**. Note that the user sample application, **var.c,** can be used to verify that the floating point conversions are correct - in many cases no system specific work will need to be done here. IEEE 754 format is supported with no changes.

High Resolution Timers

Some of the UCA profile components make use of high-resolution timer functions. The required resolution depends on the application (e.g., MAS Radios) but it is desirable to achieve < 10ms resolution if possible. The source module to be examined is **stime.c**.

Memory Allocation

MMS-*Lite* allocates memory as required using an intermediate layer that is referred to as the **mem_chk** library. This library makes use of the standard malloc family of calls to execute the memory allocation/free requests, and optionally provides significant debugging assistance such as invalid free, buffer overwrites, and usage tracking. Note that these calls may be customized as required for the target system. The primary allocation functions are **`chk_malloc`**, **`chk_calloc`**, **`chk_realloc`**, **`chk_strdup`**, and **`chk_free`**. MMS-*Lite* contains both full and Lite versions of the **mem_chk** libraries (the “Lite” version is **mem_chkl.c**).

MMS-*Lite* treats memory allocation failures as fatal, non-recoverable errors. The user can elect to be notified via function pointer when memory allocation failures are detected, and can return valid **`malloc`** memory or can exit. The sample applications demonstrate use of these features.

Logging Mechanisms

SISCO recommends implementing a logging subsystem in the target application. All SISCO components can perform error and debug logging that is controlled by bit-masked control variables. This logging code can be compiled in by using the define **DEBUG_SISCO**. The logging subsystem used by MMS-*Lite* is called "slog" (**S**ISCO **Log**ging), and there are two versions supplied. The full-featured SLOG library is included. This library provides selectable file, memory, and user defined log streams. A "Lite" version of SLOG (SLOGL) is included. The source for this library is presented in stub form, to be customized for the target environment; for instance, it may be modified to log to a serial port or some other mechanism specific to the implementation.

The MVL sample applications demonstrate the use of the logging subsystem. Note that these samples make use of SLOG for application level logging as well as MMS-*Lite* internal logging.

Please refer to *Appendix C: Logging Tools* for more information.

Global Variables

The following is a partial list of global variables used by MMS-*Lite*.

```
MVL_CFG_INFO  *mvl_cfg_info;            /* critical config parameters    */
ST_UCHAR      *mmsl_enc_buf;            /* encode buffer              */
MVL_NET_INFO  mvl_calling_conn_ctrl;    /* array of calling connection*/
                                        /* control structures         */
MVL_NET_INFO  *mvl_called_conn_ctrl;    /* array of called connection */
                                        /* control structures         */
```

Global Variable Initialization

MMS-*Lite* has many global variables, some of which are initialized at compile time and which may be changed during program execution. This can cause problems in some environments where initialized global data is placed in a code segment and is subject to checksum verification. The define, **NO_GLB_VAR_INIT**, can be used in the source code to avoid global variable initializations. If this feature is used, the user application must call **mvl_init_glb_vars** before any other MVL or MMS-*Lite* activity.

mvl_init_glb_vars

Usage: This function initializes all global variables that cannot be initialized by the compiler.

Function Prototype: `ST_VOID mvl_init_glb_vars (ST_VOID);`

Parameters: NONE

Return Value: `ST_VOID`

Creating MMS-*Lite* Libraries

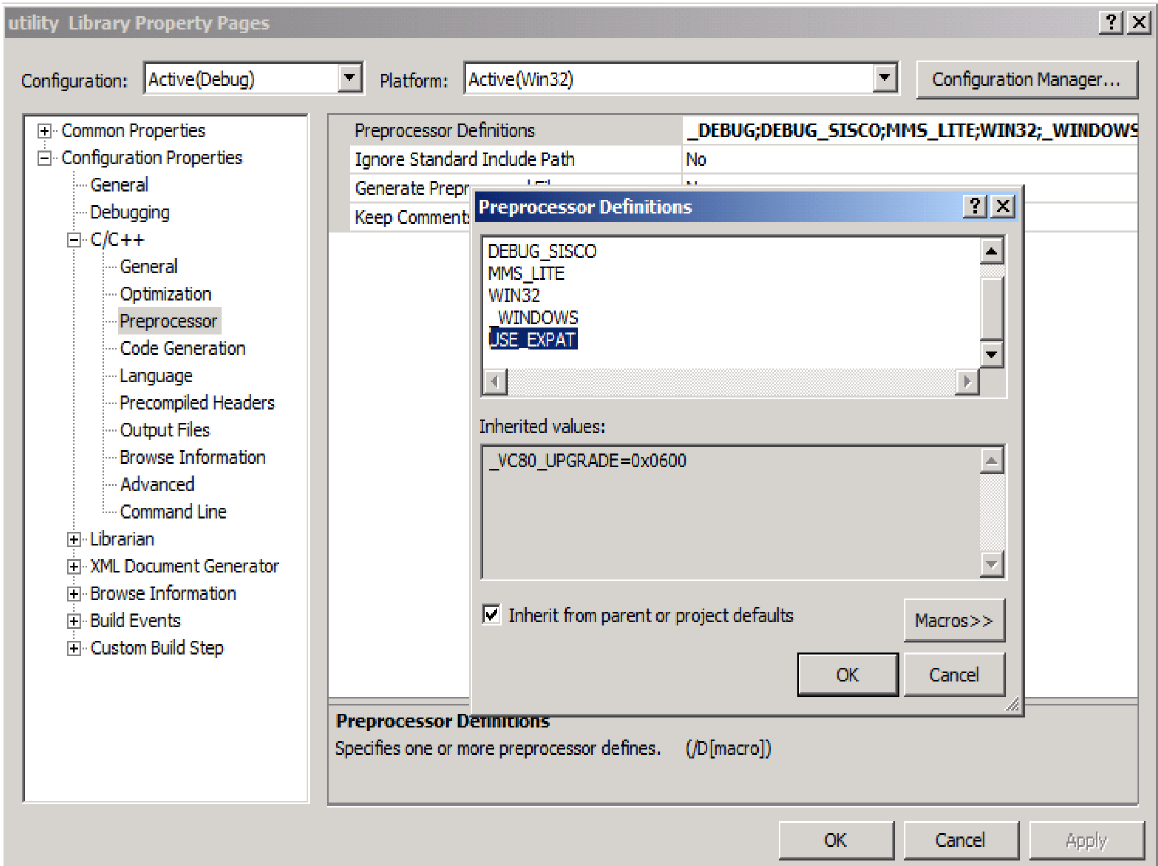
As MMS-*Lite* is provided in source code form only, the first step is to create the object libraries required. When executed correctly, this procedure will result in the following libraries. Note that there are four configurations provided for most libraries. The debug versions contain additional code for logging and error checking. Further, note that not all libraries are to be created for all supported build environments.

There are four configurations for each project: “Release No Logging”, “Release”, “Debug No Logging”, and “Debug”. These configurations will exist for all projects: libraries, samples, and utilities, and a suffix convention is used to identify the configuration. The table below summarizes the configurations.

Configuration	Debug	SLOG	Suffix _x	Comment
Release	No debug	Yes	“_l” example: mmsl_l.lib	This is the configuration typically used for both development and deployment of applications. It supports SISCO **log**ging (SLOG), but has no debugging information.
Release No Logging	No debug	No	“_n” example: mmsl_n.lib	This configuration can be used for deployment when the application is not to make use of SISCO logging.
Debug	C7 compatible	Yes	“_ld” example: mmsl_ld.lib	This configuration is used when debugging problems within the MMS-*Lite* components. It can also be useful for use in field diagnostics.
Debug No Logging	C7 compatible	No	“_nd” example: mmsl_nd.lib	This configuration is used when debugging problems within the MMS- *Lite* components without SISCO logging.

Using Expat

MMS-*Lite* has the option to use the “Expat” XML parser by simply defining **USE_EXPAT** when compiling **sx_dec.c** and linking to an appropriate “Expat” library. The “Expat” parser seems to be much better at detecting errors in XML files and dealing with unexpected whitespace characters. The “Expat” library is not included with the product, but version 2.0.1 of the “expat” package from http://expat.sourceforge.net/ can be downloaded.



The downloaded file should be a “tar” file. Use an appropriate tool to extract the files. If you extract them to **C:** you should end up with a new directory “**C:\expat-2.0.1**”.
NOTE: the directory structure may be slightly different depending on when you download the files.

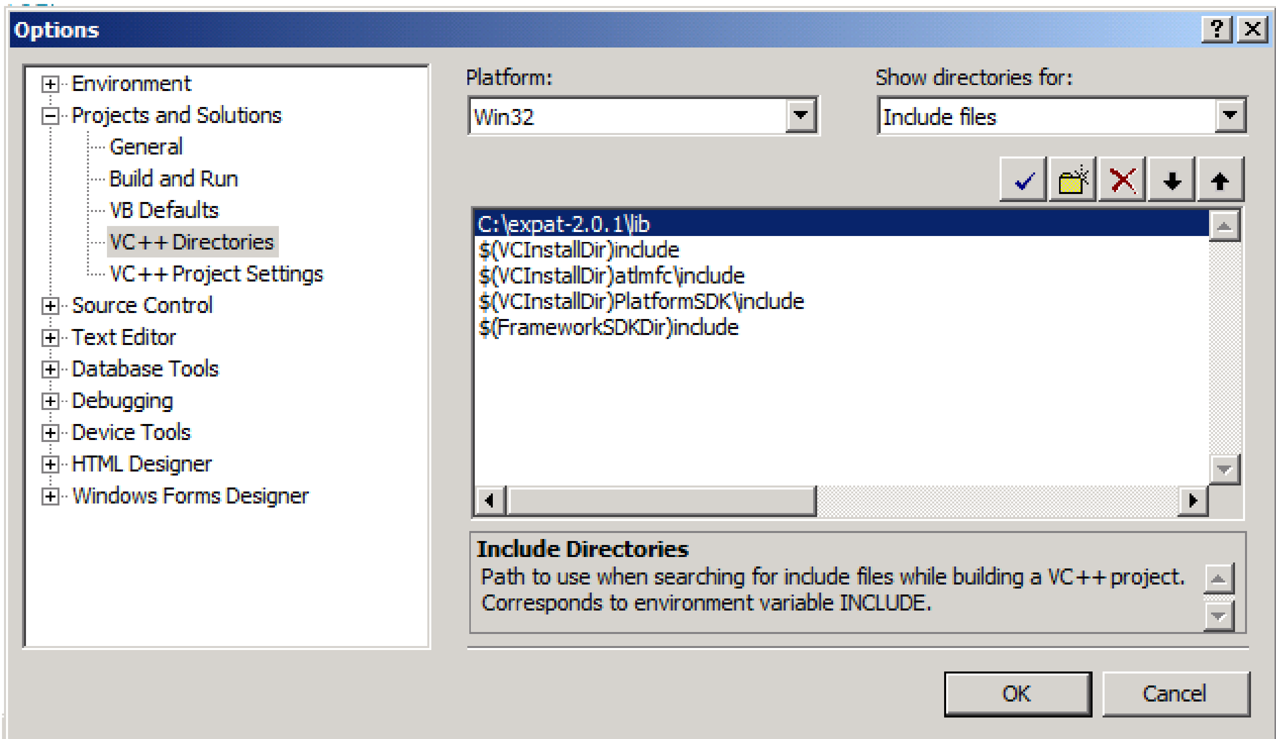
On Windows, it should be easy to integrate it with the “Visual Studio 2005” solution as follows:

1. Add the Expat include directory to “Additional Include Directories” for the **utility** library. To access the header files it is necessary to add the **C:\expat-2.0.1\lib** directory to the Visual Studio include file path set:

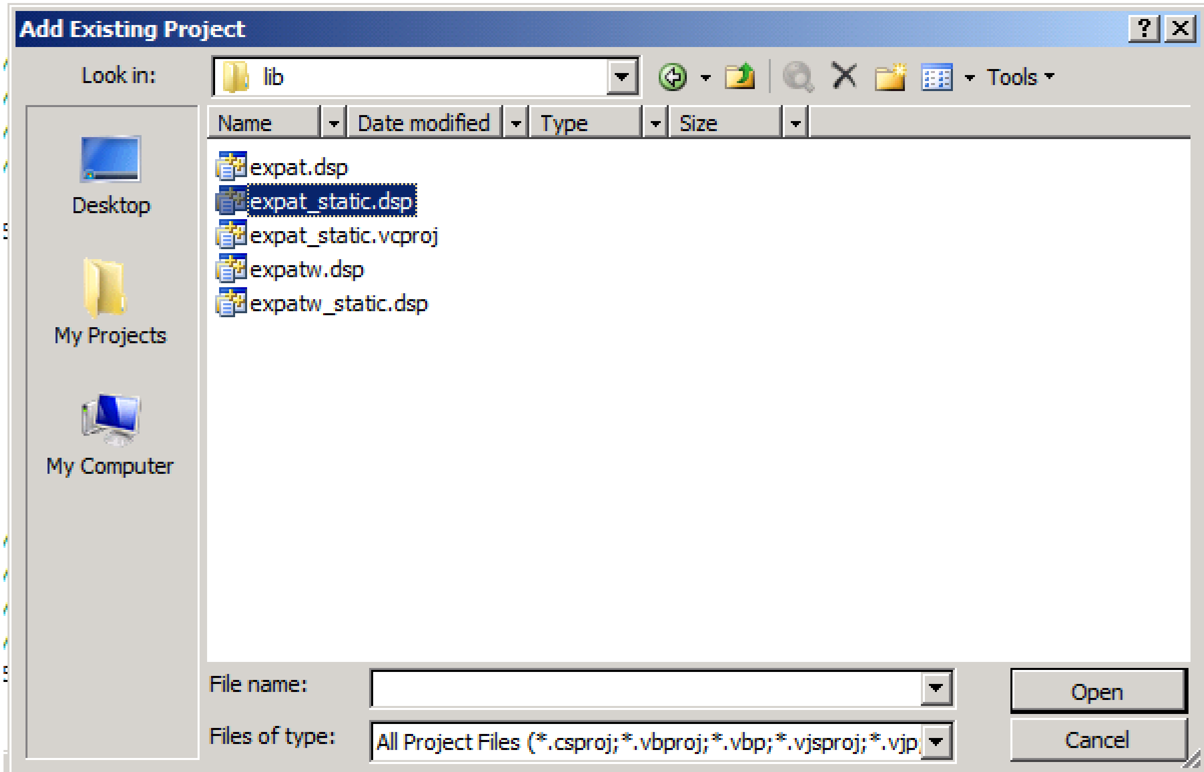
Tools→Options→Projects and Solutions→VC++ Directories

2. To do this change the **Show directories for:** drop down combo box to **Include files**, click the **new item** icon and type in:

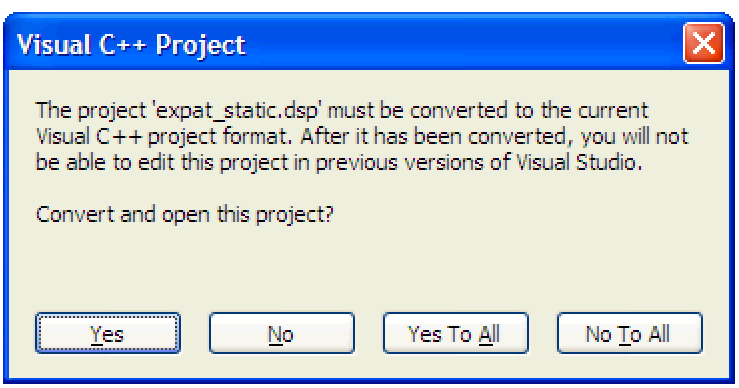
    C:\expat-2.0.1\lib



3. Convert the Expat library project file **expat_static.dsp** to **expat_static.vcproj** and add it to the VS2005 solution as a *library*. In the Solution Explorer pane of the Visual Studio, where the MMS-Lite solution is loaded, right click on the word *Libraries.* Then select **Add →Existing Project**. The following dialog box will appear, Change the **Files of Type:** choice to **Compatible Project File (*.dsp; *.vcp)**.



4. Navigate to the **C:\expat-2.0.1\lib** directory. Then select **expat_static.dsp**.



5. Select **Yes**.

6. Add a dependency to each executable project to depend on the **expat_static** library. For example to change the cositcps0 Client App to use the **expat_static** library, right click on the *General MMS Sample* name **cositcps0** and select the *Project* **Dependencies**. Then click the check box for **expat_static**.

7. Add **USE_EXPAT** to the **Preprocessor Definitions** for each configuration of the "utility" project.

8. Build the solution.

WIN32 Development Environment

MMS-*Lite* includes workspace and project files for Microsoft Visual Studio .NET version 2005, and these files are located in **\mmslite\cmd\win32**. The following WIN32 projects are included in the main Microsoft Visual Studio .NET 2005 solutions, which is **mmsliteXXX.sln** (where "XXX" may be "801" or "802" depending on the product version). ***Note that libraries from this release cannot be linked with applications using Visual Studio C++ V6.0 or Visual Studio .NET 2003 compilers.*** The projects can be built in batch mode or individually, but should be built in the following order:

1. Libraries
2. Utility applications
3. Sample applications

makelibs.vcproj	Makes all the libraries
makesamples.vcproj	Makes all the samples
makeutils.vcproj	Makes all the utilities
asn1.vcproj	ASN.1 encode/decode library
gse_mgmt.vcproj	IEC 61850 GSE Management library
mem.vcproj	Memory allocation library - full featured version
meml.vcproj	Memory allocation library - *Lite* version
mlog.vcproj	MMS operation specific logging library
mmsl.vcproj	Main MMS encode/decode library
mmsle.vcproj	Extended MMS encode/decode library
mvl.vcproj	MVL library
mvlu.vcproj	MVL UCA and IEC 61850 library
ositcps.vcproj	TCP/IP (via RFC1006) stack library using non-blocking sockets
ositpxs.vcproj	Library that includes TCP/IP (via RFC1006) using non-blocking sockets over Ethernet
slog.vcproj	SISCO logging library - full featured version
slogl.vcproj	SISCO logging library - *Lite* version
smem.vcproj	Memory allocation library using "pools".
smpval.vcproj	IEC 61850 Sampled Value library
utility.vcproj	SISCO utility library
Utility applications	
foundry.vcproj	**foundry.exe** utility application
mmslog.vcproj	**mmslog.exe** utility application
Sample Applications	
cositcps0.vcproj	Client sample application for TCP/IP using **ositcps** stack library
cositpxs0.vcproj	Client sample application for TCP/IP over Ethernet using **ositpxs** stack library
gse_mgmt_test.vcproj	IEC 61850 GSE Management sample application

iecgoose.vcproj	IEC 61850 GOOSE Framework sample application
scl_srvr.vcproj	IEC 61850 Server sample application using SCL
scl_tpxs0.vcproj	Same as **scl_srvr** but including Sampled Value support
sositcps0.vcproj	Server sample application for TCP/IP using **ositcps** stack library
sositpxs0.vcproj	Server sample application for TCP/IP over Ethernet using **ositpxs** stack library

GNU Development Environment

MMS-*Lite* includes makefiles that work with the GNU Make utility that is available on many UNIX-like platforms. These files are located in **\mmslite\cmd\gnu**. These makefiles should work with little or no modification on any system using GNU Make or a similar UNIX-like make utility. A shell script **mmsliteXXX.sh** (where "XXX" may be "801" or "802" depending on the product version) is provided to execute all the necessary make commands and to build everything in the following order:

1. Libraries
2. Utility applications
3. Sample applications

asn1.mak	ASN.1 encode/decode library
cositcps0.mak	Client sample application for TCP/IP using **ositcps** stack library
cositpxs0.mak	Client sample application for TCP/IP over Ethernet using **ositpxs** stack library
findalgn.mak	**findalgn.exe** utility application
foundry.mak	**foundry.exe** utility application
gse_mgmt.mak	IEC 61850 GSE Management library
gse_mgmt_test.mak	IEC 61850 GSE Management sample application
iecgoose.mak	IEC 61850 GOOSE Framework sample application
mem.mak	Memory allocation library - full featured version
meml.mak	Memory allocation library - *Lite* version
mlogl.mak	MMS operation specific logging library - *Lite* version
mmsl.mak	Main MMS encode/decode library
mmsle.mak	Extended MMS encode/decode library
mmslog.mak	**mmslog.exe** utility application
mvl.mak	MVL library
mvlu.mak	MVL UCA and IEC 61850 library
ositcps.mak	TCP/IP (via RFC1006) stack library using non-blocking sockets
ositpxs.mak	Library that includes TCP/IP (via RFC1006) using non-blocking sockets over Ethernet
platform.mak	Included by all other makefiles to specify platform dependent defines
scl_srvr.mak	IEC 61850 Server sample application using SCL
scl_tpxs0.mak	Same as **scl_srvr** but including Sampled Value support

slog.mak	SISCO logging library - full featured version
smem.mak	Memory allocation library using “pools”.
smpval.mak	IEC 61850 Sampled Value library
sositcp0.mak	Server sample application for TCP/IP using **ositcps** library
sositpxs0.mak	Server sample application for TCP/IP over Ethernet using **ositpxs** stack library
util.mak	SISCO utility library

Building MMS-*Lite* Step-by-Step

The steps below are all to be executed on the **host** system, and will result in a set of libraries that can be used to create a MMS-*Lite* application that can be transferred to and executed on the **target** system.

1. Edit **glbtypes.h** and map the SISCO data types onto the target system’s native C data types. This file contains type definitions for many sample environments. Normally for a completely new operating system, you would need to add a new section like this in **glbtypes.h** (where "SYSTEM_XYZ" would be something that is defined your build environment):

```
#if defined(SYSTEM_XYZ)

#define SD_BYTE_ORDER    SD_BIG_ENDIAN
#define SD_END_STRUCT  /* nothing needed to align end of struct*/

/* We can tolerate machine-dependent sizes for these types      */
#define ST_CHAR    char
#define ST_INT     signed int
#define ST_LONG    signed long int
#define ST_UCHAR   unsigned char
#define ST_UINT    unsigned int
#define ST_ULONG   unsigned long
#define ST_VOID    void
#define ST_DOUBLE  double
#define ST_FLOAT   float

/* General purpose return code                        */
#define ST_RET signed int

/* We need specific sizes for these types                */
#define ST_INT8   signed char
#define ST_INT16  signed short
#define ST_INT32  signed long
#define ST_INT64  signed long long
#define ST_UINT8  unsigned char
#define ST_UINT16 unsigned short
#define ST_UINT32 unsigned long
#define ST_UINT64 unsigned long long
#define ST_BOOLEAN  unsigned char

/* This define indicates we support 64 bit integers      */
#define INT64_SUPPORT

/* This define indicates all required types defined.     */
#define _SISCOTYPES_DEFINED
#endif    /* SYSTEM_XYZ */
```

2. Edit **sysincs.h** and select appropriate system header files for the development environment. Any place you need to make special changes for your version of your operating system, you should just add an appropriate **`#ifdef`** or **`#ifndef`**.

   Contact SISCO if there are specific system defines, structures or functions that are completely missing on your system, and we will try to suggest alternatives.
3. Edit the file **align.cfg** in order to specify the alignment requirements of the target environment. Samples are included for QNX and WIN32 in subdirectories under **\mmslite\mvl\util\foundry**. If the target system alignment requirements are not well known, compile and execute the executable **findalgn.exe** in the target environment.
4. Review system specific code, such as floating-point format and high-resolution timers.
5. If logging is desired, make sure all code is compiled with **`DEBUG_SISCO`** defined.
6. Review and port stack components. See page 27 for information on stack portation.
7. Modify the MMS-*Lite* make files as required to allow building target libraries on the host.
8. Build the MMS-*Lite* libraries to be used in creating applications for the target environment.
9. The **mmslite801.sh** or **mmslite802.sh** shell scripts are written to compile libraries and link MMS Lite applications on Linux, QNX, or any system with the " bash" shell. They may require slight modifications on other platforms. Before they will run, you must add execute permission to the shell script with the following command:

   ```
   chmod +x mmsliteXXX.sh
   ```

   where "XXX" is replaced with "801" or "802". It is also best if you use the same login used when you transferred the files with FTP (or you may log in as superuser).

Both shell scripts take arguments or they will not run. They will send usage information to stdout if used the wrong way. There is documentation in the beginning of each shell script that describe their usage. The first argument is mandatory and represents the Operating System.

Compile warnings and errors are redirected to a file in the gnu folder called **cc.lst**. The second argument, ***`clean`***, is optional and will delete the **cc.lst** file. Here are some examples:

```
./mmslite802.sh LINUX
./mmslite802.sh QNX clean
```

Note: As a suggestion, the ASN.1 library is a good makefile to use as a starting point. It has a modest number of files to work with and no stack or MMS Lite foundry dependencies.

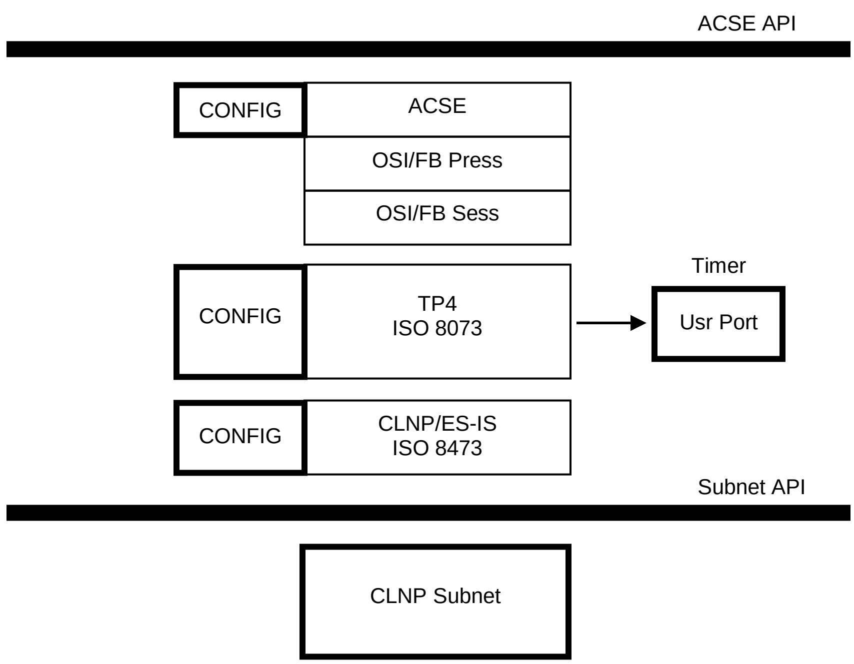
Chapter 4

MMS-*Lite* Lower Layers

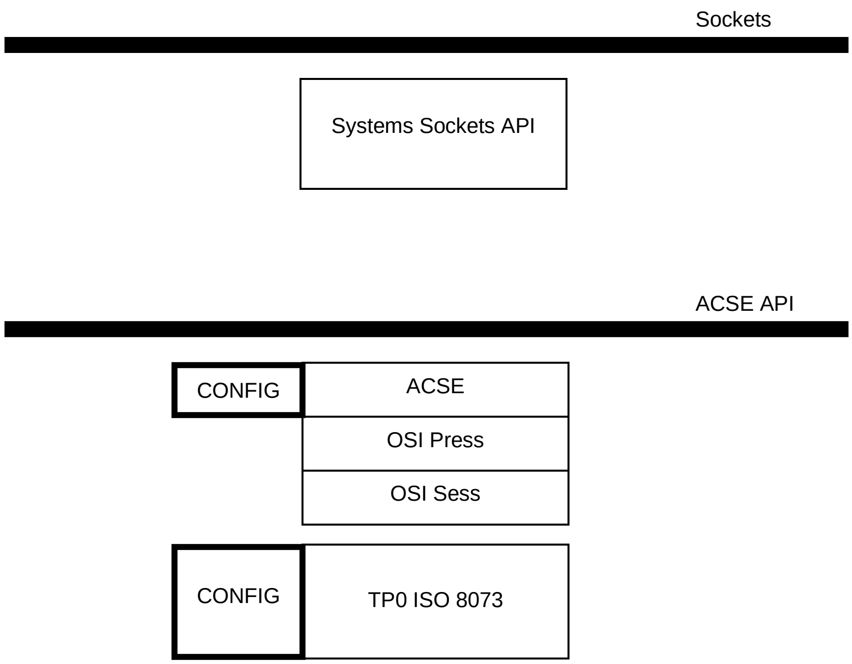
Profile Options

The "MMS-*Lite* Stack Components" is an implementation of various Open Systems Interconnection (OSI) protocol layers. It is designed for systems with very limited resources such as some embedded systems and to be modular so that only the protocol layers required for a particular application need to be used. It consists of several C source code modules which can easily be compiled for any embedded system. It contains only ANSI standard C except for a few simple functions (isolated in the **tp4port.c** module) which may need to be modified for a particular system. In the terminology of the OSI Reference Model, each protocol layer is described as providing "services" to the layer above it. In this implementation, these "services" are provided by means of an Application Programming Interface (API) which is simply a C function call interface. The diagrams below show the relationships between the OSI protocol layers and the APIs between them.

All MVL Profiles



TCP/IP (via RFC1006)



Lower Layer Component Portation

TCP/IP (via RFC1006)

The TCP/IP (via RFC1006) Protocol Stack is made up of the following components:

- ACSE
- OSI Presentation
- OSI Session
- TP0 (OSI Transport Class 0)
- TCP/IP (provided by the operating system with a Berkeley Sockets interface)

tp4_init_timer

Usage: This function is called from the TP4 initialization (from **`tp4_initialize`**). This function should do anything necessary to initialize the timer service.

Function Prototype: `ST_VOID tp4_init_timer (ST_VOID);`

Parameters: None

Return Value: `ST_VOID`

tp4_check_timer

Usage: This function is called from **`tp4_event`**. This function should check the timer and if one second has elapsed, it should call **`tp4_timer_tick`**. The example function, supplied by SISCO, is appropriate for most systems, but it may be freely modified if a more efficient approach is available on the target system.

On event driven systems, it is important to be sure that **`mvl_comm_serve`** is called at least once every second so that this function is also called. Therefore, the system should never go to sleep for more than one second. However, this restriction only applies if TP4 transport is used (i.e., the OSI/TP4 stack is used).

Function Prototype: `ST_VOID tp4_check_timer (ST_VOID);`

Parameters: None

Return Value: `ST_VOID`

WARNING: Do not call **`tp4_timer_tick`** from an interrupt handler. It must only be called from **`tp4_check_timer`**, which is only called by **`tp4_event`**.

Overview of Sockets Interface Implementation

The sockets interface for MMS-*Lite* assumes that the operating system provides the standard Berkeley Sockets interface (or a very similar interface). It uses “non-blocking” sockets so that the user application is not delayed waiting for a blocking “recv” or “send” call to finish.

Sockets Interface Porting

There should be very little, if any, porting required for the Sockets Interface. A few defines might need slight modifications on some systems. These defines can be found in **gensock2.h**. There are defines already for Windows, Linux, VxWorks, etc.

The interface may optionally use threads on systems that support threads. This can be done by compiling with **S_MT_SUPPORT** defined. Performance is usually almost the same with or without threads.

The following modules provide the Sockets Interface:

\mmslite\src\gensock2.c	(interface to sockets)
\mmslite\uca\leant\tp0_socks.c	(TP0 interface to gensock2)

Compile Time Options

All of the code for the TCP/IP (via RFC1006) Stack is compiled into the **ositcps.lib** library (**ositcps.a** on UNIX-like systems). If OSI support is also required, the **ositpxs.lib** library may be used instead. The following compile time options MUST be used so that the correct code is enabled in the following libraries:

```
-D LEAN_T
-D MOSI
-D TP0_ENABLED
```

The following is an optional compile time option:

`-D S_MT_SUPPORT` Use multiple threads

Subnetwork Layer Portation

The user must provide the Subnetwork API. This is needed for OSI, GOOSE, GSSE, GSE Management, and SampledValues. Refer to *Appendix H :Subnetwork API,* for more information.

Protocol Stack Configuration

TCP/IP Configuration

The user must fill in the following global structure to configure the TP0 API required for the **TCP/IP** (via RFC1006) stack:

```
typedef struct
  {
  ST_UINT16  max_tpdu_len;       /* max len of TPDU.                  */
                                 /* Use to allocate TPDU buffers.     */
  ST_UCHAR   max_tpdu_len_enc;   /* Binary encoded MAX TPDU len. Computed*/
                                 /* from max_tpdu_len by tp0_initialize. */
  ST_UCHAR   max_num_conns;      /* Max # Connections                 */
  ST_BOOLEAN keepalive;          /* Use KEEPALIVE option on Sockets.  */
  } TP0_CFG;                     /* For TP0/RFC1006 only.             */
```

The user must set each parameter before calling **`tp0_initialize`**. Behavior is undefined if this structure is modified after **`tp0_initialize`**. This may be done in any way appropriate for the target platform. An example of hard coding is provided in the following module:

tp4_hc.c

This can also be configured with the file **osicfg.xml**. Please refer to the following section entitled *General Configuration Issues*.

The user must set each parameter before calling **`tp4_initialize`**. Behavior is undefined if this structure is modified after **`tp4_initialize`**. This may be done in any way appropriate for the target platform. An example of hard coding is provided in the module called **t4_hc.c**.

This can also be configured with the file **osicfg.xml**. Please refer to the following section entitled *General Configuration Issues*.

Network Layer (CLNP/ES-IS) Configuration

The user must fill in the following global structure to configure the Network (CLNP) API:

```
typedef struct
  {
  ST_UCHAR   pdu_lifetime;
                                 /* PDU lifetime (in 500 msec units) for */
                                 /* outgoing DT PDUs.                 */
                                 /*   init to CLNP_DEF_PDU_LIFETIME    */
  ST_UCHAR   pdu_lifetime_dec;
                                 /* PDU lifetime decrement (1=500msec)   */
                                 /* for incoming DT or ER PDUs.        */
                                 /*   init to CLNP_DEF_PDU_LIFETIME_DEC  */
  ST_UINT16  esh_cfg_timer;
                                 /* How often we report our presence to  */
                                 /* other network entities (in seconds)  */
                                 /*   init to CLNP_DEF_ESH_CFG_TIMER     */
  ST_UINT16  esh_delay;          /* Delay time before first ESH is sent  */
                                 /*   init to CLNP_DEF_ESH_DELAY         */
  ST_UCHAR   loc_mac  [CLNP_MAX_LEN_MAC];
                                 /* Local MAC address                 */
                                 /* For ADLC the NS-USER sets the loc_mac*/
                                 /* DEBUG: Now the loc_mac has to match  */
                                 /* the address in adlc.cfg !!!        */
                                 /* For the Ethernet this param will be  */
                                 /* read from the driver during init     */
   ST_UCHAR  loc_nsap [1+CLNP_MAX_LEN_NSAP];
                                 /* Local len & NSAP address           */
  }CLNP_PARAM;
```

The user must set each parameter before calling **`clnp_init`**. Behavior is undefined if this structure is modified after **`clnp_init`**. This may be done in any way appropriate for the target platform. An example of hard coding is provided in the module called **clnp_hc.c**.

This can also be configured with the file **osicfg.xml**. Please refer to the following section entitled *General Configuration Issues*.

Network Addresses

MMS-*Lite* defines the term “Application Reference Name”, or “AR Name”. An AR Name is an ASCII string of up to 32 characters that is used to collectively identify Application Entity information (AP Title and AE Qualifier) and the Presentation Address associated with an application. In other words, an AR Name is not something that is exchanged between two applications over the network, but rather a human-readable shorthand for the ACSE and addressing information that it represents. MMS-*Lite* applications use AR Names when calling MMS Connection Management APIs.

To configure the Network Addresses, the user must set the following global pointers to point to arrays of **`DIB_ENTRY`** structures:

`DIB_ENTRY *loc_dib_table;`	Local Addresses (must have at least one)
`DIB_ENTRY *rem_dib_table;`	Remote Addresses (only needed for Client)

```
typedef struct
  {
  ST_LONG    reserved;          /* reserved field                        */
  ST_CHAR    *name;             /* AR Name */
  ST_CHAR    local;             /* SD_TRUE if local, SD_FALSE if remote    */
  ST_UCHAR   AP_title_pres;     /* present flag                          */
  MMS_OBJ_ID AP_title;          /* AP title                              */
  ST_UCHAR   AP_inv_id_pres;    /* present flag                          */
  ST_INT32   AP_invoke_id;      /* AP invocation ID                       */
  ST_UCHAR   AE_qual_pres;      /* present flag                          */
  ST_INT32   AE_qual;           /* AE qualifier                          */
  ST_UCHAR   AE_inv_id_pres;    /* present flag                          */
  ST_INT32   AE_invoke_id;      /* AE invocation ID                       */
  PRES_ADDR  pres_addr;         /* Presentation address.                  */
  } DIB_ENTRY;
```

This **`DIB_ENTRY`** definition references the **`PRES_ADDR`** structure defined below:

```
typedef struct tagPRES_ADDR
  {
  int     psel_len;
  char    psel [MAX_PSEL_LEN];
  int     ssel_len;
  char    ssel [MAX_SSEL_LEN];
  ST_INT  tp_type;                 /* Transport Type: TP_TYPE_TP4,      */
                                   /* TP_TYPE_TCP, or TP_TYPE_TPX.      */
  int     tsel_len;
  char    tsel [MAX_TSEL_LEN];
  int     nsap_len;
  char    nsap [MAX_IP_ADDR_LEN];  /* If TP_TYPE_TP4, contains NSAP.    */
                                   /* If TP_TYPE_TCP, contains IP addr. */
                                   /* Only used for “remote” addresses. */
  } PRES_ADDR;
```

Note: *Based on the review of current OSI agreements, the PSEL, SSEL and TSEL parameters are all being changed to a maximum of 4 bytes, improving the memory usage of MMS-Lite. The standards recommend the following:*

PSEL 4 - International Standard Profiles
SSEL 2 - GOSIP Ver2
TSEL 2 - GOSIP Ver2

The transport type **`TP_TYPE_TPX`**, may be used only for a "local" entry. It indicates that both TP4 and TCP are to be supported.

Setting the pointers **`loc_dib_table`** and **`rem_dib_table`** may be done in any way appropriate for the target platform. Examples of hard-coding are provided in the sample code modules of **server.c** and **client.c** (the code is executed only if **HARD_CODED_CFG** is defined):

This can also be configured with the file **osicfg.xml**. See details below.

Protocol Stack Configuration using XML Input File

An example of using the SISCO General Purpose Configuration Utility to configure the TP4 API, CLNP API, as well as DIB entries is provided in the module **osicfgx.c**.

This code processes the configuration file **osicfg.xml**.

The configuration file **osicfg.xml** is divided into four sections for TP4, TCP, CLNP, and DIB entries (Network Addresses) respectively. A complete description of this file and the SISCO General Purpose Configuration Utility is beyond the scope of this document.

ACSE Authentication

The following describes the ACSE Authentication per Annex B of the ISO/IEC 8650-1.

The **acseauth.h** file contains the authentication structure **`ACSE_AUTH_INFO`** that is passed to/from the user and the ASN.1 parser.

If ACSE Authentication is not desired, the calling node may call **`mvla_initiate_req`** to send an initiate request PDU to the called node. If ACSE Authentication is needed, the ACSE user must call **`mvla_initiate_req_ex`** and pass a pointer to an **`ACSE_AUTH_INFO`** structure containing the authentication information they wish to send to the called node. The encoding of the authentication information is per the ACSE specification and is done in **acse2enc.c**.

The called side will receive the request PDU with authentication, and decode it in **acse2dec.c**. An **`ACSE_AUTH_INFO`** structure is filled out and passed to the user using **`u_mvl_connect_ind_ex`**. The user can accept the authentication, and return success, or reject for a variety of reasons, which will cause an abort PDU to be sent to the calling node. The reject reasons are a part of the constants in **acseauth.h** and are encoded in the abort PDU.

Also, the user is passed a pointer to a responding authentication structure, which may be sent back to the calling node during the connect confirm. Using this method of exchanging authentication information in both the associate request and associate response APDUs provides bi-directional authentication.

If the calling side does in fact receive authentication in the AARE APDU this information is passed to the user in **`u_mvl_connect_cnf_ex`**. Again, this function may return success or an error diagnostic, which will be encoded and sent in an abort PDU.

The authentication value itself is defined in the ACSE specification. The **`ACSE_AUTH_INFO`** structure may use a password mechanism (as defined in the ACSE spec) or some other mechanism. In the case of the "other" mechanism, the user is expected to handle the ASN.1 decoding and encoding of the authentication value. In addition, SISCO can provide certificate-based ACSE authentication mechanism.

ACSE authentication encoding/decoding is compiled into the MMS-*Lite* library code. For ACSE Authentication sample code, please see the provided client or server in the **\mmslite\mvl\usr** directory.

Chapter 5

MVL Application Program Interface

MMS-*Lite* includes a high-level interface layer referred to as MVL (**M**MS-**V**irtual-**L**ite). MVL is closely coupled to the lower layer subsystem components provided by SISCO and provides an application framework that is suitable for most applications.

MVL is integrated with the SISCO protocol stack based on TCP/IP (using RFC1006). MVL provides full integration with the SISCO ACSE layer, including the connection oriented and connectionless modes of operation. MVL allows the use of the MMS Application Association object scope for connection oriented ACSE profiles.

For Server applications, application development is as simple as defining the MMS variables, variable lists, and types to be exposed to client applications then letting MVL do the rest. Hooks are provided to allow the application to participate in handling indications if desired, and MVL has the flexibility to handle most application programming requirements.

For Client applications, MVL provides an easy to use API for performing MMS connection control, Read, Write, and Identify services. Other services are easily added as required.

The most complete and accurate vehicle for developer documentation will be the MVL sample applications and the MVL header files. The Server sample is **\mmslite\mvl\usr\server\server.c** and the Client sample is **\mmslite\mvl\usr\client\client.c**. Most MVL features are demonstrated in these fully functional applications and most applications can easily be constructed using these samples as a starting point.

Advantages of the MVL interface include:

- MVL is a flexible application framework and provides useful general MMS services such as communications service, incoming PDU handling, etc.
- Works with SISCO's MMS Object Foundry, a utility that greatly simplifies creating and using MMS objects.
- Complete integration to the SISCO lower layer components (ACSE and below) is provided.
- Complete and flexible MMS object management code is provided, with an appropriate and conformant model.
- MMS Data conversion issues are addressed in a developer friendly manner.
- Fully functional Client and Server application examples are provided.
- Asynchronous response capability for the server.
- Multiple outstanding client request management is provided.
- This is the fastest way to get up and running.

MVL currently supports a limited set of MMS services, but can easily be extended to handle any number of services as client, server, or both. Please refer to *Appendix K: IEC61850 Product Pics.*

MMS-*Lite* is designed to operate as a single threaded application. After initialization, all MMS service is performed using the service function **`mvl_comm_serve`**. From within this call, all network service is performed including getting MMS PDUs from the network, decoding and operating on the MMS PDU, and calling any appropriate user functions. Note that global variables are used within MMS-*Lite* and MVL, and so these functions are not reentrant.

MVL provides a MMS object framework such that development of a server application can be quite straightforward, requiring only application specific data types and variables to be integrated into the sample application. Generally, the application programmer can simply tell MMS-*Lite* which variables are to be accessible using MMS and provide a data access mechanism.

MVL Application Build Process

Many embedded environments require the use of a cross compiler, which runs on a *host* computer and the resulting programs are transferred to the *target* system for execution. In this discussion, the term *host* will refer to the environment where the application is compiled and linked, and *target* will refer to the environment where the application is to be executed.

The steps below are all to be executed on the host system and will result in an application that can be transferred to and executed on the target system. Note that this list assumes that the MMS-*Lite* library build steps have already been successfully completed.

1. Create an MMS **O**bject **D**efinition **F**ile (ODF) for the application (named **srvrobj.odf** in the sample server applications). This text file is used to define all the MMS server objects and data types to be used by the application. It is then used by MMS Object Foundry to create C code that will be used to realize the objects. See *MMS Object Foundry* on page 247 for more information on MMS Object Foundry and Object Definition Files.
2. Create, compile, and link the sample application. Files to be included in the link include **mmsop_en.c**, **srvrobj.c**, **mvl_acse.c**, and MMS-*Lite* libraries.

   See the MVL samples for make files for this process.

Code Generation Utility Programs

MMS-*Lite* includes two utility applications that are used to generate C source and header files to be used in the application. DOS and Win32 executable versions of these programs and associated source code are included with the MMS-*Lite* distribution. Note that the building of these executables to run on the host will require building the MMS-*Lite* libraries for the host environment as well as the target environment.

MMS Object Foundry

This application is used to generate a C module for creating the MMS Objects for a MVL application. This executable takes as input an **O**bject **D**efinition **F**ile (ODF) which defines the MMS objects for the application, as well as a file describing the data alignment requirements for the target environment (**align.cfg**). See *MMS Object Foundry* on page 247 for more information regarding this utility program.

Network Profiles

MMS-*Lite* includes options for several stack profiles, including TCP/IP (via RFC1006), IEC 61850 GOOSE, IEC 61850 GSSE, and IEC 61850 SampledValues. The TCP/IP profile makes use of SISCO’s ACSE as the upper interface, and so it is possible to develop the target application in such a manner as to be profile independent. When this is done, the developer simply selects the stack profile to be used by linking in alternate stack libraries. Of course, there will be some configuration differences between the various profiles.

MVL takes advantage of this common ACSE interface, using the MVL module **mvl_acse.c** as a bond between MVL and ACSE. Both connectionless and connection oriented operations are supported by MVL when available in the profile. MVL supports both CALLED and CALLING connection management with user hooks provided to allow the desired interaction with the application.

Selecting MMS Services Set

The MMS-*Lite* decode tree makes use of a set of function pointer and opcode control tables in the source module **mmsop_en.c**. The contents of these tables are controlled at compile time by the include file **mmsop_en.h**. This file must be edited to select the MMS PDUs to be decoded. This which must be done before the MMS source file **mmsop_en.c** is complied.

By default, MMS-*Lite* will not support modifiers or companion standards, and will generate decode errors when they are encountered. To enable support for these elements, edit the **mmsintr2.c** file and define **MOD_SUPPORT** for Modifier support and **CS_SUPPORT** for Companion Standard support.

MVL Configuration

MVL requires some configuration to perform as required by the application. Configuration for MMS-*Lite* means initialization of memory based data structures. The items listed below are configurable. Note that additional configuration will be required for the selected stack profiles.

MMS Parameters

Maximum Message Size

This is configured set by configuring the **<Max_Mms_Pdu_Length>** tag in the **osicfg.xml** file or by manually setting the **`max_msg_size`** parameter in the **`MVL_CFG_INFO`** structure, which is passed to the function **`mvl_start_acse`**.

This parameter represents the maximum MMS PDU size to be supported. This value is used for both calling and called connections and will impact the memory requirements of MVL. The MVL global variable **`mmsl_max_msg_size`** will be set to this value.

Maximum Number Of Connections

Setting the **`num_calling`** and **`num_called`** parameters in the **`MVL_CFG_INFO`** structure, which is passed to the function **`mvl_start_acse`**, controls the number of calling and called connections.

MMS Services Supported

The client and server service set and MMS parameter support items are configured by use of the header file **mmsop_en.h**. See *Appendix A: Subset Creation* for more information on using this file to control the service set.

Other MMS Initiate Parameters

The remaining MMS initiate parameters such as the number of outstanding requests, max structure nesting level, and MMS version are to be set dynamically by the user application when establishing a MMS connection.

Network Addressing

Local AR Names

Before calling the **`mvl_start_acse`** startup function, the application needs to select the local AR Names to be used. These names are alias's for all required addressing for the node, and must be present in the applications DIB. See page 30 for more information on configuring AR Names.

For connection oriented ACSE, the local AR Name is set in the **`MVL_CFG_INFO`** structure, passed to the function **`mvl_start_acse`**. For connectionless ACSE, the local AR Name is passed to **`mvl_init_audt_addr`** to get the local address.

MVL Connection Management

MVL Network Information Structure

The following data structure is used to maintain information about a connection to a remote device. It represents the device the PDU is sent to or received from and is implementation specific.

```
typedef struct
  {
   struct mvl_aa_obj_ctrl *aa_objs; /* AA object ctrl                    */
   struct mvl_vmd_ctrl    *rem_vmd; /* Remote VMD                        */
   struct mvl_ind_pend    *pend_ind;
   ST_BOOLEAN              conn_active;
                                  /* Set SD_TRUE when the connection is up */
  ST_INT                   max_pdu_size;
  ST_INT                   index;  /* NET_INFO table index for this elmnt  */
  ST_INT                   maxpend_req; /* num outstanding reqs negotiated*/
  ST_INT                   numpend_req; /* num reqs currently outstanding */

#ifdef ICCP_LITE_SUPP
  ST_BOOLEAN                mi_in_use;
  struct _mi_conn           *mi_conn;
#endif
  INIT_INFO                 rem_init_info;
                                   /* Services supported by remote dev*/
  INIT_INFO                 locl_init_info; /* Initiate info we sent       */
  AARQ_APDU                 ass_ind_info;
                                  /* Items below are used by MVL only */
  ST_BOOLEAN                in_use; /* Flag that this 'NET_INFO' is in use  */
  ST_INT32                  acse_conn_id;       /* ACSE's connection ID     */
  ST_VOID                   *user_info;
                                  /* MVL user can use this for 'whatever'*/

  } MVL_NET_INFO;
```

`STRUCT MVL_AA_OBJ_CTRL *AA_OBJS`

This pointer references the control structure containing all Application Association Specific objects associated with the connection.

`STRUCT MVL_VMD_CTRL    *REM_VMD`

This pointer was used to receive InformationReports from the remote device. There is a different mechanism in place for receiving InformationReports and this pointer is no longer part of it. It is left in for backward compatibility. Please refer to function **`u_mvl_info_rpt_ind`** for further details on receiving Information Reports.

`STRUCT MVL_IND_PEND    *PEND_IND;`

Used to reference outstanding pending indications.

`ST_BOOLEAN conn_active`

This field is set to **`SD_TRUE`** when the connection is up.

ST_INT max_pdu_size

This is the size of the largest MMS PDU, which may be sent or received from the remote device. It is negotiated between the two devices and may be less than the global variable **mmsl_max_msg_size**.

ST_INT index

This is the position of the **MVL_NET_INFO** structure in its global table.

ST_INT maxpend_req

The possible number of outstanding requests on this connection.

ST_INT numpend_req

The current number of outstanding requests on this connection.

ST_BOOLEAN mi_in_use

Not used by MMS-*Lite*

STRUCT _MI_CONN *MI_CONN

Not used by MMS-*Lite*

INIT_INFO rem_init_info

This field contains the MMS Initiate information from the remote node. Among other things it includes the MMS service support string.

INIT_INFO locl_init_info

This field contains the local MMS Initiate information sent to the remote node.

AARQ_APDU ass_ind_info

This field contains the ACSE Application Request PDU information. Calling and called AP Title, AE Qualifier information may be found there.

ST_BOOLEAN in_use

This field tells when the **MVL_NET_INFO** structure is in use.

ST_INT32 acse_conn_id

This field contains the ACSE connection ID.

ST_VOID *user_info

This is reserved for application use and is not modified by MMS-*Lite*.

MVL Functions

mvla_initiate_req_ex

Usage: This function initiates a MMS connection to the selected Remote AR. The **`remAr`** name must be present in the **`DIB_ENTRY`** table.

Function Prototype:

```
ST_INT mvla_initiate_req_ex (ST_CHAR            *remAr,
                             INIT_INFO          *req_info,
                             INIT_INFO          *resp_info,
                             MVL_NET_INFO       **net_info_out,
                             MVL_REQ_PEND       **req_out,
                             ACSE_AUTH_INFO     *auth_info,
                             S_SEC_ENCRYPT_CTRL *encrypt_info);
```

Parameters:

`remAr`	Remote AR Name (see the section on *Network Address Configuration* on page 30.)
`req_info`	Pointer to the proposed Initiate parameters (sent on request). The **`INIT_INFO`** structure is defined in **mms_pcon.h**.
`resp_info`	Pointer to the negotiated Initiate parameters (received on response).
`net_info_out`	Pointer to pointer to connection control structure. The function allocates a **`MVL_NET_INFO`** structure and sets (**`*net_info_out`**) to the address of the allocated structure. For example, if there is a variable **`MVL_NET_INFO *net_info`**, and **`&net_info`** is passed to the function, it will set **`net_info`** to the address of the new structure. The **`MVL_NET_INFO`** structure is defined in **mvl_defs.h**.
`req_out`	Pointer to pointer to request control structure. The function allocates a **`MVL_REQ_PEND`** structure and sets **`(*req_out)`** to the address of the allocated structure. For example, if there is a variable **`MVL_REQ_PEND *req_pend`**, and **`&req_pend`** is passed to the function, it will set **`req_pend`** to the address of the new structure. The **`MVL_NET_INFO`** structure is defined in **mvl_defs.h**. The structure must be freed sometime after the response is received and processed by calling **`mvl_free_req_ctrl`**(**`req_pend`**).
`auth_info`	Pointer to structure containing ACSE Authentication information for this connection.
`encrypt_info`	For future implementation – currently must be NULL.

Return Value: `ST_RET` `SD_SUCCESS` if OK, or an error code.

mvla_concl

Usage: This is an asynchronous function for sending a MMS Conclude.

Function Prototype:

```
ST_RET mvla_concl (MVL_NET_INFO   *net_info,
                   MVL_REQ_PEND   **req_out);
```

Parameters:

`net_info` Network connection information.

`req_out` See the description of **`req_out`** on page 152.

Return Value: `ST_RET` `SD_SUCCESS` if OK, or an error code.

u_mvl_concl_ind

Usage: This is a user function called by MVL when a conclude indication is received. It should do all appropriate cleanup before sending the Conclude response. At a minimum, it should call **`mplas_concl_resp`** to send the response. See the file **server.c** for an example of this function.

Function Prototype:

```
ST_VOID u_mvl_concl_ind (MVL_COMM_EVENT *event);
```

Parameters:

`event` This is the communications event control structure.

Return Value: `ST_VOID`

mplas_concl_resp

Usage: This function sends the Conclude response.

Function Prototype:

```
ST_VOID mplas_concl_resp (MVL_COMM_EVENT *event);
```

Parameters:

`event`	This is the communications event control structure.

Return Value: `ST_VOID`

mplas_concl_err

Usage: This function is used to send an error response to a Conclude indication.

Function Prototype:

```
ST_RET mplas_concl_err (MVL_COMM_EVENT  *event ,
                        ST_INT16        err_class,
                        ST_INT16        err_code);
```

Parameters:

`event`	This is the communications event control structure.
`err_class`	Error class (should always be set to 9 for Conclude error)
`err_code`	Error code to send (should always be set to 0 or 1 for Conclude error)

Return Value: `ST_RET` `SD_SUCCESS` if OK, or an error code.

mvl_abort_req

Usage: This function is used to abort a MMS connection. It causes abrupt termination of the connection.

Function Prototype:

```
ST_RET mvl_abort_req (MVL_NET_INFO *net_info);
```

Parameters:

`net_info`	Network connection information.

Return Value: `ST_RET` `SD_SUCCESS` if OK, or an error code.

mvl_abort_req_ex

Usage: This function is used to abort a MMS connection. It causes abrupt termination of the connection.

Function Prototype:

```
ST_RET mvl_abort_req_ex (MVL_NET_INFO      *cc,
                         ST_BOOLEAN        diagnostic_pres,
                         ST_ACSE_AUTH      diagnostic);
```

Parameters:

`cc` Pointer to the network connection information.

`diagnostic_pres` Flag indicating whether the **`diagnostic`** value should be sent in an Abort PDU.

`diagnostic` Diagnostic value to sent in an Abort PDU. Must be one of the following:

ACSE_AUTH_SUCCESS	0
ACSE_DIAG_NO_REASON	1
ACSE_DIAG_PROTOCOL_ERR0R	2
ACSE_DIAG_AUTH_MECH_NAME_NOT_RECOGNIZED	3
ACSE_DIAG_MECH_NAME_REQUIRED	4
ACSE_DIAG_AUTH_FAILURE	5
ACSE_DIAG_AUTH_REQUIRED	6

Return Value: `ST_RET` `SD_SUCCESS` or error code

u_mvl_connect_ind_ex

Usage: This is a user-defined function that must handle connect indications.

IMPORTANT NOTICE: Unlike the previously used function pointer, **`u_mvl_connect_ind_fun`**, this function is required to be implemented by the user. It may break some older existing applications that will refuse to link until this function is implemented.

Function Prototype:

```
ST_ACSE_AUTH u_mvl_connect_ind_ex (MVL_NET_INFO      *cc,
                                   INIT_INFO         *init_info,
                                   ACSE_AUTH_INFO    *req_auth_info,
                                   ACSE_AUTH_INFO    *rsp_auth_info);
```

Parameters:

`cc`	Pointer to the network connection information. The **`MVL_NET_INFO`** structure is defined in **mvl_defs.h**.
`init_info`	Proposed Initiate parameters. The **`INIT_INFO`** structure is defined in **mms_pcon.h**.
`req_auth_info`	A pointer to the **`ACSE_AUTH_INFO`** structure that was received from the calling partner. Please see the MVL sample server (**server.c**) in the function **`u_mvl_connect_ind_ex`** for a sample of how to use password-based ACSE authentication.
`rsp_auth_info`	A pointer to the **`ACSE_AUTH_INFO`** structure that will be encoded and returned to the calling partner. Please see the MVL sample server (**server.c**) in the function **`u_mvl_connect_ind_ex`** for a sample of how to use password-based ACSE authentication.

Return Value:

`ST_ACSE_AUTH` One of the following defined values. If the return value is **`ACSE_AUTH_SUCCESS`**, a positive Initiate response is sent to the calling node. If the return value is not **`ACSE_AUTH_SUCCESS`**, an ACSE Abort PDU is sent using the return value as the ABRT-diagnostic.

```
#define ACSE_AUTH_SUCCESS                              0
#define ACSE_DIAG_NO_REASON                            1
#define ACSE_DIAG_PROTOCOL_ERROR                       2
#define ACSE_DIAG_AUTH_MECH_NAME_NOT_RECOGNIZED        3
#define ACSE_DIAG_AUTH_MECH_NAME_REQUIRED              4
#define ACSE_DIAG_AUTH_FAILURE                         5
#define ACSE_DIAG_AUTH_REQUIRED                        6
```

u_mvl_connect_cnf_ex

Usage: This is a user-defined function that must handle connect confirms.

Function Prototype:

```
ST_ACSE_AUTH u_mvl_connect_cnf_ex (MVL_NET_INFO *cc,
                                   AARE_APDU *assoc_rsp_info);
```

Parameters:

`cc` — Pointer to the network connection information. The **`MVL_NET_INFO`** structure is defined in **mvl_defs.h**.

`assoc_rsp_info` — A pointer to the **`ACSE_AUTH_INFO`** structure that was received from the called partner. Please see the MVL sample client (**client.c**) in the function **`u_mvl_connect_cnf_ex`** for a sample of how to use password-based ACSE authentication.

Return Value:

`ST_ACSE_AUTH` — One of the following defined values. If the return value is not **`ACSE_AUTH_SUCCESS`**, an Abort PDU is sent using the return value as the ABRT-diagnostic.

```
#define ACSE_AUTH_SUCCESS                          0
#define ACSE_DIAG_NO_REASON                        1
#define ACSE_DIAG_PROTOCOL_ERROR                   2
#define ACSE_DIAG_AUTH_MECH_NAME_NOT_RECOGNIZED    3
#define ACSE_DIAG_AUTH_MECH_NAME_REQUIRED          4
#define ACSE_DIAG_AUTH_FAILURE                     5
#define ACSE_DIAG_AUTH_REQUIRED                    6
```

u_mvl_disc_ind_fun

Usage: This is a user defined function pointer that handles disconnect indications.

```
#define MVL_ACSE_RELEASE_IND  1
#define MVL_ACSE_ABORT_IND    2
```

Function Pointer Global Variable:

```
extern ST_VOID (*u_mvl_disc_ind_fun)
                MVL_NET_INFO *net_info,
                ST_INT discType);
```

Parameters:

`net_info` — This is the Network connection information.

`discType` — Indicates the type of disconnect. **`MVL_ACSE_RELEASE_IND`** if release, **`MVL_ACSE_ABORT_IND`** if abort.

Return Value: `ST_VOID`

Using MVL with MMS *Lite* ACSE Components

MVL is fully integrated with the MMS-*Lite* ACSE components. This integration provides the MVL application developer with an easy to use mechanism for managing MMS connections. The MVL sample client application demonstrates the use of calling connections and the MVL sample server application demonstrates the use of called connections.

Connection Management

MVL provides full ACSE connection management facilities via the source module **mvl_acse.c**. The MVL function **`mvl_start_acse`** must be called in order to initialize the lower layer subsystem. Before exiting the application, the MVL function **`mvl_end_acse`** should be called.

Building mvl_acse

The MVL source module **mvl_acse.c** must be compiled and linked to the application in order to access the ACSE functionality of MMS-*Lite*. Compile time switches are used to control the connection management capabilities of this module. The **MMS_INIT_EN** define in the file **mmsop_en.h** is used to control the inclusion of calling and/or called code.

The module **mvl_acse.c** will provide a table of **`MVL_NET_INFO`** data structures for calling and called connection management (e.g., **`mvl_calling_conn_ctrl`** and **`mvl_called_conn_ctrl`**), that can be referenced by the user application in managing connections as required.

Being a Called Node

When an ACSE associate indication is received, MVL will parse the user information field looking for a MMS Initiate PDU. If one is present and can be decoded correctly, the user function **`u_mvl_connect_ind_ex`** is called. If the user returns **`ACSE_AUTH_SUCCESS`** from this function, MVL will respond positively to the Initiate using the Initiate response information provided by the global pointer **`mvl_init_resp_info`**. If the user returns any other value, an ACSE Abort PDU is sent using this value as the ABRT-Diagnostic.

Connection Activity Notifications

The user may set the following function pointer, **`u_mvl_disc_ind_fun`**, in order to be notified when a Conclude or Abort indication is received.

See the sample server application for an example of how this function pointer may be used.

Extending the MVL Service Set

MVL Server: Adding Support for another Service

To add another server service to the existing code framework, the following steps should be followed. This is most easily accomplished by selecting a similar existing service and using it as a template.

1. Modify the function `mvl_ind_rcvd` in **mvlop_en.c** to check for the new opcode and call a new processing function `mvl_process_xxx_ind`. The opcode defines can be found in **mms_def2.h**, located in the **\mmslite\inc** directory.
2. Edit **mvl_defs.h** and add the function prototype for the new `mvl_process_xxx_ind` function that will be used to process the indication.
3. Create a new module to contain the indication processing function. Copy an existing **s_xxxx.c** module, such as **s_ident.c**, and modify the `mvl_process_xxx_ind` function name and code as appropriate. Note that the MMS service aspect must be handled by the new indication processing function. That is, the requested MMS service activity must be correctly carried out per the MMS services specification.
4. In the server application, modify **mmsop_en.h** to enable decode of the indication for the new service (the define should be either **RESP_EN or REQ_RESP_EN**, depending if the application will also act as a client for the service).
5. Make any required changes to the MVL library make files and to the server application to support the new service.

MVL Client: Adding Support for Another Service

To add another client service to the existing code framework, the following steps should be followed:

1. Modify **mmsop_en.h** to enable decode of the confirm for the new service. The define should be either **REQ_EN** or **REQ_RESP_EN**, depending if the application will also act as a server for the service.
2. Modify the function `mvl_conf_rcvd` in **mvlop_en.c** to check for the new opcode and call a new processing function `mvl_process_xxx_conf`. The opcode defines can be found in **mms_def2.h**, in the **\mmslite\inc** directory.
3. Create a new module to contain the confirm processing function. Copy an existing **c_xxxx.c** module (**c_ident.c** or **c_read.c**) and modify the `mvl_process_xxx_conf` function name and code as appropriate.
4. Add the `mvl_process_xxxx_conf` function prototype to **mvl_defs.h**.

MVL Support Functions

Communication Service Functions

mvl_comm_serve

Usage: MVL Communication Service is a function that should be called periodically by the application. It will check for communications events and act on them, which will include decoding MMS PDUs and calling service functions. The mechanism used to determine when this function should be called is system specific and will depend on the lower layer service provider. This should be done at least once per second and whenever a low level network event is detected. The detection and use of network events is to be addressed during the porting phase.

Function Prototype: `ST_BOOLEAN mvl_comm_serve (ST_VOID);`

Parameters: None

Return Value:	`ST_BOOLEAN`	`SD_TRUE`	If there is more communication service to be done (i.e., **`mvl_comm_serve`** should be called again).
		`SD_FALSE`	**`mvl_comm_serve`** does not need to be called until one-second elapses or a communication event is detected.

Notes:

1. **Server Considerations**

   Once the MVL object configuration is complete, most services are handled transparently for the user, and any user code does not need to be directly involved. One area where the user application may be involved is in variable access, using the MVL pre/post processing functions for variables.

2. **Client Considerations**

   If the user application makes use of asynchronous client request functions (such as **`mvla_read_variables`**), the **`u_req_done`** callback function from the **`MVL_REQ_PEND`** structure will be invoked (if not **`NULL`**) from within the **`mvl_comm_serve`** function.

3. **ACSE Considerations**

   If the user application sets the ACSE disconnect callback function pointer (**`u_mvl_disc_ind_fun`**), the function will be invoked from within the **`mvl_comm_serve`** function.

Type Management Functions

mvl_init_type_ctrl

Usage: This function is used to initialize the MVL type control subsystem. It must be called before any communications activity can take place. This function is in the source module produced by the MMS Object Foundry.

Function Prototype:
```
ST_VOID mvl_init_type_ctrl (ST_VOID);
```

Parameters: None

Return Value: `ST_VOID`

mvl_get_runtime

Usage: This function takes the TypeID and provides a pointer to the runtime type and its size as output.

Function Prototype:
```
ST_RET mvl_get_runtime (ST_INT          type_id,
                        RUNTIME_TYPE    **rt_ptr_out,
                        ST_INT          *num_rt_out);
```

Parameters:

`type_id`	This is the MMS-*Lite* TypeID for which the Runtime Type is to be returned.
`rt_ptr_out`	This output parameter references the beginning of the runtime type array.
`num_rt_out`	This output parameter indicates the number of runtime type elements in the runtime type array.

Return Value: `ST_RET` `SD_SUCCESS`

ms_rt_el_tag_text

Usage: This function converts the **`el_tag`** member of a **`RUNTIME_TYPE`** structure to text.

Function Prototype:

```
ST_CHAR *ms_rt_el_tag_text (SD_CONST RUNTIME_TYPE *rt_type);
```

Parameters:

`rt_type` Pointer to the **`RUNTIME_TYPE`** structure to be modified.

Return Value: `(ST_CHAR *)` Pointer to a static string indicating the **`el_tag`** value.

Example: **`If (rt_type>el_tag==RT_STR_START)`**, this function returns a pointer to a static string **`RT_STR_START`**.

mvl_mod_arr_size

Usage: This function can be used to modify the number of elements in an array of runtime types. For instance, this can be useful to avoid having to define all possible array Runtime types for alternate access support. The size of the array may be increased or decreased.

Function Prototype:

```
ST_VOID mvl_mod_arr_size (RUNTIME_TYPE *rt,
                          ST_INT num_elmnts);
```

Parameters:

`rt` This is a pointer to the Runtime type to be modified.

`num_elmnts` This is the new value for the number of elements in the array.

Return Value: `ST_VOID`

Special Type Management Functions

u_mvl_rt_element_supported

Usage: This function returns a **SD_TRUE** or **SD_FALSE** as a way of determining if the functional constraint and/or common data class is supported in the logicial node. The application can also return a runtime reference. Examples of runtime references are specific floating point or Boolean values. The runtime reference returned by this function will be passed back to the application during the read or write access of the leaf. This function is called from the function **mvl_derive_new_type**.

Function Prototype:

```
ST_BOOLEAN u_mvl_rt_element_supported (RUNTIME_TYPE   *rt,
                                        ST_CHAR        *element_name;
                                        ST_RTREF       *ui;
                                        ST_CHAR        *handle);
```

Parameters:

rt	This is a pointer to the Runtime Type to be modified.
element_name	This is the fully qualified name of the new runtime type. It includes the prefix as well as the first argument.
ui	This is an opaque pointer to the user info. It is used to access the data for that leaf.
handle	This is a void pointer the application can get back from the call back function.

Return Value: ST_BOOLEAN

SD_TRUE

SD_FALSE

mvl_derive_new_type

Usage: This function will derive a new Named Type from a preexisting Named Type created by the MMS Object Foundry. Normally the new type is derived from a standard UCA type or a base class. The derivation is one which deletes type members from the base class so that the result models the data supported in a particular GOMSFE brick. New type members are not added with this function and if new members are required, the associated **.odf** file must be modified prior to running the MMS Object Foundry and calling this function. The function allocates and modifies the memory associated with Named Type overhead and inserts it into the MMS-*Lite* database. The **`typeIdOut`** parameter contains the newly created Named TypeID. A user-supplied function called **`u_mvl_rt_element_supported`** is invoked for each member of the base class. See also the related function **`u_mvl_rt_element_supported`**.

Note: Special code is needed to release the overhead associated with TypeIDs created when calling **`mvl_derive_new_type`**. Do not call **`mvl_type_id_destroy`** with TypeIDs returned from this function. The results will be unpredictable.

Function Prototype:

```
ST_RET  mvl_derive_new_type (ST_CHAR    *base_name,
                             ST_INT     typeIdIn,
                             ST_INT     *typeIdOut,
                             ST_CHAR    *handle);
```

Parameters:

`base_name`	This is the string that will be prefixed onto the derived named type object.
`typeIdIn`	This is the TypeID of the existing Named Type that is used as the base class for derivation.
`typeIdOut`	This output parameter is the TypeID of the derived type. It may be used to add a Named Variable. See associated function **`mvl_vmd_var_add`**.
`handle`	This is a pointer to any user defined string or object that the application may need to see when examining individual type members in **`u_mvl_rt_element_supported`**.

Return Value:

`ST_RET`	`SD_SUCCESS`	No error code
	`<0`	Error code

ACSE Interface Functions

MVL_CFG_INFO

The ACSE interface functions make use of the following structure:

```
typedef struct
{
ST_INT    num_calling;                   /* number of calling connections */
ST_INT    num_called;                    /* number of called connections  */
ST_INT    max_msg_size;                  /* Max MMS message size          */
ST_CHAR   local_ar_name[MAX_AR_LEN+1];   /* Local AR Name                 */
} MVL_CFG_INFO;
```

osicfgx

Usage: This function reads the XML file that contains configuration parameters for MVL and the OSI Stack.

Function Prototype:

```
ST_RET osicfgx (ST_CHAR *xml_filename,
                MVL_CFG_INFO *mvlCfg);
```

Parameters:

`xml_filename`	This is the name of the XML file to read.
`mvlCfg`	This is a pointer to a user structure containing parameters that are filled in by this function.

Return Value: `ST_RET` `SD_SUCCESS` or error code.

mvl_start_acse

Usage: This function is used to start the MVL ACSE subsystem.

Function Prototype: `ST_RET mvl_start_acse (MVL_CFG_INFO *mvlCfg);`

Parameters:

`mvlCfg`	This is a pointer to a user structure containing parameters that are used to configure MVL. The structure must be filled in by calling **`osicfgx`** or by some other means.

Return Value: `ST_RET` `SD_SUCCESS` or error code.

mvl_end_acse

Usage: This function is used to terminate the MVL ACSE subsystem.

Function Prototype: `ST_RET mvl_end_acse (ST_VOID);`

Parameters: NONE

Return Value: `ST_VOID`

Miscellaneous Functions

mvl_vmd_find_dom

Usage: This function is used to find a MVL Domain.

Function Prototype:

```
MVL_DOM_CTRL *mvl_vmd_find_dom (MVL_VMD_CTRL       *vmd_ctrl,
                                ST_CHAR            *name);
```

Parameters:

`vmd_ctrl`	This pointer identifies the VMD in which to find the domain.
`name`	Name of domain to find.

Return Value: `MVL_DOM_CTRL *` Pointer to the Domain object. **`NULL`** if not found. The structure **`MVL_DOM_CTRL`** is defined in **mvl_defs.h**.

mvl_vmd_find_jou

Usage: This function is used to find a MVL Journal object given the MMS Object Name, which includes scope information.

Function Prototype:

```
MVL_JOURNAL_CTRL *mvl_vmd_find_jou (MVL_VMD_CTRL     *vmd_ctrl,
                                    OBJECT_NAME      *obj_name,
                                    MVL_NET_INFO     *net_info);
```

Parameters:

`vmd_ctrl`	This pointer identifies the VMD in which to find the journal.
`obj_name`	The MMS Object Name of the Journal object to find. The structure **`OBJECT_NAME`** is defined in **mms_mp.h**.
`net_info`	This pointer identifies the Application Association (i.e., connection) in which to find the NamedVariableList (only used if the object is Application Association-specific).

Return Value: `MVL_JOURNAL_CTRL *` Pointer to the Journal object. **`NULL`** if not found. The structure **`MVL_JOURNAL_CTRL`** is defined in **mvl_defs.h**.

mvl_vmd_find_nvl

Usage: This function is used to find a MVL Named Variable List object given the MMS Object Name. This includes scope information.

Function Prototype:

```
MVL_NVLIST_CTRL *mvl_vmd_find_nvl (MVL_VMD_CTRL      *vmd_ctrl,
                                   OBJECT_NAME       *obj_name,
                                   MVL_NET_INFO      *net_info);
```

Parameters:

`vmd_ctrl` This pointer identifies the VMD in which to find the NamedVariableList.

`obj_name` The MMS Object Name of the Named Variable List object to find. The structure **`OBJECT_NAME`** is defined in **mms_mp.h**.

`net_info` This pointer identifies the Application Association (i.e., connection) in which to find the NamedVariableList (only used if the object is Application Association-specific).

Return Value: `MVL_NVLIST_CTRL *` Pointer to the Named Variable List object. **`NULL`** if not found. The structure **`MVL_NVLIST_CTRL`** is defined in **mvl_defs.h**.

mvl_vmd_find_var

Usage: This function can be used to find a MVL Variable Association given the MMS Object Name, which includes scope information.

Function Prototype:

```
MVL_VAR_ASSOC *mvl_vmd_find_var (MVL_VMD_CTRL  *vmd_ctrl,
                                 OBJECT_NAME   *obj_name,
                                 MVL_NET_INFO  *net_info);
```

Parameters:

`vmd_ctrl` This pointer identifies the VMD in which to find the variable.

`obj_name` The MMS Object Name of the Named Variable object to find. The structure **`OBJECT_NAME`** is defined in **mms_mp.h**.

`net_info` This pointer identifies the Application Association (i.e., connection) in which to find the Named Variable (only used if the object is Application Association-specific).

Return Value: `MVL_VAR_ASSOC *` Pointer to the Named Variable object. **`NULL`** if not found. The structure **`MVL_VAR_ASSOC`** is defined in **mvl_defs.h**.

Manufactured Object Processing Functions

u_mvl_get_va_aa

Usage: The function will be called when a variable is being read or written and it is not present in the MVL Variable Association control tables. The user application can resolve the association and return a **MVL_VARIABLE_ASSOCIATION** if appropriate. Note that this function is only used when MVL is compiled with **MVL_AA_SUPP** and **USE_MANUFACTURED_OBJ** defined.

If ***alt_access_done_out** is set **SD_TRUE**, MVL will assume that the alternate access operation has been addressed by the called function.

Function Prototype:

```
MVL_VAR_ASSOC *u_mvl_get_va_aa (MVL_VMD_CTRL   *vmd_ctrl,
                                ST_INT         service,
                                OBJECT_NAME    *obj,
                                MVL_NET_INFO   *netInfo,
                                ST_BOOLEAN     alt_access_pres,
                                ALT_ACCESS     *alt_acc,
                                ST_BOOLEAN     alt_access_done_out);
```

Parameters:

vmd_ctrl	This pointer identifies the VMD in which to "get" the variable.
service	The MMS service requiring VariableAccess look up. Values may be **MMSOP_WRITE**, **MMSOP_MVLU_RPT_VA**, **MMSOP_INFO_RPT**, or **MMSOP_GET_VAR**.
obj	The name and scope of the variable needing to be resolved by the application.
netInfo	A pointer to connection information, this provides the application with the means to resolve ApplicationAssociation specific variables. The structure **MVL_NET_INFO** is defined in **mvl_defs.h.**
alt_access_pres	Tells the application if AlternateAccess information is present. Values are **SD_TRUE** and **SD_FALSE**.
alt_acc	When the **alt_access_pres** parameter is set to **SD_TRUE**, this points to AlternateAccess information for the application to use when performing the VariableAccess.
alt_access_done_out	When the **alt_access_pres** parameter is set to **SD_TRUE**, this is set by the application if AlternateAccess is performed by the application.

Return Value:

!=NULL	The application successfully manufactured the variable association.
NULL	An error meaning the application did not resolve the variable.

u_mvl_free_va

Usage: When MVL is done using a manufactured Variable Association, it will call a user function selected by this function to allow the user to free the associated resources. Note that this function is only used when MVL is compiled with **`USE_MANUFACTURED_OBJ`** defined.

Function Prototype:

```
ST_VOID u_mvl_free_va (ST_INT          service,
                       MVL_VAR_ASSOC   *va,
                       MVL_NET_INFO    *netInfo);
```

Parameters:

`service` The MMS service passed to the application when the **`MVL_VAR_ASSOC`** was manufactured. Values may be **`MMSOP_WRITE`**, **`MMSOP_MVLU_RPT_VA`**, **`MMSOP_INFO_RPT`**, or **`MMSOP_GET_VAR`**.

`va` A pointer to the data structure originally returned from the application.

`netInfo` A pointer to connection information associated with the variable that provides the application with the means to resolve ApplicationAssociation specific variables. The structure **`MVL_NET_INFO`** is defined in **mvl_defs.h**

Return Value: `ST_VOID`

u_mvl_get_nvl

Usage: This function will be called when a NamedVariableList is being read or written and it is not present in the MVL NamedVariableList control tables. The user application can resolve the association and return a **`MVL_NVLIST_CTRL`** if appropriate. **`NULL`** is returned when the NamedVariableList is unrecognized. Note that this function is only used when MVL is compiled with **USE_MANUFACTURED_OBJ** defined.

Function Prototype:

```
MVL_NVLIST_CTRL *u_mvl_get_nvl (ST_INT         service,
                                OBJECT_NAME    *obj,
                                MVL_NET_INFO   *netInfo);
```

Parameters:

`service` The service that is referencing the NamedVariableList object. Possible values are **`MMSOP_GET_VLIST`** and **`MMSOP_READ`**.

`obj` The MMS Object Name of the NamedVariableList object to find. The structure **`OBJECT_NAME`** is defined in **mms_mp.h**.

`netInfo` A pointer to connection information associated with the NamedVariableList, this provides the application with the means to resolve ApplicationAssociation specific variables. The structure **`MVL_NET_INFO`** is defined in **mvl_defs.h**

Return Value:

`!=NULL`	The application successfully manufactured the NamedVariableList.
`NULL`	An error meaning the application did not manufacture the NamedVariableList.

u_mvl_free_nvl

Usage: When MVL is done using a manufactured NamedVariableList control, it will call a user function selected by this function to allow the user to free the associated resources. Note that this function is only used when MVL is compiled with **USE_MANUFACTURED_OBJ** defined.

Function Prototype:

```
ST_VOID u_mvl_free_nvl (ST_INT                  service,
                        MVL_NVLIST_CTRL         *nvl,
                        MVL_NET_INFO            *netInfo);
```

Parameters:

`service` The MMS service passed to the application when the **`MVL_NVLIST_CTRL`** was manufactured. Possible values are **`MMSOP_GET_VLIST`** and **`MMSOP_READ`**.

`nvl` A pointer to the data structure originally returned from the application.

`netInfo` A pointer to connection information associated with the NamedVariableList that provides the application with the means to resolve ApplicationAssociation specific variables. The structure **`MVL_NET_INFO`** is defined in **mvl_defs.h**

Return Value: `ST_VOID`

u_gnl_ind_vars

Usage: When the application is making use of the manufactured object approach, it will also be necessary to provide the list of objects to be returned when a MMS GetNameList indication is received. The user must provide this function. Note that this function is only called when MVL is compiled with **USE_MANUFACTURED_OBJ** defined.

Function Prototype:

```
ST_INT u_gnl_ind_vars (MVL_NET_INFO         *net_info,
                       NAMELIST_REQ_INFO    *req_info,
                       ST_CHAR              **ptr,
                       ST_BOOLEAN           *moreFollowsOut,
                       ST_INT               maxNames);
```

Parameters:

`net_info` A pointer to connection information associated with the NamedVariableList that provides the application with the means to resolve ApplicationAssociation specific variables. The structure **`MVL_NET_INFO`** is defined in **mvl_defs.h**

`req_info` GetNameList request information. It is necessary to examine this structure to determine if there is a name to continue after. The structure **`NAMELIST_REQ_INFO`** is defined in **mms_pvmd.h**.

`ptr` An array of pointers to variable name character strings. The user must fill in the array.

`moreFollowsOut` Set **`*moreFollowsOut`** = **`SD_TRUE`** if not all variable names being manufactured by the application will fit in the NameList response. The maximum number of variable names that may be returned is supplied as the parameter **`maxNames`**. Set **`*moreFollowsOut`** = **`SD_FALSE`** when the function reports the last known manufactured variable name in the set.

`maxNames` The maximum number of variable names that may be returned by the function per call.

Return Value: `ST_INT` The number of variable names returned in the pointer table. 0 indicates that the function did not return any manufactured variable names.

u_gnl_ind_nvls

Usage: When the application is making use of the manufactured object approach, it will also be necessary to provide the list of objects to be returned when a MMS GetNameList indication is received. The user must provide this function. Note that this function is only called when MVL is compiled with **USE_MANUFACTURED_OBJ** defined.

Function Prototype:

```
ST_INT u_gnl_ind_nvls (MVL_NET_INFO         *net_info,
                       NAMELIST_REQ_INFO    *req_info,
                       ST_CHAR              **ptr,
                       ST_BOOLEAN           *moreFollowsOut,
                       ST_INT               maxNames);
```

Parameters:

`net_info` A pointer to connection information associated with the NamedVariableList that provides the application with the means to resolve ApplicationAssociation specific variables. The structure **`MVL_NET_INFO`** is defined in **mvl_defs.h**

`req_info` GetNameList request information. It is necessary to examine this structure to determine if there is a name to continue after. The structure **`NAMELIST_REQ_INFO`** is defined in **mms_pvmd.h**.

`ptr` An array of pointers to named variable list name character strings. The user must fill in the array.

`moreFollowsOut` Set **`*moreFollowsOut`** = **`SD_TRUE`** if not all named variable list names being manufactured by the application will fit in the NameList response. The maximum number of named variable list names that may be returned is supplied as the parameter **`maxNames`**. Set **`*moreFollowsOut`** = **`SD_FALSE`** when the function reports the last known manufactured named variable list name in the set.

`maxNames` The maximum number of named variable list names that may be returned by the function per call.

Return Value: `ST_INT` The number of named variable list names returned in the pointer table. 0 indicates that the function did not return any manufactured named variable list names.

u_gnl_ind_doms

Usage: When the application is making use of the manufactured object approach, it will also be necessary to provide the list of objects to be returned when a MMS GetNameList indication is received. The user must provide this function. Note that this function is only called when MVL is compiled with **USE_MANUFACTURED_OBJ** defined.

Function Prototype:

```
ST_INT u_gnl_ind_doms (NAMELIST_REQ_INFO      *req_info,
                       ST_CHAR                **ptr,
                       ST_BOOLEAN             *moreFollowsOut,
                       ST_INT                 maxNames);
```

Parameters:

`req_info` GetNameList request information. It is necessary to examine this structure to determine if there is a name in the domain name space to continue after. The structure **`NAMELIST_REQ_INFO`** is defined in **mms_pvmd.h**.

`ptr` An array of pointers to domain name character strings. The user must fill in the array.

`moreFollowsOut` Set **`*moreFollowsOut`** = **`SD_TRUE`** if not all domain names being manufactured by the application will fit in the NameList response. The maximum number of domain names that may be returned is supplied as the parameter **`maxNames`**. Set **`*moreFollowsOut`** = **`SD_FALSE`** when the function reports the last known manufactured domain name in the set.

`maxNames` The maximum number of domain names that may be returned by the function per call.

Return Value: `ST_INT` The number of domain names returned in the pointer table. 0 indicates that the function did not return any manufactured domain names.

u_gnl_ind_jous

Usage: When the application is making use of the manufactured object approach, it will also be necessary to provide the list of objects to be returned when a MMS GetNameList indication is received. The user must provide this function. Note that this function is only called when MVL is compiled with **USE_MANUFACTURED_OBJ** defined.

Function Prototype:

```
ST_INT u_gnl_ind_jous (MVL_NET_INFO       *net_info,
                        NAMELIST_REQ_INFO  *req_info,
                        ST_CHAR            **ptr,
                        ST_BOOLEAN         *moreFollowsOut,
                        ST_INT             maxNames);
```

Parameters:

`net_info` A pointer to connection information associated with the NamedVariableList that provides the application with the means to resolve ApplicationAssociation specific variables. The structure **`MVL_NET_INFO`** is defined in **mvl_defs.h**

`req_info` GetNameList request information. It is necessary to examine this structure to determine if there is a name to continue after. The structure **`NAMELIST_REQ_INFO`** is defined in **mms_pvmd.h**.

`ptr` An array of pointers to journal name character strings. The user must fill in the array.

`moreFollowsOut` Set **`*moreFollowsOut`** = **`SD_TRUE`** if not all journal names being manufactured by the application will fit in the NameList response. The maximum number of journal names that may be returned is supplied as the parameter **`maxNames`**. Set **`*moreFollowsOut`** = **`SD_FALSE`** when the function reports the last known manufactured journal name in the set.

`maxNames` The maximum number of journal names that may be returned by the function per call.

Return Value: `ST_INT` The number of journal names returned in the pointer table. 0 indicates that the function did not return any manufactured journal names.

MVL Dynamic Object Management

MVL provides functions for adding and deleting MMS objects (e.g., Named Types, Named Variables, Named Variable Lists, Domains, and Journals) at runtime. These functions are useful for systems where the objects are not known at compile time.

MVL_MAX_DYN Data Structure

This structure contains the maximum number of various objects that may be "dynamically created" at runtime.

```
typedef struct
  {
  ST_INT      aa_nvls;
  ST_INT      aa_vars;
  ST_INT      doms;
  ST_INT      dom_nvls;
  ST_INT      dom_vars;
  ST_INT      journals;
  ST_INT      types;
  ST_INT      vmd_nvls;
  ST_INT      vmd_vars;
  } MVL_MAX_DYN;
```

`extern MVL_MAX_DYN mvl_max_dyn;`

`aa_nvls`	Indicates the maximum number of "dynamic" AA-specific NamedVariableLists.
`aa_vars`	Indicates the maximum number of "dynamic" AA-specific variables.
`doms`	Indicates the maximum number of "dynamic" domains
`dom_nvls`	Indicates the maximum number of "dynamic" domain-specific NamedVariableLists.
`dom_vars`	Indicates the maximum number of "dynamic" domain-specific variables.
`journals`	Indicates the maximum number of "dynamic" journals
`types`	Indicates the maximum number of "dynamic" data types
`vmd_nvls`	Indicates the maximum number of "dynamic" VMD-specific NamedVariableLists.
`vmd_vars`	Indicates the maximum number of "dynamic" VMD-specific variables.

See **mvl_defs.h** for default values of the members of **`mvl_max_dyn`**. If a structure member is 0 when **`mvl_init_mms_objs`** is called, the function sets the value to one of these constants.

Note: The **`mvl_init_mms_objs`** function is in the source code generated by the MMS Object Foundry.

```
#define MVL_NUM_DYN_DOMS          10
#define MVL_NUM_DYN_VMD_VARS      10
#define MVL_NUM_DYN_VMD_NVLS      10
#define MVL_NUM_DYN_JOUS          10
#define MVL_NUM_DYN_DOM_VARS      10
#define MVL_NUM_DYN_DOM_NVLS      10
#define MVL_NUM_DYN_AA_VARS       10
#define MVL_NUM_DYN_AA_NVLS       10
```

```
/* MVL_UCA requires dynamic types to function */
#if defined(MVL_UCA)
#define MVLU_NUM_DYN_TYPES 100
#else
#define MVLU_NUM_DYN_TYPES 0
#endif
```

It is also possible to adjust the number of dynamic objects associated with the VMD by calling **mvl_vmd_resize**. The number of objects associated with a domain can be adjusted by calling **mvl_dom_resize**.

In applications where the MMS Object Foundry does not generate code to add any of a certain type of object, the constants found in **mvl_defs.h** are not used to generate the overhead necessary for dynamic object management. It is necessary to resize the number of objects using the **mvl_vmd_resize** and **mvl_dom_resize** functions. The maximum and current numbers of objects of any type are found by referencing the **mvl_vmd** control structure and is also found in **mvl_defs.h**

MVL Dynamic Object Management Functions

mvl_vmd_dom_add

Usage: This function will add a Domain, allocate and modify the memory associated with its overhead, and insert it into the MMS-*Lite* database. The value returned is a pointer to the new Domain.

Function Prototype:

```
MVL_DOM_CTRL *mvl_vmd_dom_add (MVL_VMD_CTRL    *vmd_ctrl,
                               ST_CHAR         *name,
                               ST_INT          max_num_var,
                               ST_INT          max_num_nvl,
                               ST_INT          max_num_jou,
                               ST_BOOLEAN      copy_name);
```

Parameters:

vmd_ctrl	This pointer identifies the VMD in which to add the domain.
name	Name of the new Domain object.
max_num_var	Maximum number of Named Variables to allow in the Domain.
max_num_nvl	Maximum number of Named Variable Lists to allow in the Domain.
max_num_jou	Maximum number of Journals to allow in the Domain.
copy_name	Flag to indicate if the name should be copied to an allocated buffer. If **SD_FALSE**, the argument *name* must be the address of nonvolatile memory where the name is stored.

Return Value: MVL_DOM_CTRL * — Pointer to the new Domain object. **NULL** if operation failed. The structure **MVL_DOM_CTRL** is defined in **mvl_defs.h**.

mvl_vmd_dom_remove

Usage: This function will remove the **MVL_DOM_CTRL** structure from the MMS-*Lite* database and deallocate and adjust the overhead associated with it. User callback function ***u_mvl_dom_destroy** is invoked in the process to allow the application a chance to deallocate any application specific resources associated with the Domain. Please see function **u_mvl_dom_destroy** for further details.

Function Prototype:

```
ST_RET mvl_dom_remove (MVL_VMD_CTRL     *vmd_ctrl,
                       ST_CHAR          *dom_name);
```

Parameters:

vmd_ctrl	This pointer identifies the VMD from which to remove the domain.
dom_name	This is the name of the domain to delete from the MMS-*Lite* database.

Return Value:

ST_RET	SD_SUCCESS	No error code
	<>0	Error code

mvl_vmd_dom_find_last

Usage: This function will find the last domain in the list of domains for this VMD.

Function Prototype:

```
MVL_DOM_CTRL *mvl_vmd_dom_find_last (MVL_VMD_CTRL *vmd_ctrl);
```

Parameters:

vmd_ctrl	This pointer identifies the VMD in which to find the domain.

Return Value:

MVL_DOM_CTRL *	Pointer to the Domain object. **NULL** if not found. The structure **MVL_DOM_CTRL** is defined in **mvl_defs.h**.

u_mvl_dom_destroy

Usage: When set by the application, this function pointer is invoked by the MMS-*Lite* library during the process of removing a Domain from the MMS-*Lite* database. The intent is to allow the application a chance to deallocate any resources associated with the Domain. By default, this function pointer is not set.

Function Pointer Global Variable:

```
extern ST_VOID (*u_mvl_dom_destroy)
                (MVL_DOM_CTRL *dom);
```

Parameters:

dom	A pointer to a domain control structure being freed from the MMS-*Lite* database.

Return Value: ST_VOID

mvl_type_id_create

Usage: This function will parse an ASN.1 encoded Named Type and add the resulting runtime type. The function allocates and modifies the memory associated with Named Type overhead and inserts it into the MMS-*Lite* database. The return value can be used to perform variable access. See associated **mvla_getvar**, **mvla_read_variables**, and **mvla_write_variables** functions.

Note: This function is similar to **mvl_vmd_type_id_create** but it assumes the type belongs to the global VMD (**mvl_vmd**).

Function Prototype:

```
ST_RET mvl_type_id_create (ST_CHAR   *type_name,
                           ST_UCHAR  *asn1_data,
                           ST_UINT   asn1_len);
```

Parameters:

type_name	Name of this type. Stored with type definition. May be used later to find this TypeID using **mvl_typename_to_typeid**. Use **NULL** if name is not needed.
asn1_data	This is the ASN.1 encoded type specification typically seen in an MMS GetVariableAccessAttributes-Response. See **GETVAR_RESP_INFO** for more information.
asn1_len	This is the length of the ASN.1 encoded type specification.

Return Value:

ST_RET	-1	Type creation failed
	>=0	Type creation succeeded and this is the new TypeID.

mvl_type_id_create_from_tdl

Usage: This function creates a type definition from TDL.

Note: This function is similar to **mvl_vmd_type_id_create_from_tdl** but it assumes the type belongs to the global VMD (**mvl_vmd**).

Function Prototype:

```
ST_RET mvl_type_id_create_from_tdl (ST_CHAR *type_name,
                                    ST_CHAR *tdl);
```

Parameters:

type_name	Name of this type. This is stored with type definition. May be used later to find this TypeID using **mvl_typename_to_typeid**. Use NULL if name is not needed.
tdl	TDL string to define new type.

Return Value:

ST_RET	-1	Type creation failed
	>=0	Type creation succeeded and this is the new TypeID.

mvl_type_id_destroy

Usage: This function will release the overhead associated with a TypeID, which was created by calling **`mvl_type_id_create`**.

Note: This function is similar to **`mvl_type_id_destroy`** but it assumes the type belongs to the global VMD (**`mvl_vmd`**).

Function Prototype:

```
ST_VOID mvl_type_id_destroy (ST_INT TypeId);
```

Parameters:

`TypeId`	This is a TypeID created by a call to **`mvl_type_id_create`**.

Return Value: `ST_VOID`

mvl_vmd_type_id_create

Usage: This function will add a type to the selected VMD and return a type identifier to be passed to other MVL functions. The return value can be used to perform variable access. See associated **`mvla_getvar`**, **`mvla_read_variables`**, and **`mvla_write_variables`** functions.

Function Prototype:

```
ST_INT mvl_vmd_type_id_create (MVL_VMD_CTRL      *vmd_ctrl,
                               ST_CHAR           *type_name,
                               RUNTIME_CTRL      *rt_ctrl);
```

Parameters:

`vmd_ctrl`	This pointer identifies the VMD in which to add the TypeID.
`type_name`	Name of this type. Stored with type definition. May be used later to find this TypeID using **`mvl_typename_to_typeid`**. Use NULL if name is not needed.
`rt_ctrl`	Pointer to **`RUNTIME_CTRL`** structure defining the type.

Return Value:

`ST_INT`	-1	Type creation failed
	`>=0`	Type creation succeeded and this is the new TypeID.

mvl_vmd_type_id_destroy

Usage: This function will release the overhead associated with a TypeID, which was created by calling **`mvl_vmd_type_id_create`**.

Function Prototype:

```
ST_VOID mvl_vmd_type_id_destroy (MVL_VMD_CTRL  *vmd_ctrl,
                                 ST_INT        TypeId);
```

Parameters:

`vmd_ctrl`	This pointer identifies the VMD in which to find the TypeID.
`TypeId`	This is a TypeID created by a call to **`mvl_vmd_type_id_create`**.

Return Value: `ST_VOID`

mvl_vmd_type_id_destroy_all

Usage: This function will destroy ALL types reserved for a particular VMD.

Function Prototype: `ST_VOID mvl_vmd_type_id_destroy_all (MVL_VMD_CTRL *vmd_ctrl);`

Parameters:

`vmd_ctrl` This pointer identifies the VMD in which to destroy all the TypeIDs.

Return Value: `ST_VOID`

mvl_type_ctrl_find

Usage: This function will find the type ctrl structure corresponding to the TypeId.

Function Prototype: `MVL_TYPE_CTRL *mvl_type_ctrl_find (ST_INT TypeId);`

Parameters:

`TypeId` This is a TypeID created by a call to **`mvl_type_id_create`**.

Return Value: `MVL_TYPE_CTRL` pointer or **`NULL`** on error.

mvl_vmd_type_ctrl_find

Usage: This function will find the type ctrl structure corresponding to the TypeID for a particular VMD.

Function Prototype:

```
MVL_TYPE_CTRL *mvl_vmd_type_ctrl_find (MVL_VMD_CTRL   *vmd_ctrl,
                                       ST_INT         TypeId);
```

Parameters:

`vmd_ctrl` This pointer identifies the VMD in which to find the TypeID

`TypeId` This is a TypeID created by a call to **`mvl_vmd_type_id_create`** for this VMD.

Return Value: **`MVL_TYPE_CTRL`** pointer or **`NULL`** on error.

mvl_var_create

Usage: This function creates the variable association for the specified variable. These are temporary variables needed by the server. For example, **`mvl_var_create`** should be used (not **`mvl_vmd_var_add`**) to create local variables to store data received later in IEC/UCA reports. This variable must not be added to the list of variables sent in the GetNameList response.

Function Prototype:

```
MVL_VAR_ASSOC *mvl_var_create (OBJECT_NAME   *obj,
                               ST_INT        type_id,
                               ST_VOID       *data,
                               MVL_VAR_PROC  *proc,
                               ST_BOOLEAN    copy_name);
```

Parameters:

`obj`	The MMS Object Name of the Named Variable object to add. The structure **`OBJECT_NAME`** is defined in **mms_mp.h**.
`type_id`	This is the MMS Object Foundry generated TypeID that represents the data type associated with the NamedVariable.
`data`	This is a pointer to where the variable resides in memory.
`proc`	This is an optional pointer to a structure of type **`MVL_VAR_PROC`**. It associates specific functions to be called when the NamedVariable is read or written.
`copy_name`	Flag to indicate if the name should be copied to an allocated buffer. If **`SD_FALSE`**, the argument *name* must be the address of nonvolatile memory where the name is stored.

Return Value: `MVL_VAR_ASSOC *` Pointer to the new Named Variable object. **`NULL`** if operation failed. The structure **`MVL_VAR_ASSOC`** is defined in **mvl_defs.h**.

u_mvl_var_destroy

Usage: When set by the application, this function pointer is invoked by the MMS-*Lite* library during the process of removing a Variable from the MMS-*Lite* database. The intent is to allow the application a chance to deallocate any resources associated with the Variable. By default, this function pointer is not set.

Function Pointer Global Variable: `extern ST_VOID *u_mvl_var_destroy)(MVL_VAR_ASSOC *va);`

Parameters:

`va`	A pointer to a variable association control structure being freed from the MMS-*Lite* database.

Return Value: `ST_VOID`

mvl_vmd_var_add

Usage: This function will add a Named Variable, allocate and modify the memory associated with its overhead, and insert it into the MMS-*Lite* database.

The value returned is a pointer to the new Named Variable.

Function Prototype:

```
MVL_VAR_ASSOC *mvl_vmd_var_add (MVL_VMD_CTRL      *vmd_ctrl,
                                OBJECT_NAME       *obj,
                                MVL_NET_INFO      *net_info,
                                ST_INT            type_id,
                                ST_VOID           *data,
                                MVL_VAR_PROC      *proc,
                                ST_BOOLEAN        copy_name);
```

Parameters:

vmd_ctrl	This pointer identifies the VMD in which to add the variable
obj	The MMS Object Name of the Named Variable object to add. The structure **OBJECT_NAME** is defined in **mms_mp.h**.
net_info	Network connection information required when the scope of the named variable is **AA_SPEC**. This may be **NULL** when the scope is **VMD_SPEC** or **DOM_SPEC**.
type_id	This is the MMS Object Foundry generated TypeID that represents the data type associated with the NamedVariable.
data	This is a pointer to where the variable resides in memory.
proc	This is an optional pointer to a structure of type **MVL_VAR_PROC**. It associates specific functions to be called when the NamedVariable is read or written.
copy_name	This is a flag to indicate if the name should be copied to an allocated buffer. If **SD_FALSE**, the argument *name* must be the address of nonvolatile memory where the name is stored.

Return Value: (MVL_VAR_ASSOC *) Pointer to the new Named Variable object. **NULL** if operation failed. The structure **MVL_VAR_ASSOC** is defined in **mvl_defs.h**.

mvl_vmd_var_remove

Usage: This function will remove the **`MVL_VAR_ASSOC`** structure from the MMS-*Lite* database and deallocate and adjust the overhead associated with it. The user callback function, **`*u_mvl_var_destroy`** is invoked in the process to allow the application a chance to deallocate any application specific resources associated with the Named Variable. Please see the function **`u_mvl_var_destroy`** for further details.

Function Prototype:

```
ST_RET mvl_vmd_var_remove (MVL_VMD_CTRL    *vmd_ctrl,
                           OBJECT_NAME     *obj,
                           MVL_NET_INFO    *net_info);
```

Parameters:

`vmd_ctrl` This pointer identifies the VMD from which to remove the variable.

`obj` The MMS Object Name of the Named Variable object to remove. The structure **`OBJECT_NAME`** is defined in **mms_mp.h**.

`net_info` Network connection information required when the scope of the named variable is **`AA_SPEC`**. This may be **`NULL`** when the scope is **`VMD_SPEC`** or **`DOM_SPEC`**.

Return Value:

`ST_RET`	`SD_SUCCESS`	No error code
	`<> 0`	Error code

mvl_vmd_nvl_add

Usage: This function will add a Named Variable List, allocate and modify the memory associated with its overhead, and insert it into the MMS-*Lite* database. The value returned is a pointer to the new Named Variable List.

Function Prototype:

```
MVL_NVLIST_CTRL *mvl_vmd_nvl_add (MVL_VMD_CTRL    *vmd_ctrl,
                                  OBJECT_NAME     *obj,
                                  MVL_NET_INFO    *net_info,
                                  ST_INT          num_var,
                                  OBJECT_NAME     *var_obj,
                                  ST_BOOLEAN      copy_name);
```

Parameters:

`vmd_ctrl` This pointer identifies the VMD in which to add the NamedVariableList.

`obj` The MMS Object Name of the Named Variable List object to add. The structure **`OBJECT_NAME`** is defined in **mms_mp.h**.

`net_info` Network connection information required when the scope of the named variable is **`AA_SPEC`**. This may be **`NULL`** when the scope is **`VMD_SPEC`** or **`DOM_SPEC`**. The structure **`MVL_NET_INFO`** is defined in **mvl_defs.h**

`num_var` This is the number of variables in the **`var_obj`** array.

`var_obj` MMS Object Name array of Named Variables included in the Named Variable List. The structure **`OBJECT_NAME`** is defined in **mms_mp.h**.

`copy_name` This is a flag to indicate if the name should be copied to an allocated buffer. If **`SD_FALSE`**, the argument *name* must be the address of nonvolatile memory where the name is stored.

Return Value: `(MVL_NVLIST_CTRL *)` Pointer to the new Named Variable List object. **`NULL`** if the operation failed. The structure **`MVL_NVLIST_CTRL`** is defined in **mvl_defs.h**.

mvl_vmd_nvl_remove

Usage: This function will remove the **`MVL_NVLIST_CTRL`** structure from the MMS-*Lite* database and deallocate and adjust the overhead associated with it. User callback function **`*u_mvl_nvl_destroy`** is invoked in the process to allow the application a chance to deallocate any application specific resources associated with the Named Variable List. Please see function **`u_mvl_nvl_destroy`** for further details.

Function Prototype:

```
ST_RET mvl_vmd_nvl_remove(MVL_VMD_CTRL   *vmd_ctrl,
                          OBJECT_NAME    *obj,
                          MVL_NET_INFO   *net_info);
```

Parameters:

`vmd_ctrl` This pointer identifies the VMD from which to remove the NamedVariableList.

`obj` The MMS Object Name of the Named Variable List object to remove. The structure **`OBJECT_NAME`** is defined in **mms_mp.h**.

`net_info` This is required when the scope of the Named Variable List is **`AA_SPEC`**. This may be **`NULL`** when the scope is **`VMD_SPEC`** or **`DOM_SPEC`**. The structure **`MVL_NET_INFO`** is defined in **mvl_defs.h**.

Return Value:

`ST_RET`	`SD_SUCCESS`	No error code
	`<>0`	Error code

u_mvl_nvl_destroy

Usage: When set by the application, this function pointer is invoked by the MMS-*Lite* library during the process of removing a Named Variable List from the MMS-*Lite* database. The intent is to allow the application a chance to deallocate any resources associated with the Variable. By default, this function pointer is not set.

Function Pointer Global Variable:

```
extern ST_VOID (*u_mvl_nvl_destroy)
               (MVL_NVLIST_CTRL *nvl);
```

Parameters:

`nvl` A pointer to a Named Variable List control structure being freed from the MMS-database.

Return Value: `ST_VOID`

mvl_vmd_jou_add

Usage: This function will add a Journal, allocate and modify the memory associated with its overhead, and insert it into the MMS-*Lite* database. The value returned is a pointer to the new Journal.

Function Prototype:

```
MVL_JOURNAL_CTRL *mvl_vmd_jou_add (MVL_VMD_CTRL     *vmd_ctrl,
                                   OBJECT_NAME      *obj,
                                   MVL_NET_INFO     *net_info,
                                   ST_BOOLEAN       copy_name);
```

Parameters:

`vmd_ctrl` This pointer identifies the VMD in which to add the journal.

`obj` The MMS Object Name of the Journal object to add. The structure **`OBJECT_NAME`** is defined in **mms_mp.h**.

`net_info` This is required when the scope of the Journal is **`AA_SPEC`**. This may be **`NULL`** when the scope is **`VMD_SPEC`** or **`DOM_SPEC`**. The structure **`MVL_NET_INFO`** is defined in **mvl_defs.h**.

`copy_name` This is a flag to indicate if the name should be copied to an allocated buffer. If **`SD_FALSE`**, the argument *name* must be the address of nonvolatile memory where the name is stored.

Return Value: `(MVL_JOURNAL_CTRL *)` Pointer to the new Journal object. **`NULL`** if the operation failed. The structure **`MVL_JOURNAL_CTRL`** is defined in **mvl_defs.h**.

mvl_vmd_jou_remove

Usage: This function will remove the **`MVL_JOURNAL_CTRL`** structure from the MMS-*Lite* database and deallocate and adjust the overhead associated with it. User callback function **`*u_mvl_jou_destroy`** is invoked in the process to allow the application a chance to deallocate any application specific resources associated with the Journal. Please see **`u_mvl_jou_destroy`** for further details.

Function Prototype:

```
ST_RET mvl_vmd_jou_remove (MVL_VMD_CTRL    *vmd_ctrl,
                           OBJECT_NAME     *obj,
                           MVL_NET_INFO    *net_info);
```

Parameters:

`vmd_ctrl` This pointer identifies the VMD from which to remove the journal.

`obj` The MMS Object Name of the Journal object to remove. The structure **`OBJECT_NAME`** is defined in **mms_mp.h**.

`net_info` This is required when the scope of the Journal is **`AA_SPEC`**. This may be **`NULL`** when the scope is **`VMD_SPEC`** or **`DOM_SPEC`**. The structure **`MVL_NET_INFO`** is defined in **mvl_defs.h**.

Return Value: `ST_RET`

`SD_SUCCESS`	No error code
`<>0`	Error code

u_mvl_jou_destroy

Usage: When set by the application, this function pointer is invoked by the MMS-*Lite* library during the process of removing a Journal from the MMS-*Lite* database. The intent is to allow the application a chance to deallocate any resources associated with the Journal. By default, this function pointer is not set.

Function Pointer Global Variable:

```
extern ST_VOID (*u_mvl_jou_destroy)
               (MVL_JOURNAL_CTRL *jou);
```

Parameters:

`jou`	A pointer to a Journal control structure being freed from the MMS-*Lite* database.

Return Value: `ST_VOID`

mvl_vmd_resize

Usage: This function sets up the overhead for the maximum number of objects that may be added to the VMD specific portion of the MMS-*Lite* database. The parameter values may be increased or decreased as memory requirements permit. Note that these values must take into consideration the total number of objects the MMS Object Foundry (static) added and those that were dynamically added. The current number of each type of object may be found by examining members of the global variable **`mvl_vmd`**. The **`MVL_VMD_CTRL`** structure is defined in **mvl_defs.h**.

Function Prototype:

```
ST_VOID mvl_vmd_resize (ST_INT   max_dom,
                        ST_INT   max_var,
                        ST_INT   max_nvl,
                        ST_INT   max_jou);
```

Parameters:

`max_dom`	The new maximum number of Domain objects associated with the VMD.
`max_var`	The new maximum number of Named Variable objects associated with the VMD.
`max_nvl`	The new maximum number of Named Variable List objects associated with the VMD.
`max_jou`	The new maximum number of Journal objects associated with the VMD.

Return Value: `ST_VOID`

mvl_vmd_create

Usage: This function creates a new VMD and sets the maximum number of objects allowed.

Function Prototype:

```
MVL_VMD_CTRL *mvl_vmd_create (ST_INT     max_num_dom,
                              ST_INT     max_num_var,
                              ST_INT     max_num_nvl,
                              ST_INT     max_num_journal);
```

Parameters:

`max_num_dom`	Maximum number of domains allowed.
`max_num_var`	Maximum number of variables allowed.
`max_num_nvl`	Maximum number of NamedVariableLists allowed.
`max_num_dom`	Maximum number of journals allowed.

Return Value: `(MVL_VMD_CTRL *)` Pointer to the new VMD object. **`NULL`** if the operation failed. The structure **`MVL_VMD_CTRL`** is defined in **mvl_defs.h**.

mvl_vmd_destroy

Usage: This function destroys all objects in a VMD and frees up the associated memory. If the VMD was created by mvl_vmd_create, the **`MVL_VMD_CTRL`** structure itself is also freed. If the VMD is the global VMD, **`mvl_vmd`**, most resources are freed, but the **`MVL_VMD_CTRL`** structure and the arrays it points to are not freed because they are allocated by "Foundry-generated" code.

Function Prototype: `ST_RET mvl_vmd_destroy (MVL_VMD_CTRL *vmd_ctrl);`

Parameters:

`vmd_ctrl`	Pointer to the VMD to be destroyed.

Return Value: `ST_RET` `SD_SUCCESS` If OK, or an error code.

mvl_dom_resize

Usage: This function sets up the overhead for the maximum number of objects that may be added to a Domain specific portion of the MMS-*Lite* database. The parameter values may be increased or decreased as memory requirements permit. Note that these values must take into consideration the total number of objects the MMS Object Foundry (static) added and those that were dynamically added. The current number of each type of object may be found by examining the **`MVL_DOM_CTRL`** structure. To find the **`MVL_DOM_CTRL`** call the function **`mvl_vmd_find_dom`**.

Function Prototype:

```
ST_VOID mvl_dom_resize (MVL_DOM_CTRL    *dom,
                        ST_INT          max_var,
                        ST_INT          max_nvl,
                        ST_INT          max_jou);
```

Parameters:

`dom`	A pointer to a MVL control structure representing the Domain. The **`MVL_DOM_CTRL`** structure is defined in **mvl_defs.h**.
`max_var`	The new maximum number of Named Variable objects associated with the Domain.
`max_nvl`	The new maximum number of Named Variable List objects associated with the Domain.
`max_jou`	The new maximum number of Journal objects associated with the Domain.

Return Value: `ST_VOID`

MMS Object Control

Configured and Manufactured MMS Server Objects

Server objects are those MMS variables, variable lists, and domains that are visible to MMS Clients. MVL supports both configured and manufactured variables and variable lists.

Configured objects are those that are configured in the **`MVL_VMD_CTRL`** data structure and that MVL can handle transparently if desired. This is the simplest way to handle variable access, and most applications should use this approach.

Manufactured objects are those that are NOT configured in the **`MVL_VMD_CTRL`** data structure; so the user must resolve the MMS object to local mapping dynamically. This takes a bit more work than using configured objects, but can be useful under some conditions. When using manufactured objects, the user must also handle the MMS GetNameList indications directly.

It is possible to mix configured and manufactured objects, and the MVL server sample application does just that. The define, **USE_MANUFACTURED_OBJS**, is used to isolate the sections of code required for manufactured objects in the sample server application.

MVL Type Handling

In MVL, types are referenced by an integer index into a table of **`MVL_TYPE_CTRL`** elements. This table is created off-line by using MMS Object Foundry with an Object Definition File containing TDL strings. MMS Object Foundry creates a C file that contains all code required to create the type table.

MMS Object Scope

The following figure provides a review of the MMS object scopes. The MMS specifications will also provide useful information in this regard. Please refer to *Prerequisites* on page 3 for additional information MMS specifications.

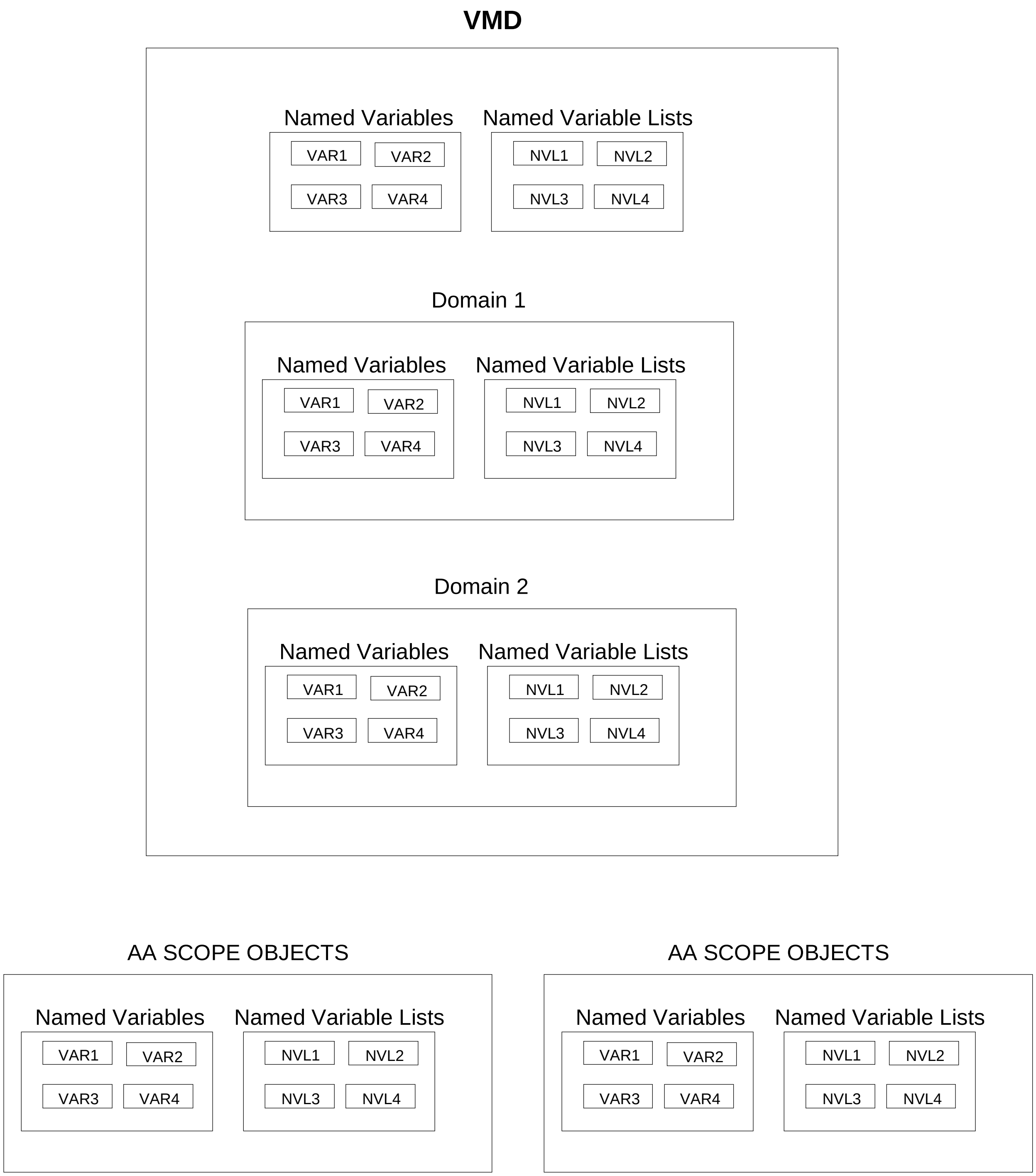


Figure 1: MMS Object Scope Overview

The MVL VMD Control Data Structure

MMS-*Lite* provides a MMS VMD model that is used to associate MMS (Named Variables, Named Variable Lists, and Domains) to local objects; implemented by the **MVL_VMD_CTRL** data.

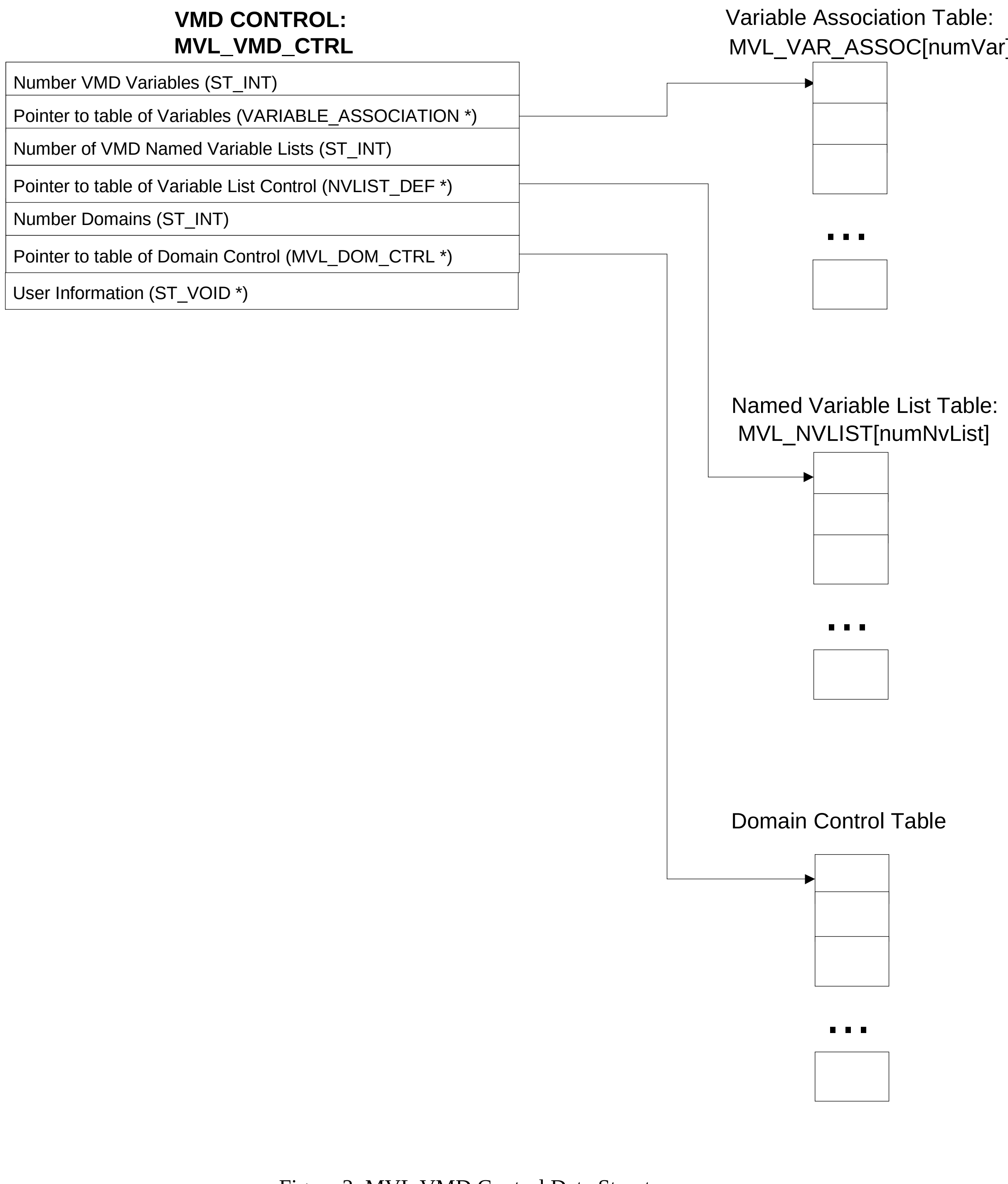


Figure 2: MVL VMD Control Data Structure

```
typedef struct mvl_vmd_ctrl
  {
  ST_INT                  max_num_var_assoc;
  ST_INT                  num_var_assoc;
  MVL_VAR_ASSOC           **var_assoc_tbl;

#if defined (MVL_DESCR_SUPP)
  ST_INT                  num_descr_addr;
  MVL_DESCR_ADDR_ASSOC    *descr_addr_assoc_tbl;
#endif

  ST_INT                  max_num_nvlist;
  ST_INT                  num_nvlist;
  MVL_NVLIST_CTRL         **nvlist_tbl;

  ST_INT                  max_num_dom;
  ST_INT                  num_dom;
  MVL_DOM_CTRL            **dom_tbl;

  ST_INT                  max_num_jou;
  ST_INT                  num_jou;
  MVL_JOURNAL_CTRL        **jou_tbl;

  ST_BOOLEAN              foundry_objects;    /* Flag for internal use         */

  ST_VOID                 *user_info;         /* MVL user use this for whatever */
  } MVL_VMD_CTRL;
```

The MVL Domain Control Data Structure

The MMS-*Lite* VMD model supports Domain scope objects (Named Variables and Named Variable Lists). This data structure references arrays of these objects and MVL provides transparent access to client applications.

```
typedef struct mvl_dom_ctrl
  {
  ST_CHAR *name;

  ST_INT               max_num_var_assoc;
  ST_INT               num_var_assoc;
  MVL_VAR_ASSOC        **var_assoc_tbl;

  ST_INT               max_num_nvlist;
  ST_INT               num_nvlist;
  MVL_NVLIST_CTRL      **nvlist_tbl;

  ST_INT               max_num_jou;
  ST_INT               num_jou;
  MVL_JOURNAL_CTRL     **jou_tbl;

  GETDOM_RESP_INFO     *get_dom_resp_info;   /* Optional                       */

  ST_BOOLEAN           foundry_objects;      /* Flag for internal use          */
  ST_VOID              *user_info;           /* MVL user can use this for whatever */
  } MVL_DOM_CTRL;
```

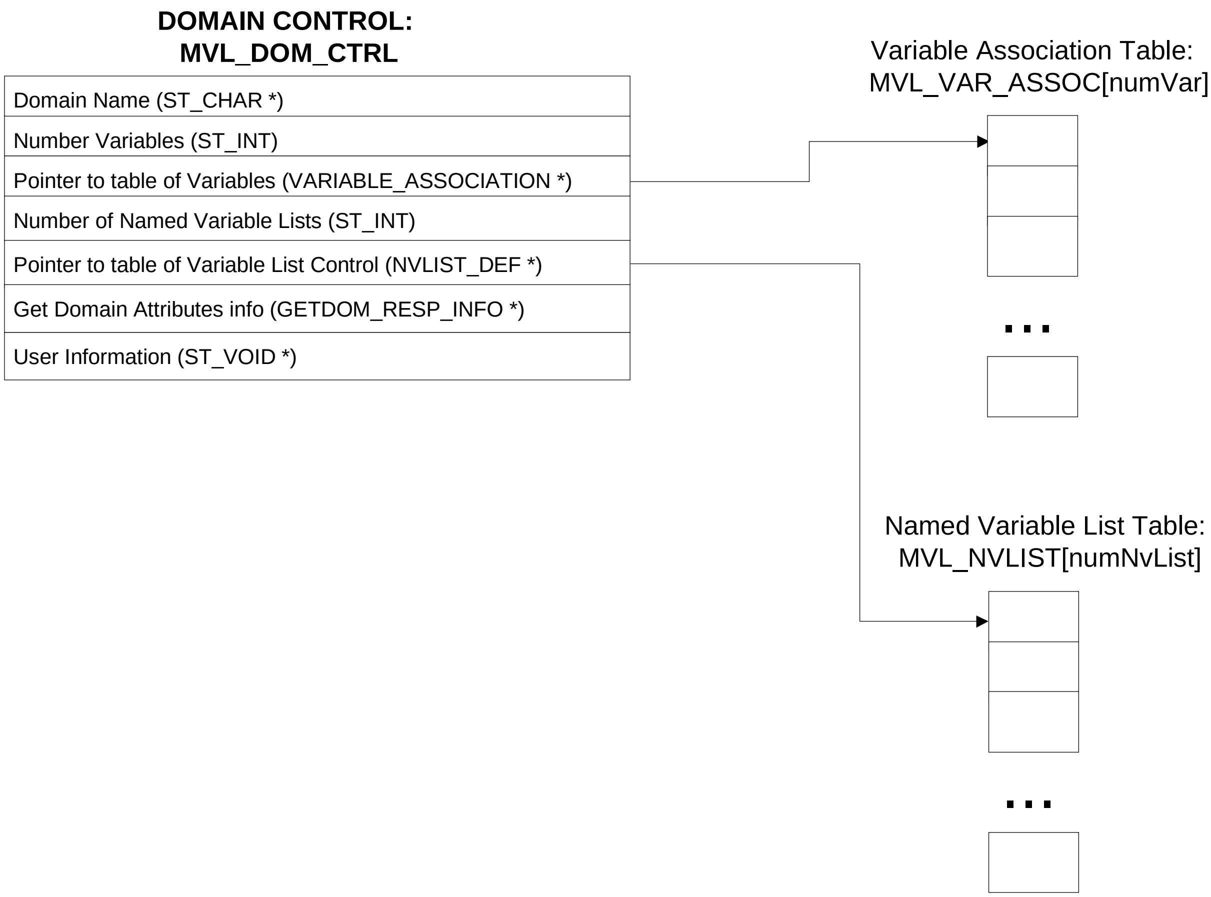


Figure 3: MVL Domain Control Data Structure

The MVL AA Control Data Structure

The MMS-*Lite* Application Association object control structure is used to expose local objects (Named Variables and Named Variable Lists) as MMS AA scope objects. AA scope objects are typically used to give each client application an independent copy of named objects. For instance, AA scope is useful to allow a MMS client to select reports to be generated by the server. In MMS-*Lite*, this data structure can be attached to each MMS connection.

```
typedef struct mvl_aa_obj_ctrl
  {
  ST_INT            max_num_var_assoc;
  ST_INT            num_var_assoc;
  MVL_VAR_ASSOC     **var_assoc_tbl;

  ST_INT            max_num_nvlist;
  ST_INT            num_nvlist;
  MVL_NVLIST_CTRL   **nvlist_tbl;

  ST_INT            max_num_jou;
  ST_INT            num_jou;
  MVL_JOURNAL_CTRL  **jou_tbl;
  ST_BOOLEAN        foundry_objects;    /* Flag for internal use             */
  ST_VOID           *user_info;         /* MVL user can use this for whatever*/
  } MVL_AA_OBJ_CTRL;
```

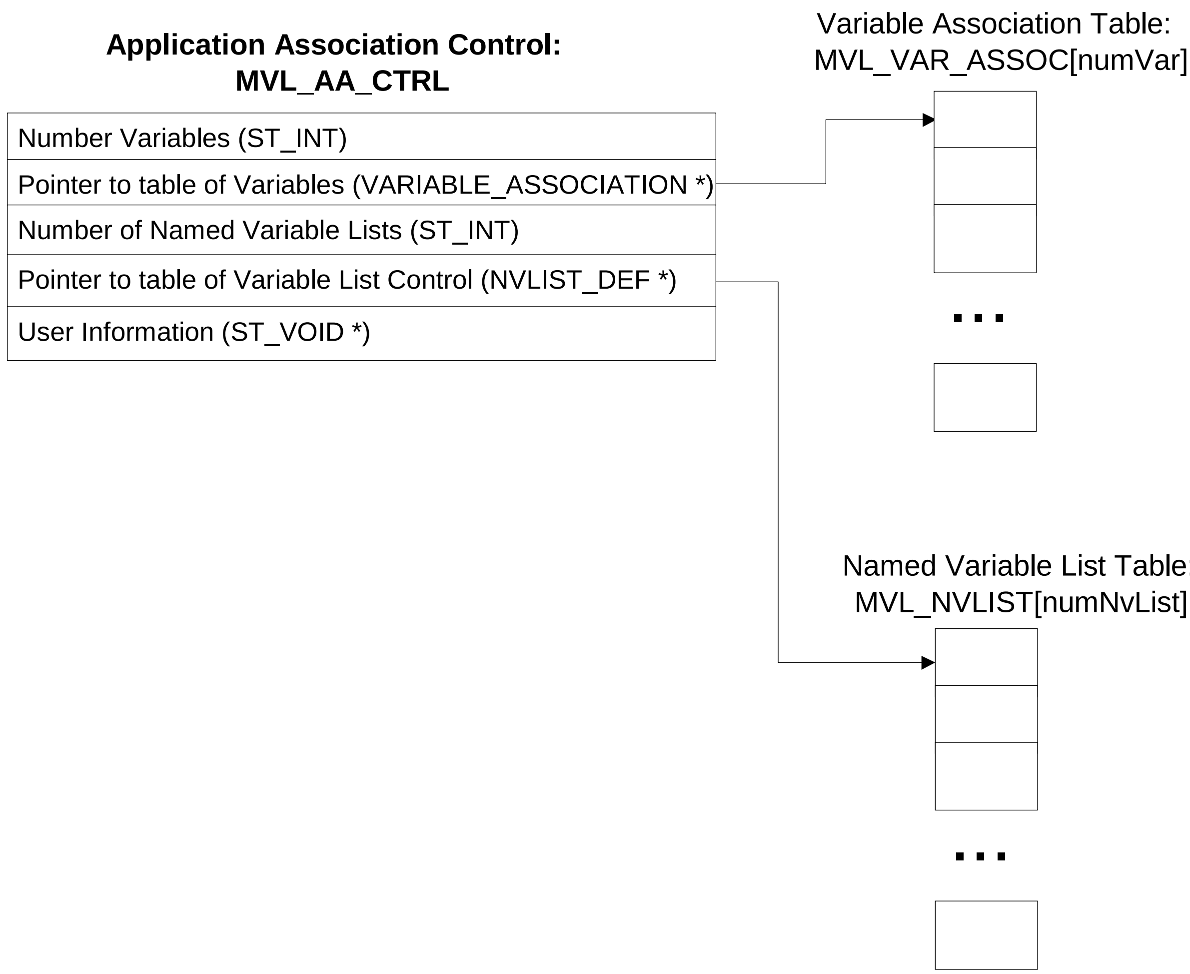


Figure 4: MVL AA Control Data Structure

The MVL Named Variable List Data Structure

A MMS-*Lite* Named Variable List control structure simply references a set of Variable Association control structures. Note that in UCA, a DataSet is implemented by a MMS Named Variable List.

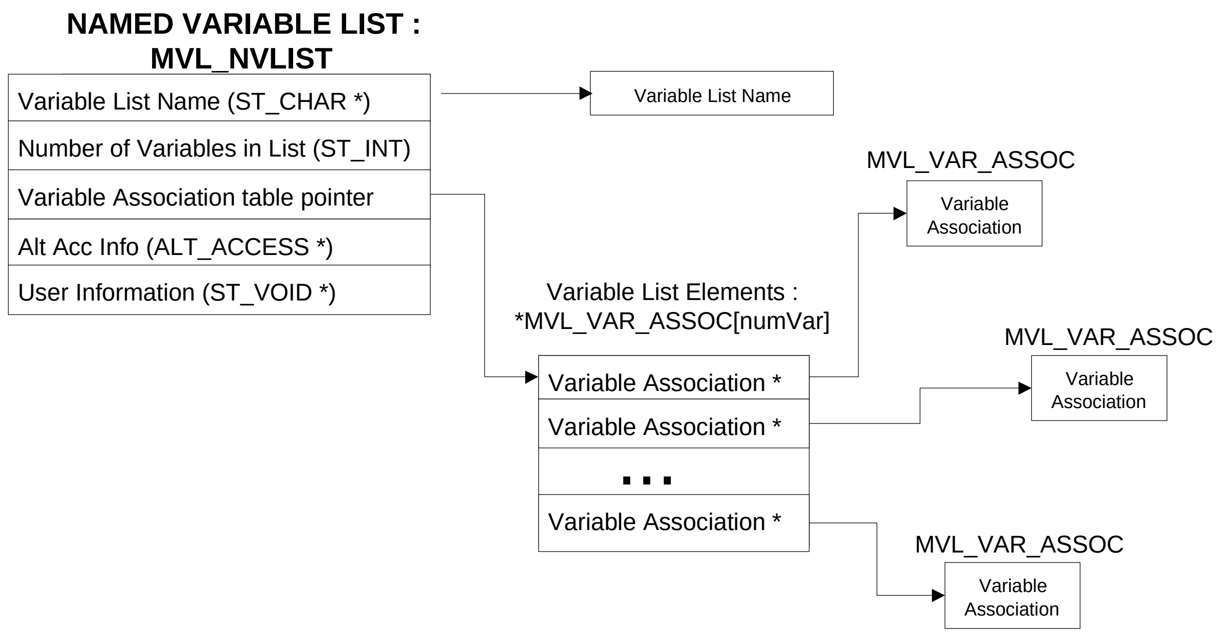


Figure 5: MVL Named Variable List Data Structure

```
typedef struct mvl_nvlist_ctrl
{
ST_CHAR             *name;          /* name of the named variable list   */
ST_INT              num_of_entries; /* number of variables in the list   */
MVL_VAR_ASSOC       **entries;
MVL_SCOPE           nvl_scope;       /* scope of this NVL                 */
MVL_SCOPE           *va_scope;
ALT_ACCESS          **altAcc;        /* Alternate Access array for var's  */
ST_BOOLEAN          mms_deletable;
ST_VOID             *user_info;      /* MVL user can use this for whatever*/
} MVL_NVLIST_CTRL;
```

MVL MMS Server Facilities

MVL provides a subsystem that performs the actual services requested by the remote device for many MMS services. These functions require only appropriate configuration, and no other user code is involved unless required by the application. MVL provides a straightforward mechanism by which named variable access can be mapped to local variables. MVL supports VMD, Domain, and AA scopes. Please refer to the MVL sample server source code (**server.c**) for more details.

Synchronous vs. Asynchronous Response - Indication Control

The user application can respond to any MMS indication either synchronously or asynchronously, as needed. A user indication function is called from **`mvl_comm_serve`** whenever a MMS indication is received. A pointer to an indication control structure (**`MVL_IND_PEND`**) is passed to each indication function. It contains both request and response data for the indication. To send the response for an indication, the same pointer that is passed to the indication function must be passed to the response function. If the indication can be processed immediately (i.e., synchronously), the indication function should set the response data and then call the response function (as is done in most of the sample server source code). However, some applications are not able to respond immediately to some types of indications. For instance, the application may need to acquire read data via a serial link before it is able to respond. Other applications may not want responses sent automatically. In these cases, the application can simply save the pointer to the indication control structure (**`MVL_IND_PEND`**), and call the response function sometime later when the response is ready (i.e., asynchronously).

Error Response Function

The following function may be used to send an error response for any indication.

mplas_err_resp

Usage: This function is used to send an error response (result(-)) PDU for any confirmed service request except for Cancel, Conclude, and Initiate.

Function Prototype:

```
ST_RET mplas_err_resp (MVL_IND_PEND     *ind_pend,
                       ST_INT16         err_class,
                       ST_INT16         code);
```

Parameters:

`ind_pend`	This is the same parameter that is passed to all user-defined Indication functions.
`err_class`	This integer contains the particular class of the error per ISO 9506.
`code`	This integer contains the code indicating the specific reason that the service was not executed corresponding to the specified **`err_class`**, per ISO 9506.

Return Value:	`ST_RET`	`SD_SUCCESS`	No Error.
		`!= SD_SUCCESS`	Error (error response not sent).

MVL Indication Control Structure

The following is the MVL Indication Control Structure:

```
typedef struct mvl_ind_pend
  {
  DBL_LNK l;
  MVL_COMM_EVENT    *event;
  ST_INT            op;                 /* MMS Opcode (MMSOP_READ, etc.) */
  union
    {
    MVLAS_READ_CTRL        rd;
    MVLAS_WRITE_CTRL       wr;
    MVLAS_IDENT_CTRL       ident;
    MVLAS_STATUS_CTRL      status;
    MVLAS_NAMELIST_CTRL    namelist;
    MVLAS_GETVAR_CTRL      getvar;
    MVLAS_GETDOM_CTRL      getdom;
    MVLAS_FOPEN_CTRL       fopen;
    MVLAS_FREAD_CTRL       fread;
    MVLAS_FCLOSE_CTRL      fclose;
    MVLAS_FDIR_CTRL        fdir;
    MVLAS_OBTFILE_CTRL     obtfile;
    MVLAS_FDELETE_CTRL     fdelete;
    MVLAS_FRENAME_CTRL     frename;
    MVLAS_DEFVLIST_CTRL    defvlist;
    MVLAS_GETVLIST_CTRL    getvlist;
    MVLAS_DELVLIST_CTRL    delvlist;
    MVLAS_JINIT_CTRL       jinit;
    MVLAS_JREAD_CTRL       jread;
    MVLAS_JSTAT_CTRL       jstat;
    MVLAS_GETCL_CTRL       getcl;
    } u;
  ST_VOID    *usr_ind_ctrl;
  ST_VOID    *usr;               /* For user to use as they see fit      */
  } MVL_IND_PEND;
```

Status Service

This service is used to allow a client to determine the general condition or status of a server node.

Status Data Structures

The following is the Status Indication Control Structure:

```
typedef struct
  {
  STATUS_REQ_INFO          *req_info;
  STATUS_RESP_INFO         *resp_info;
  } MVLAS_STATUS_CTRL;
```

status_req_info

The client to issue the Status request uses the operation-specific structure described below. The server receives it when a Status indication is received.

```
struct status_req_info
  {
  ST_BOOLEAN extended;
  };
typedef struct status_req_info STATUS_REQ_INFO;
```

`extended`	**`SD_FALSE`**. Response should be generated using the non-extended derivation method. **`SD_TRUE`**. Response should be generated using an extended derivation method if available (such as invoking a self-diagnostics routine).

status_resp_info

The server in issuing the Status response uses the operation specific data structure described below. The client receives it when a Status confirm is received.

```
struct status_resp_info
  {
  ST_INT16     logical_stat;
  ST_INT16     physical_stat;
  ST_BOOLEAN   local_detail_pres;
  ST_INT       local_detail_len;
  ST_UCHAR     local_detail[MAX_STAT_DTL_LEN];
  };
typedef struct status_resp_info STATUS_RESP_INFO;
```

`logical_stat`	This required field indicates the logical status of the VMD: **0** State changes are allowed (All supported services can be used). **1** No state changes are allowed (services that modify the state of a VMD object). **2** Limited services are permitted (Abort, Conclude, Status, and Identify) **3** Support services are allowed (all services supported by the VMD except Start, Stop, Reset, Resume and Kill).
`physical_stat`	This required field indicates the physical status of the VMD: **0** Fully operational. **1** Partially operational. **2** Inoperable. **3** Needs Commissioning (manual intervention may be needed).
`local_detail_pres`	**`SD_FALSE`**. Do not include **`local_detail`** in PDU. **`SD_TRUE`**. Include **`local_detail`** in PDU.
`local_detail_len`	This is the length, IN BITS, of the **`local_detail`**. This cannot be greater than 128.
`local_detail`	This implementation-specific bitstring contains additional data about the status of the VMD. It is defined by the particular VMD and is an array of 16 bytes (i.e., 128 bits).

Status Functions

u_mvl_status_ind

Usage: This is a user-defined function called when a Status indication is received. The user must first examine the request parameters contained in the **MVL_IND_PEND** structure. Second, do whatever is necessary to process the request. Third, fill in the response parameters in the **MVL_IND_PEND** structure. And finally, call **mplas_status_resp** to send the response (or **mplas_err_resp** to send an error response).

Function Prototype: `ST_VOID u_mvl_status_ind (MVL_IND_PEND *ind_pend);`

Parameters:

`ind_pend` This is the same parameter that is passed to all user defined Indication functions. It contains a union of request and/or response parameters that is used for several different services. The request parameters are set by MVL before calling this function. The user must set the response parameters before calling the response function (i.e., **mplas_status_resp**). The parameters to be used for this service are as follows:

Request parameters: `ind_pend->u.status.req_info`
See **STATUS_REQ_INFO** for more information.

Response parameters: `ind_pend->u.status.resp_info`
See **STATUS_RESP_INFO** for more information.

Return Value: `ST_VOID`

mplas_status_resp

Usage: This function encodes and sends the Response for a previously received Status indication. The Response parameters in the **MVL_IND_PEND** structure must be filled in before this function is called. The (**MVL_IND_PEND ***) argument passed to this function must be the same as the (**MVL_IND_PEND ***) argument passed to the user defined function **u_mvl_status_ind** when the indication was received.

Function Prototype: `ST_VOID mplas_status_resp (MVL_IND_PEND *ind_pend);`

Parameters:

`ind_pend` This is the same parameter that is passed to all user defined Indication functions. It contains a union of request and/or response parameters that is used for several different services. The request parameters are set by MVL before calling this function. The user must set the response parameters before calling the response function (i.e., **mplas_status_resp**). The parameters to be used for this service are as follows:

Request parameters: `ind_pend->u.status.req_info`
See **STATUS_REQ_INFO** for more information.

Response parameters: `ind_pend->u.status.resp_info`
See **STATUS_RESP_INFO** for more information.

Return Value: `ST_VOID`

Identify Service

This service is used to obtain identifying information such as a vendor name and model number from a responding node.

Identity Data Structures

The following is the Identify Indication Control Structure:

```
typedef struct
  {
  IDENT_RESP_INFO      *resp_info;
  } MVLAS_IDENT_CTRL;
```

ident_resp_info

The server in issuing an Identify response uses the operation specific structure described below. The client receives it when an Identify confirm is received.

```
#define VEND_LEN       64
#define MOD_LEN        16
#define REV_LEN        16


struct ident_resp_info
  {
  ST_CHAR       vend [MAX_VEND_LEN+1];
  ST_CHAR       model[MAX_MOD_LEN+1];
  ST_CHAR       rev  [MAX_REV_LEN+1];
  ST_INT        num_as;
/*MMS_OBJ_ID    as [num_as];                            */
  SD_END_STRUCT
  };
typedef struct ident_resp_info IDENT_RESP_INFO;
```

`vend`	This null-terminated character string identifies the organization (e.g., company name) that developed the VMD for which the identifying information is being provided.
`model`	This null-terminated character string contains the manufacturer's model number of the system.
`rev`	This null-terminated character string contains the revision level of the system specified by the VMD vendor.

Note: *The MMS specification allows indefinite length strings for these members, but implementor's agreements specify that only 64, 16, and 16 bytes, as indicated in the* **`#define`** *statements above, are considered significant.*

`num_as`	This indicates the number of abstract syntaxes pointed to by **`as`**.
`as`	This array of pointers of structure type **`MMS_OBJ_ID`** contains the abstract syntaxes associated with this VMD. This structure may be followed by the abstract syntaxes.

Note: *FOR RESPONSE ONLY, when allocating a data structure of type* **`IDENT_RESP_INFO`**, *enough memory must be allocated to hold the information for the abstract syntaxes contained in* **`as`**. *The following C statement can be used:*

```
info = (IDENT_RESP_INFO *) chk_malloc (sizeof(IDENT_RESP_INFO +
         (num_as * (ST_CHAR *))));
```

Identify Functions

u_mvl_ident_ind

Usage: This is a user-defined function called when an Identify Indication is received. The user must first examine the request parameters contained in the **`MVL_IND_PEND`** structure. Second, do whatever is necessary to process the request. Third, fill in the response parameters in the **`MVL_IND_PEND`** structure. And finally, call **`mplas_ident_resp`** to send the response (or **`mplas_err_resp`** to send an error response).

Function Prototype: `ST_VOID u_mvl_ident_ind (MVL_IND_PEND *ind_pend);`

Parameters:

`ind_pend` This is the same parameter that is passed to all user defined Indication functions. It contains a union of request and/or response parameters that is used for several different services. The request parameters are set by MVL before calling this function. The user must set the response parameters before calling the response function (i.e., **`mplas_ident_resp`**). The parameters to be used for this service are as follows:

Request parameters: NONE

Response parameters: `ind_pend->u.ident.resp_info`
See **`IDENT_RESP_INFO`** for more information.

Return Value: `ST_VOID`

mplas_ident_resp

Usage: This function encodes and sends the Response for a previously received Identify indication. The Response parameters in the **`MVL_IND_PEND`** structure must be filled in before this function is called. The (**`MVL_IND_PEND *`**) argument passed to this function must be the same as the (**`MVL_IND_PEND *`**) argument passed to the user defined function **`u_mvl_ident_ind`** when the indication was received.

Function Prototype: `ST_VOID mplas_ident_resp (MVL_IND_PEND *ind_pend);`

Parameters:

`ind_pend` This is the same parameter that is passed to all user defined Indication functions. It contains a union of request and/or response parameters that is used for several different services. The user must set the response parameters before calling the response function (i.e., **`mplas_ident_resp`**). The parameters to be used for this service are as follows:

Request parameters: NONE

Response parameters: `ind_pend->u.ident.resp_info`
See **`IDENT_RESP_INFO`** for more information.

Return Value: `ST_VOID`

GetNameList Service

This service is used to request that a responding node return a list (or part of a list) of object names that exist at the VMD.

GetNameList Data Structures

The following is the GetNameList Indication Control Structure:

```
typedef struct
  {
  NAMELIST_REQ_INFO        *req_info;
  NAMELIST_RESP_INFO       *resp_info;
  } MVLAS_NAMELIST_CTRL;
```

namelist_req_info

The client in issuing a GetNameList request uses this operation specific structure described below. The server receives it when a GetNameList indication is received.

```
struct namelist_req_info
  {
  ST_BOOLEAN     cs_objclass_pres;
  union
    {
    ST_INT16     mms_class;
    struct
      {
      ST_INT     len;
      ST_UCHAR   *cs_class;
      } cs;
    } obj;
  ST_INT16       objscope;
  ST_CHAR        dname[MAX_IDENT_LEN+1];
  ST_BOOLEAN     cont_after_pres;
  ST_CHAR        continue_after [MAX_IDENT_LEN+1];
  SD_END_STRUCT
  };
typedef struct namelist_req_info NAMELIST_REQ_INFO;
```

`cs_objclass_pres`	**`SD_FALSE`**. This indicates to use the **`mms_class`** member of the union **`obj`**. It means the name list will be for an object specified by the MMS standard (ISO 9506). **`SD_TRUE`**. This indicates to use the **`cs`** structure member of the union **`obj`**. It means the name list will be for an object specified by a companion standard.
`mms_class`	This contains the class of the named object(s) for which a list is to be obtained. Used when **`cs_objclass_pres = 0`**.

0	Named Variable
1	Scattered Access
2	Named Variable List
3	Named Type
4	Semaphore
5	Event Condition
6	Event Action
7	Event Enrollment
8	Journal
9	Domain
10	Program Invocation
11	Operator Station

`cs.len`	This indicates the length of the companion standard defined object class pointed to by **`cs.cs_class`**.

`cs.cs_class` This pointer to the ASN.1 data specifies the companion standard defined object for which the name list is to be generated. This data must conform to the appropriate companion standard governing the particular VMD from which the name list is to be obtained.

`objscope` This indicates the scope of the object(s) for which a list is to be obtained:

VMD_SPEC.	List only VMD Specific names.
DOM_SPEC.	List only Domain Specific names.
AA_SPEC.	List only names specific to this association.

`dname` This pointer to the name of the domain is used if **objscope = DOM_SPEC**.

`cont_after_pres` **SD_FALSE**. Do Not include **continue_after** in PDU. Begin the name list response from the beginning of the list.

SD_TRUE. Include **continue_after** in PDU. Use this when multiple requests must be made to obtain the entire name list because the entire list of names will not fit into a single response.

`continue_after` This pointer to a variable string specifies the name after which the name list in the response should start.

namelist_resp_info

This operation specific structure described below is used by the server in issuing a GetNameList response. It is received by the client when a GetNameList confirm is received.

```
struct namelist_resp_info
  {
  ST_BOOLEAN     more_follows;
  ST_INT         num_names;
  SD_END_STRUCT
  };
/*ST_CHAR        *name_list[]; */
typedef struct namelist_resp_info NAMELIST_RESP_INFO;
```

`more_follows` **SD_FALSE**. There are no more names in the name list after this response.

SD_TRUE. There are more names in the name list than can be sent in this response. The requesting node will have to make more requests to obtain the entire name list.

`num_names` This indicates the number of names in this name list response PDU.

`name_list` This is an array of pointers to the names to be sent in this name list. Each name should be a null-terminated, visible string specifying a MMS identifier. They should consist of only numbers, uppercase letters, lower-case letters, the underscore "_," or the dollar sign "$." They should not exceed the length allowed for MMS Identifiers (**MAX_IDENT_LEN default = 32**).

Notes:

1. Immediately below this structure (contiguous in memory) is a list of character pointers, one for each name in the name list. The structure and name pointers must be allocated in a single call to **chk_malloc** of size: **(sizeof(NAMELIST_RESP_INFO) + num_names * sizeof(ST_CHAR *))**.

2. FOR RESPONSE ONLY, when allocating a data structure of type **NAMELIST_RESP_INFO**, enough memory must be allocated to hold the information for the name list pointers if **num_names > 0**. The following C statement can be used:

```
info = (NAMELIST_RESP_INFO *) chk_malloc (sizeof(NAMELIST_RESP_INFO) +
             (num_names * (sizeof(ST_CHAR *))));
```

GetNameList Functions

u_mvl_namelist_ind

Usage: This is a user-defined function called when a GetNameList indication is received. The user must examine the request parameters contained in the **MVL_IND_PEND** structure, do whatever is necessary to process the request, and then call **mplas_namelist_resp** or **mvlas_namelist_resp** to send the response (or **mplas_err_resp** to send an error response).

Function Prototype: `ST_VOID u_mvl_namelist_ind (MVL_IND_PEND *ind_pend);`

Parameters:

`ind_pend` This is the same parameter that is passed to all user defined Indication functions. It contains a union of request and/or response parameters that is used for several different services. The request parameters are set by MVL before calling this function. The response parameters must be set by the user before calling the response function (i.e., **mplas_namelist_resp**). The parameters to be used for this service are as follows:

Request parameters: `ind_pend->u.namelist.req_info`
See **NAMELIST_REQ_INFO** for more information.

Response parameters: `ind_pend->u.namelist.resp_info`
See **NAMELIST_RESP_INFO** for more information.

Return Value: `ST_VOID`

mplas_namelist_resp

Usage: This function encodes and sends the Response for a previously received GetNameList indication. The response parameters in the **MVL_IND_PEND** structure must be filled in before this function is called. The (**MVL_IND_PEND ***) argument passed to this function must be the same as the (**MVL_IND_PEND ***) argument passed to the user defined function **u_mvl_namelist_ind** when the indication was received.

Function Prototype: `ST_VOID mplas_namelist_resp (MVL_IND_PEND *ind_pend);`

Parameters:

`ind_pend` This is the same parameter that is passed to all user defined Indication functions. It contains a union of request and/or response parameters that is used for several different services. The request parameters are set by MVL before calling this function. The response parameters must be set by the user before calling the response function (i.e., **mplas_namelist_resp**). The parameters to be used for this service are as follows:

Request parameters: `ind_pend->u.namelist.req_info`
See **NAMELIST_REQ_INFO** for more information.

Response parameters: `ind_pend->u.namelist.resp_info`
See **NAMELIST_RESP_INFO** for more information.

Return Value: `ST_VOID`

mvlas_namelist_resp

Usage: This is a Virtual Machine response function for handling a previously received GetNameList indication. It completely processes the indication, fills in the response parameters in the **MVL_IND_PEND** structure, and then sends the response by calling **mplas_namelist_resp**. The (**MVL_IND_PEND ***) argument passed to this function must be the same as the (**MVL_IND_PEND ***) argument passed to the user defined function **u_mvl_namelist_ind** when the indication was received.

Function Prototype: `ST_VOID mvlas_namelist_resp (MVL_IND_PEND *ind_pend);`

Parameters:

`ind_pend` This is the same parameter that is passed to all user defined Indication functions. It contains a union of request and/or response parameters that is used for several different services. The request parameters are set by MVL before calling this function. The parameters to be used for this service are as follows:

Request parameters: `ind_pend->u.namelist.req_info`
See **NAMELIST_REQ_INFO** for more information.

Response parameters: `ind_pend->u.namelist.resp_info`
See **NAMELIST_RESP_INFO** for more information.

Return Value: `ST_VOID`

GetCapabilityList Service

This service is used to request that a list (or part of a list) of capabilities that exist at the VMD.

GetCapabilityList Data Structures

The following is the GetCapabilityList Indication Control Structure:

```
typedef struct
  {
  GETCL_REQ_INFO    *req_info;
  GETCL_RESP_INFO   *resp_info;
  } MVLAS_GETCL_CTRL;
```

getcl_req_info

This operation specific structure described below is used by the client in issuing a GetCapabilityList request. It is received by the server when a GetCapabilityList indication is received.

```
struct getcl_req_info
  {
  ST_BOOLEAN  cont_after_pres;
  ST_CHAR    *continue_after;
  };
typedef struct getcl_req_info GETCL_REQ_INFO;
```

`cont_after_pres`	**`SD_FALSE`**. Do not include the **`continue_after`** field in the PDU. Begin the capability list response from the beginning of the list. **`SD_TRUE`**. Include the **`continue_after`** field in the PDU.
`continue_after`	This pointer to a visible string specifies the capability after which the capability list in the response should start.

getcl_resp_info

This operation specific structure described below is used by the server in issuing a GetCapabilityList response. It is received by the client when a GetCapabilityList confirm is received.

```
struct getcl_resp_info
  {
  ST_BOOLEAN  more_follows;
  ST_INT      num_of_capab;
  /*ST_CHAR   *capab_list [num_of_capab]; */
  SD_END_STRUCT
  };
typedef struct getcl_resp_info GETCL_RESP_INFO;
```

`more_follows`	**`SD_FALSE`**; no more data follows in this list. **`SD_TRUE`**; more data follows this list. It is used to signify that there are more capabilities than could be sent in this response.
`num_of_capab`	This indicates the number of pointers in the **`capab_list`** array.
`capab_list`	This array of pointers points to null-terminated character strings containing the list of capabilities of the VMD being included in this response.

Note: FOR RESPONSE ONLY, when allocating a data structure of type **`GETCL_RESP_INFO`**, enough memory is allocated to hold the information for the list of pointers to the capabilities contained in **`capab_list`**. The following C language statement can be used:

```
info = (GETCL_RESP_INFO *) chk_malloc(sizeof(GETCL_RESP_INFO) +
  num_of_capab * sizeof(ST_CHAR *));
```

GetCapabilityList Functions

u_mvl_getcl_ind

Usage: This user function is called by MVL when a Get Capability List indication is received. It should build the response and call **`mplas_getcl_resp`** to send the response. See the file **server.c** for an example of this function.

Function Prototype: `ST_VOID u_mvl_getcl_ind (MVL_IND_PEND *ind_pend);`

Parameters:

`ind_pend` This is the same parameter that is passed to all user defined Indication functions. It contains a union of request and/or response parameters that is used for several different services. The request parameters are set by MVL before calling this function. The response parameters must be set by the user before calling the response function (i.e., **`mplas_getcl_resp`**). The parameters to be used for this service are as follows:

Request parameters: `ind_pend->u.getcl.req_info`
See **`GETCL_REQ_INFO`** for more information.

Response parameters: `ind_pend->u.getcl.resp_info`
See **`GETCL_RESP_INFO`** for more information.

Return Value: `ST_VOID`

mplas_getcl_resp

Usage: This function encodes and sends the Response for a previously received GetCapabilityList indication. The response parameters in the **`MVL_IND_PEND`** structure must be filled in before this function is called. The (**`MVL_IND_PEND *`**) argument passed to this function must be the same as the (**`MVL_IND_PEND *`**) argument passed to the user defined function **`u_mvl_getcl_ind`** when the indication was received.

Function Prototype: `ST_VOID mplas_getcl_resp (MVL_IND_PEND *ind_pend);`

Parameters:

`ind_pend` This is the same parameter that is passed to all user defined Indication functions. It contains a union of request and/or response parameters that is used for several different services. The request parameters are set by MVL before calling this function. The response parameters must be set by the user before calling the response function (i.e., **`mplas_getcl_resp`**). The parameters to be used for this service are as follows:

Request parameters: `ind_pend->u.getcl.req_info`
See **`GETCL_REQ_INFO`** for more information.

Response parameters: `ind_pend->u.getcl.resp_info`
See **`GETCL_RESP_INFO`** for more information.

Return Value: `ST_VOID`

Variable Access Overview

MVL provides a set of flexible mechanisms for supporting the MMS Variable Access services effectively in the application, including:

- Configured or manufactured Variable Associations or a combination of both
- Variable Association pre/post processing functions for Read and Write services
- Alternate Access Support

Variable Association

MVL uses a construct called a Variable Association. This is used to map local variables and processes to MMS Named variables. MMS-*Lite* has an easy to use mechanism for associating MMS Named Variables to system values and/or memory locations. The data structure that implements this is **MVL_VAR_ASSOC**. Each MMS-*Lite* variable can have user-defined pre/post functions for the various MMS variable access services and can be dynamically desired. MMS-*Lite* easily supports arbitrary data types of any complexity.

```
typedef struct mvl_var_assoc
  {
  ST_CHAR                  *name;               /* variable name           */
  ST_VOID                  *data;               /* pointer to local data   */
  ST_INT                   type_id;             /* type of variable        */
  ST_UCHAR                 flags;              /* MVL_VAR_FLAG_UCA, etc.   */
  MVL_VAR_PROC             *proc;       /* User defined pre/post processing  */
  ST_VOID                  *user_info;  /* MVL user can use this for whatever*/
  ST_VOID                  *usr_ind_ctrl;
#if defined(MVL_UCA) || defined(USE_MANUFACTURED_OBJS)
  struct mvl_var_assoc     *va_to_free;        /* Used in NVL processing    */
#endif
#if defined(MVL_UCA)
  struct mvl_var_assoc     *base_va;    /* VA from which this was derived    */
  ST_INT                   offset_from_base;  /* Used only static data buffer*/
  ST_RTREF                 ref;
  MVL_ARR_CTRL             arrCtrl;
  ST_VOID                  *mvl_internal;     /* ptrtoinfo used internally MVL*/
  ST_BOOLEAN               use_static_data;   /* data in struct points to     */
                                              /* permanent data.              */
#endif
#ifdef MVL_INFO_RPT_CLIENT
  ST_RET                   result;
#endif
  } MVL_VAR_ASSOC;
```

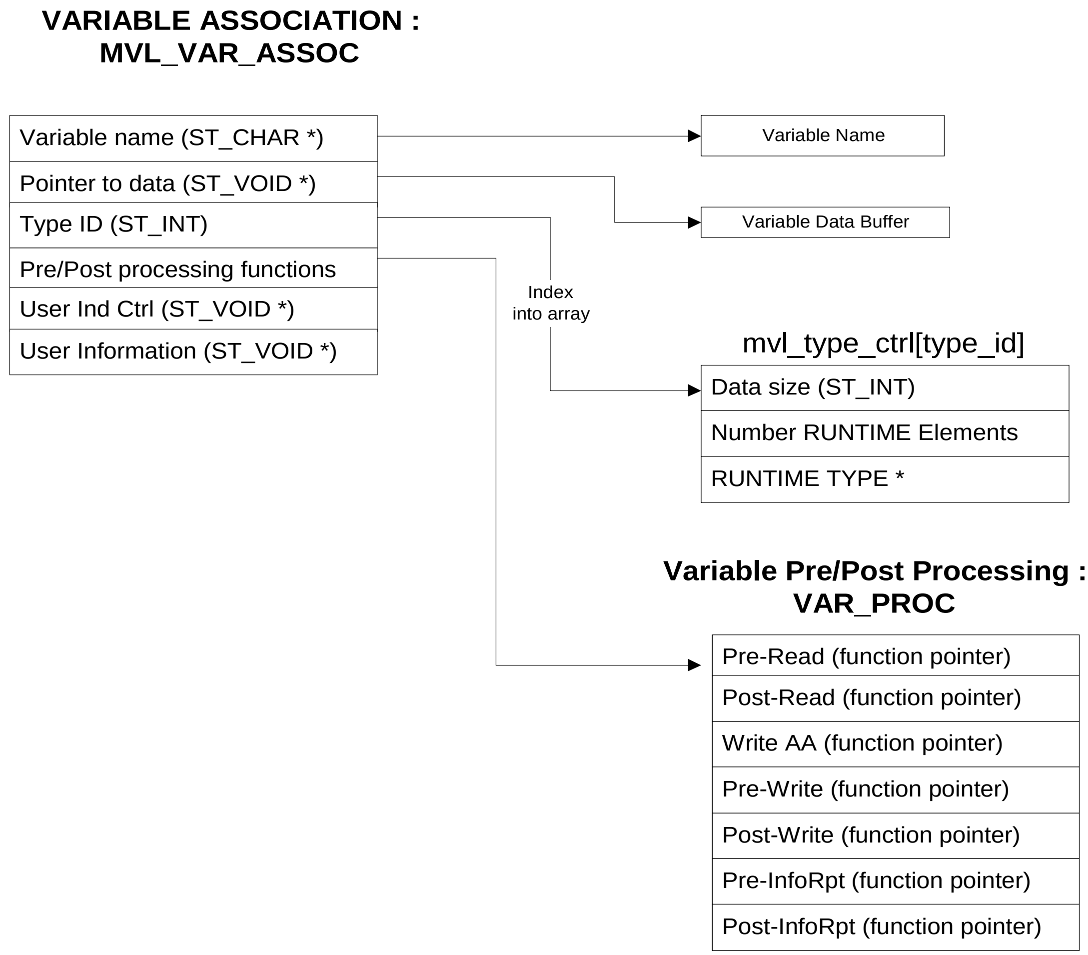


Figure 6: MVL Variable Association Data Structure

Configuring Named Variables

MVL allows the developer to configure MMS Named Variables using **MMS Object Foundry**, tool for creating MMS server objects, which most applications can and should make use of. The configured variable approach is the easiest to implement. The developer simply supplies the MMS variable names and linkages to application variables using the MMS Object Foundry **Object Definition File**. MVL will then manage all aspects of the variables automatically. The application can make use of pre/post processing functions that may be attached to any variable as well as the MVL asynchronous **Read** response capability. For instance, to expose the local variable "Temperature" as a MMS variable, the following line can be added to the **ODF** file:

```
":VD", "Temperature", "I16_TYPE",   "&Temperature"
```

This will result in MVL exposing the local variable "Temperature" as a MMS variable "Temperature", with all further application programming optional. Please refer to page 267 for more information on configuring variables.

Configuring Named Variable Lists

As with named variables, MVL allows the developer to configure MMS Named Variable Lists (NVLs) using **MMS Object Foundry**. Again, most applications can and should make use of this facility. The configured NVL approach is the easiest to implement; the developer simply declares a MMS NVL and provides a list of configured Named Variables for the list using the **MMS Object Foundry Object Definition File**. MVL will then manage all aspects of this NVL automatically. Note that to the application, variable access using either **list of variables** or **named variable list** access specifications are handled at the **Variable Association** level.

For example, to create a NVL called "TwoVars" with the MMS variables "Temperature" and "Pressure", the following line can be added to the **ODF** file:

```
":L", "TwoVars", "Temperature", "Pressure",  ":S"
```

Please refer to page 268 for more information on configuring Named Variable Lists.

Manufactured Variables

MVL provides the developer with the option of **manufacturing** variables instead of configuring them. This means that the application will have MMS visible variables that do not have static Variable Associations (VA). To enable this feature, the MVL library and the application must be compiled with **USE_MANUFACTURED_OBJS** defined. If this is defined, then the user function **`u_mvl_get_va_aa`** is called to resolve the MMS variable name to a **manufactured** Variable Association. This Variable Association must be committed until the response is sent and the function **`u_mvl_free_va`** is invoked to allow the application to free the VA and any associated resources. Note that the parameter **`alt_access_done_out`** can be set **`SD_TRUE`** if the function has resolved the alternate access when generating the Variable Association.

When using manufactured variables, the application becomes responsible for handling the MMS GetNameList (GNL) service for Named Variables and must provide the user function **`u_gnl_ind_vars`**.

Manufactured Named Variable Lists

As with Manufactured Variables, MVL allows the application to manufacture Named Variable Lists. The user functions **`u_mvl_get_nvl`** on page 55 and **`u_mvl_free_nvl`** on page 56 are called to create and destroy Named Variable Lists. Note that a manufactured NVL must contain valid references to its associated Variable Associations, which may or may not be manufactured as well. Like Manufactured Variables, the application should install a MMS GetNameList handler for Named Variable Lists via the function pointer **`u_gnl_ind_nvls`**.

Alternate Access

An application can make use of MVL support for the MMS Alternate Access feature in two ways:

First, MVL can handle the entire Alternate Access resolution transparently to the user. Complete the following steps to include this support:

1. Compile **mmsdataa.c** and link it into your application. This will replace the stub functions in the MMS library.
2. Edit **mms_tdef.c**. Find or add a definition of the following array that corresponds to the target platform. Note that this is the same text as in the MMS Object Foundry **align.cfg** file.

```
ST_INT m_def_data_algn_tbl [NUM_ALGN_TYPES]
```

3. Make sure **mms_tdef.c**, **mms_alta.c**, and **mms_rtaa.c** are included in the MMS library.

When this is done, no further action is required from the user application. The primary downside to this is the necessity of linking **mmsdataa.c**, which is rather resource intensive. In addition, this method does not work especially well with manufactured variables.

With the second method, the user can handle the alternate access and deal with it outside of MVL. That is, it can be handled in the pre-read, pre-write, or manufactured variable handlers as appropriate. This approach is preferable for simple types of alternate access and when the application uses the manufactured variable mechanism.

Read Service

MVL has flexible and easy to use support for the MMS Read service. The general flow and user options are shown on the flowcharts below.

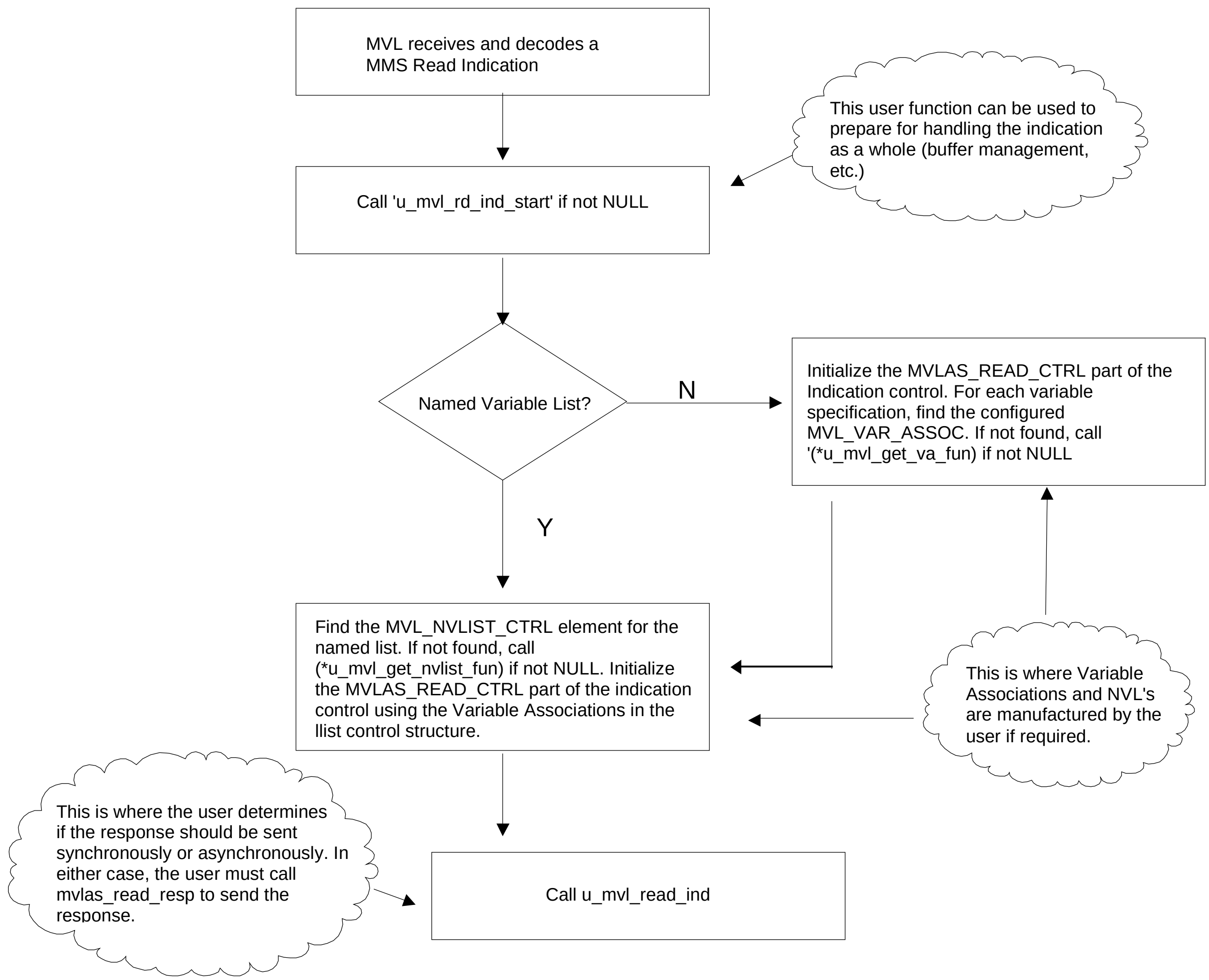


Figure 7: MVL Read Indication Processing

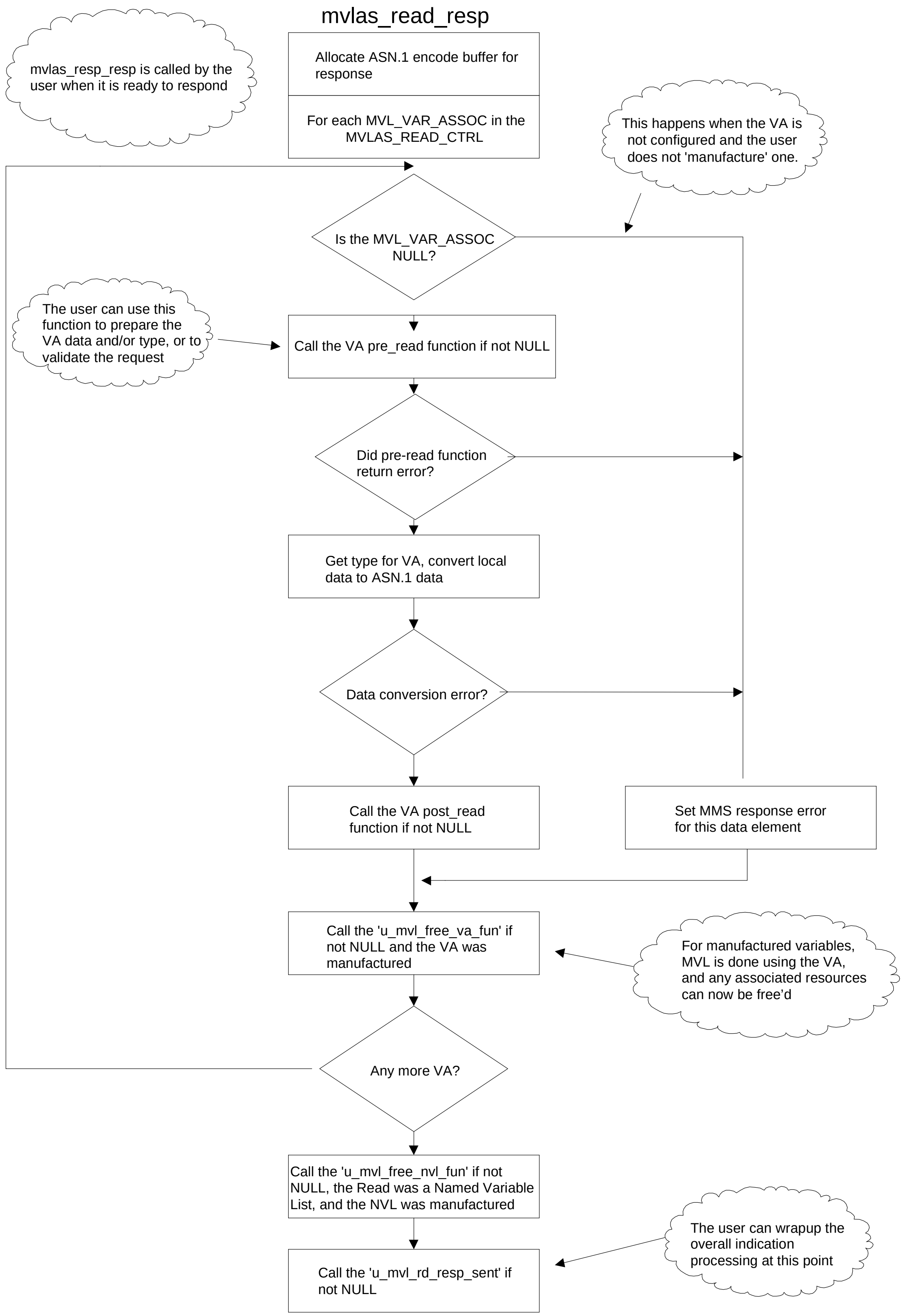


Figure 8: MVL Read Response Processing

Read Data Structures

The following are the Read Indication Control Structures.

This structure represents one Variable Association being read. The user can set the **acc_rslt_tag** to **ACC_RSLT_FAILURE** if the read does not succeed.

MVLAS_RD_VA_CTRL

```
typedef struct mvlas_rd_va_ctrl
  {
  MVL_VAR_ASSOC     *va;
  MVL_SCOPE         va_scope;    /* Variable scope: VMD, Domain, or AA   */
  ST_INT16          acc_rslt_tag;/* ACC_RSLT_SUCCESS or ACC_RSLT_FAILURE */
  ST_INT16          failure;     /* DataAccessError code for failure     */
  ST_BOOLEAN        alt_access_pres;
  ALT_ACCESS        alt_acc;

#if defined(MVL_UCA)
  ST_INT            numPrimData; /* Total primitive elements for var     */
  ST_INT            numPrimDataDone;          /* Number complete         */
#endif

  ST_VOID *usr;                  /* For user to use as seen fit          */
  } MVLAS_RD_VA_CTRL;
```

MVLAS_READ_CTRL

```
typedef struct mvlas_read_ctrl
  {
  ST_INT16          var_acc_tag;   /* VAR_ACC_NAMEDLIST or VAR_ACC_VARLIST*/
  ST_INT            numVar;        /* Variables being read                */
  MVLAS_RD_VA_CTRL *vaCtrlTbl;

  ST_BOOLEAN        usrNvl;        /* MVL internal use                    */
  MVL_NVLIST_CTRL   *nvList;
  } MVLAS_READ_CTRL;
```

Read Functions

u_mvl_read_ind

Usage: This is a user-defined function called when a Read indication is received. The user must call **mvlas_read_resp** to automatically process the indication and send the response or call **mplas_err_resp** to send an error response.

Function Prototype: `ST_VOID u_mvl_read_ind (MVL_IND_PEND *ind_pend);`

Parameters:

`ind_pend` This is the same parameter that is passed to all user defined Indication functions. It contains a union of request and/or response parameters that is used for several different services. The request parameters are set by MVL before calling this function. The response parameters must be set by the user before calling the response function. The parameters to be used for this service are as follows:

Request and response parameters: `ind_pend->u.rd`
See **MVLAS_READ_CTRL** for more information.

Return Value: `ST_VOID`

mvlas_read_resp

Usage: This is a Virtual Machine response function for handling a previously received Read indication. It completely processes the indication, fills in the response parameters in the **MVL_IND_PEND** structure, and then sends the response. This function is usually called synchronously from the **u_mvl_read_ind** function, but it may be called asynchronously whenever the service is completed. The (**MVL_IND_PEND ***) argument passed to this function must be the same as the (**MVL_IND_PEND ***) argument passed to the user defined function **u_mvl_read_ind** when the indication was received.

Function Prototype: `ST_RET mvlas_read_resp (MVL_IND_PEND *ind_pend);`

Parameters:

`ind_pend` This is the same parameter that is passed to all user defined Indication functions. It contains a union of request and/or response parameters that is used for several different services. The request parameters are set by MVL before calling this function. The parameters to be used for this service are as follows:

Request and response parameters: `ind_pend->u.rd`
See **MVLAS_READ_CTRL** for more information.

Return Value: `ST_RET` `SD_SUCCESS` If OK, or a non-zero error code.

Read Pre/Post Processing Functions

MVL provides a facility for user defined pre/post processing functions for all server variables. Each variable can have independent pre/post processing functions associated with it. These are referenced via a structure of type **`MVL_VAR_PROC`**.

pre_read

This function is called just before MVL encodes the ASN.1 data for the read response. MVL uses the information in the Variable Association (VA) in encoding the ASN.1 data.

The task for this function is to ensure that the VA is valid so that MVL can send the correct data in response to a read indication. This function is passed the VA and any alternate access information and can take whatever steps are required to resolve the VA data, type, and alternate access mode to be used. Some typical steps taken by this function can include:

- Return a different VA to be used.
- Change the data buffer (i.e., **`va->data = newDataPtr`**).
- Change the data in the data buffer.
- Change the type (i.e., **`va->type_id - newTypeId`**).
- Change the Alternate Access processing mode.

The **`pre_read`** function must return **`SD_SUCCESS`** (if the VA is ready to be used by MVL) or **`SD_FAILURE`** (if the VA is not ready to be used by MVL).

post_read

This function is called after MVL has encoded the ASN.1 data for a read response. It may be used for application specific purposes, such as freeing resources used during the read process. This function is passed the VA and any alternate access information.

Write Service

MVL has flexible and easy to use support for the MMS Write service. The general flow and user options are shown on the flowcharts below.

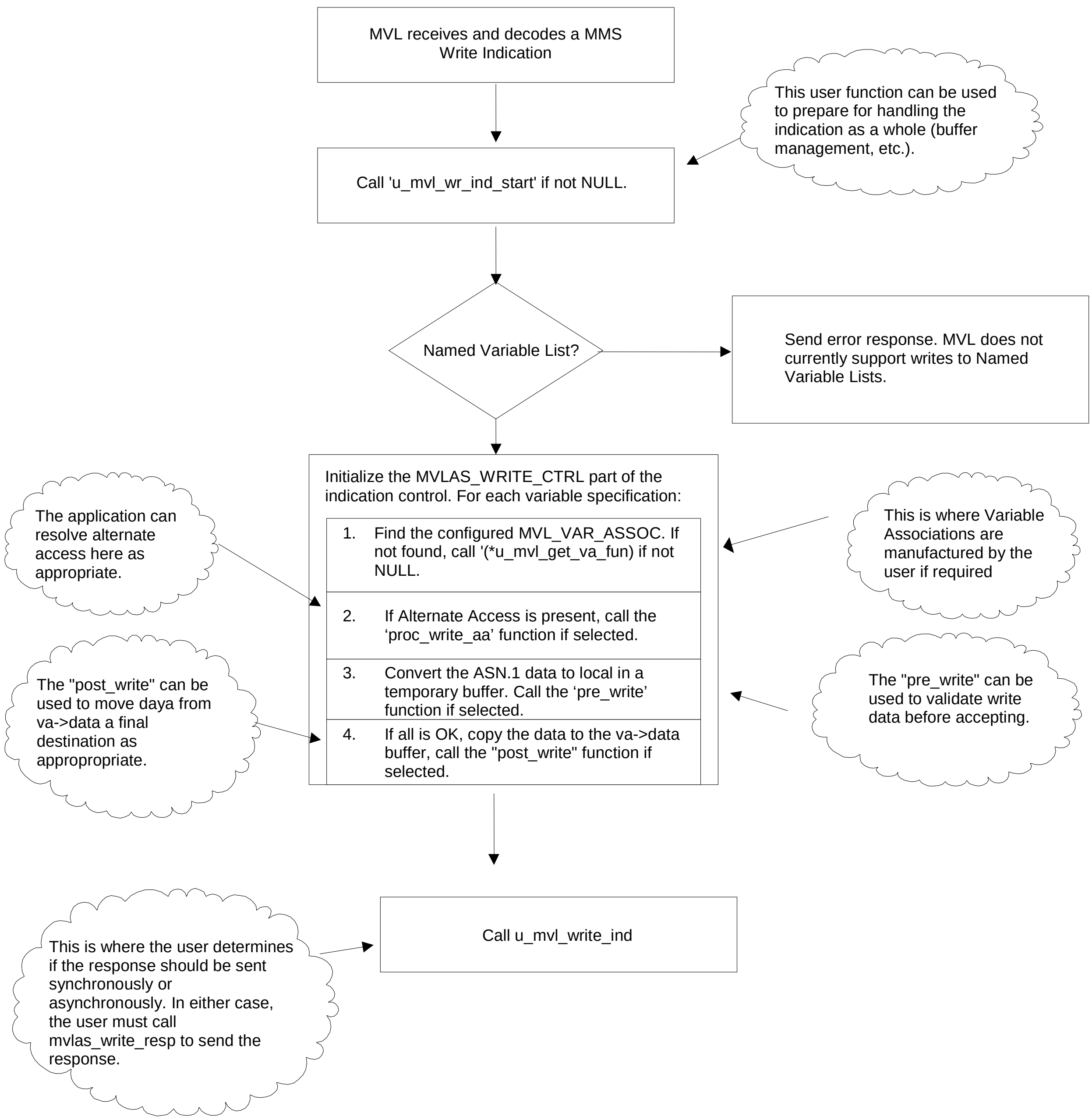


Figure 9: MVL Write Indication Processing

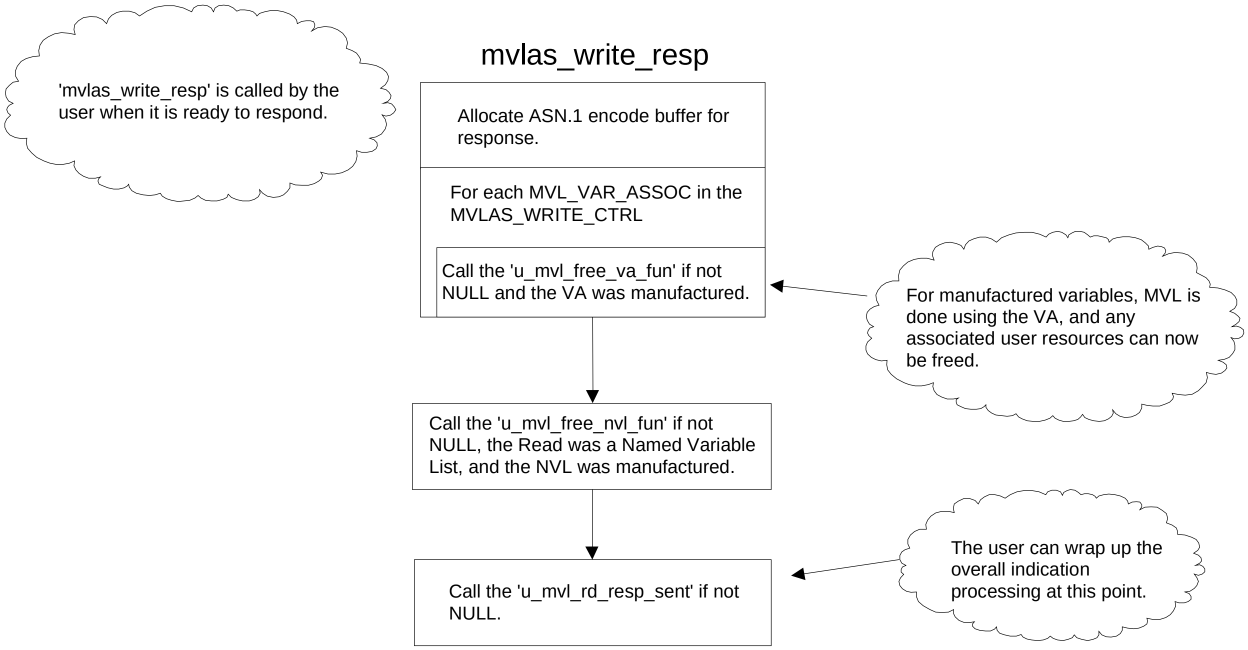


Figure 10: MVL Write Response Processing

Write Data Structures

The following are the Write Indication Control Structures:

This structure represents one Variable Association being written. The user can set the **`resp_tag`** to **`WR_RSLT_FAILURE`** if the write does not succeed.

MVLAS_WR_VA_CTRL

```
typedef struct mvlas_wr_va_ctrl
  {
  MVL_VAR_ASSOC     *va;
  MVL_SCOPE         va_scope;     /* Variable scope: VMD, Domain, or AA */
  ST_INT16          resp_tag;     /* WR_RSLT_FAILURE or WR_RSLT_SUCCESS */
  ST_INT16          failure;      /* DataAccessError code for failure       */
  ST_BOOLEAN        alt_access_pres;
  ALT_ACCESS        alc_acc;

#if defined(MVL_UCA)
  ST_INT            numPrimData;  /* Total primitive elements for var     */
  ST_INT            numPrimDataDone;    /* Number complete                */
#endif

  ST_VOID           *usr;         /* For user to use as she sees fit      */
  } MVLAS_WR_VA_CTRL;
```

MVLAS_WRITE_CTRL

```
typedef struct mvlas_write_ctrl
  {
  ST_INT            numVar;       /* Variables being written              */
  MVLAS_WR_VA_CTRL  *vaCtrlTbl;
  } MVLAS_WRITE_CTRL;
```

Write Functions

u_mvl_write_ind

Usage: This is a user defined function called when a Write indication is received. The user must call **`mvlas_write_resp`** to automatically process the indication and send the response or call **`mplas_err_resp`** to send an error response.

Function Prototype: `ST_VOID u_mvl_write_ind (MVL_IND_PEND *ind_pend);`

Parameters:

`ind_pend` This is the same parameter that is passed to all user defined Indication functions. It contains a union of request and/or response parameters that is used for several different services. The request parameters are set by MVL before calling this function. The response parameters must be set by the user before calling the response function. The parameters to be used for this service are as follows:

Request and response parameters: `ind_pend->u.wr`
See **`MVLAS_WRITE_CTRL`** for more information.

Return Value: `ST_VOID`

mvlas_write_resp

Usage: This is a Virtual Machine response function for handling a previously received Write indication. It completely processes the indication, fills in the response parameters in the **`MVL_IND_PEND`** structure, and then sends the response. This function is usually called synchronously from the **`u_mvl_write_ind`** function, but it may be called asynchronously whenever the service is completed. The (**`MVL_IND_PEND *`**) argument passed to this function must be the same as the (**`MVL_IND_PEND *`**) argument passed to the user defined function **`u_mvl_write_ind`** when the indication was received.

Function Prototype: `ST_VOID mvlas_write_resp (MVL_IND_PEND *ind_pend);`

Parameters:

`ind_pend` This is the same parameter that is passed to all user defined Indication functions. It contains a union of request and/or response parameters that is used for several different services. The request parameters are set by MVL before calling this function. The parameters to be used for this service are as follows:

Request and response parameters: `ind_pend->u.wr`
See **`MVLAS_WRITE_CTRL`** for more information.

Return Value: `ST_VOID`

Write Pre/Post Processing Functions

MVL provides the hooks for pre/post processing functions for all server variables. Each variable can have pre/post processing functions associated with it. These are referenced using a structure of type **`MVL_VAR_PROC`**.

proc_write_aa

This function is called when a MMS Write indication has been received and alternate access is present for the Variable Association. MVL calls this function before converting the ASN.1 write data to local in a temporary buffer.

This function is passed the VA and the alternate access information, and can take whatever steps are required to prepare for the data conversion process. Some typical steps take by this function can include:

- Return a different VA to be used.
- Change the type.
- Change the Alternate Access processing mode.

The **`proc_write_aa`** function must return **`SD_SUCCESS`** (if the VA is ready to be used by MVL) or **`SD_FAILURE`** if not (if the VA is not ready to be used by MVL).

pre_write

This function is called after MVL has decoded the received ASN.1 data into a temporary buffer. The task for this function is to check that the data is acceptable and that the VA is valid so that MVL can copy the data from the temporary buffer into the VA data buffer.

This function is passed the VA, the data, and any alternate access information. Some typical steps take by this function can include:

- Verify that the data is acceptable.
- Change the data buffer.

The **`pre_write`** function must return **`SD_SUCCESS`** (if the VA is ready to be used by MVL) or **`SD_FAILURE`** (if the VA is not ready to be used by MVL).

post_write

This function is called after MVL has moved the decoded data into the VA data buffer. It may be used for application specific purposes, such as moving the data into a final destination. This function is passed the VA and any alternate access information. An example of how these hooks could be used is as follows:

Assume the server has a MMS server variable called **setPoint**. Whenever the server variable “setPoint” is written by a remote client, we want to check the value to determine whether it is valid; and when the local variable value has been changed, we want to call a routine that will take action on the new setPoint value. To do this, we can use the **`pre_write`** function for the validity check (return **`SD_SUCCESS`** if OK, **`SD_FAILURE`** if not) and the **`post_write`** function to take action on the new value.

Information Report Service

This service is used to inform the other node of the value of one or more specified variables, as read by the issuing node.

Information Report Functions

mvl_info_variables

Usage: This function is used to send a MMS Information Report. It takes a `MVL_NVLIST_CTRL` as input, and sends the values over the selected network connection as either List Of Variables (**`listOfVariables == SD_TRUE`**) or a Named Variable List (**`listOfVariables == SD_FALSE`**).

Function Prototype:

```
ST_RET mvl_info_variables (MVL_NET_INFO       *net_info,
                            MVL_NVLIST_CTRL    *nvl,
                            ST_BOOLEAN         listOfVariables);
```

Parameters:

`net_info` This parameter selects the connection on which the MMS transaction is to take place.

`nvl` This is the address of a Named Variable List object that contains the data to send in the InformationReport. It may be sent as a Named Variable List or as a List of Variables depending on the value of the *listOfVariables* argument. Note that in either case the MMS data will be the same. The structure **`MVL_NVLIST_CTRL`** is defined in **mvl_defs.h**.

`listOfVariables` This parameter is used to select the form of the MMS Variable Specification to be sent. The value **`SD_TRUE`** will result in a MMS List Of Variables, **`SD_FALSE`** will result in a MMS Named Variable List.

Return Value: `ST_RET SD_SUCCESS` If OK, or a non-zero error code.

GetVariableAccessAttributes Service

This service is used to request that a VMD return the attributes of a Named Variable or an Unnamed Variable object defined at the VMD. Also, it can be used to request that a VMD return the derived type description of a Scattered Access object defined at the VMD.

GetVariableAccessAttributes Data Structures

The following is the GetvariableAccessAttributes Indication Control Structure:

```
typedef struct
  {
  GETVAR_REQ_INFO   *req_info;
  GETVAR_RESP_INFO  *resp_info;
  } MVLAS_GETVAR_CTRL;
```

getvar_req_info

The operation-specific data structure is used by the Client in issuing a GetVariableAccessAttributes request. It is received by the Server when a GetVariableAccessAttributes indication is received.

```
struct getvar_req_info
  {
  ST_INT16          req_tag;
  OBJECT_NAME       name;
  VAR_ACC_ADDR      address;
  };
typedef struct getvar_req_info GETVAR_REQ_INFO;
```

`req_tag`	This specifies the kind of variable: **`GETVAR_NAME`**. This indicates a Named Variable. **`GETVAR_ADDR`**. This indicates an Unnamed Addressed Variable.
`name`	This structure of type **`OBJECT_NAME`** contains the name of the variable and is used only if **`req_tag = GETVAR_NAME`**.
`address`	This structure of type **`VAR_ACC_ADDR`** indicates the address of the unnamed variable object and is used only if **`req_tag = GETVAR_ADDR`**.

getvar_resp_info

The operation-specific data structure described on the next page is used by the Server in issuing a GetVariableAccessAttributes response. It is received by the Client when a GetVariableAccessAttributes confirm is received.

```
struct getvar_resp_info
  {
  ST_BOOLEAN        mms_deletable;
  ST_BOOLEAN        address_pres;
  VAR_ACC_ADDR      address;
  VAR_ACC_TSPEC     type_spec;
  };
typedef struct getvar_resp_info GETVAR_RESP_INFO;
```

`mms_deletable`	**`SD_FALSE`**. The variable definition is NOT deletable using a MMS service request. **`SD_TRUE`**. The variable definition is deletable using a MMS service request.
`address_pres`	**`SD_FALSE`**. Do not include **`address`** in the PDU. **`SD_TRUE`**. Include **`address`** in the PDU. You should only include the address field if the variable is a NAMED variable, and access to it is PUBLIC.
`address`	This structure of type **`VAR_ACC_ADDR`** contains the address information for the specified public named variable.
`type_spec`	This structure of type **`VAR_ACC_TSPEC`** contains the type definition for the specified variable.

GetVariableAccessAttributes Functions

u_mvl_getvar_ind

Usage: This is a user defined function called when a GetVariableAccessAttributes indication is received. The user must examine the request parameters contained in the **`MVL_IND_PEND`** structure, do whatever is necessary to process the request, and then call **`mplas_getvar_resp`** or **`mvlas_getvar_resp`** to send the response (or **`mplas_err_resp`** to send an error response).

Function Prototype: `ST_VOID u_mvl_getvar_ind (MVL_IND_PEND *ind_pend);`

Parameters:

`ind_pend` This is the same parameter that is passed to all user defined Indication functions. It contains a union of request and/or response parameters that is used for several different services. The request parameters are set by MVL before calling this function. The response parameters must be set by the user before calling the response function (i.e., **`mplas_getvar_resp`**). The parameters to be used for this service are as follows:

Request parameters: `ind_pend->u.getvar.req_info`
See **`GETVAR_REQ_INFO`** for more information.

Response parameters: `ind_pend->u.getvar.resp_info`
See **`GETVAR_RESP_INFO`** for more information.

Return Value: `ST_VOID`

mplas_getvar_resp

Usage: This function encodes and sends the Response for a previously received GetVariableAccessAttributes indication. The Response parameters in the **`MVL_IND_PEND`** structure must be filled in before this function is called. The (**`MVL_IND_PEND *`**) argument passed to this function must be the same as the (**`MVL_IND_PEND *`**) argument passed to the user defined function **`u_mvl_getvar_ind`** when the indication was received.

Function Prototype: `ST_VOID mplas_getvar_resp (MVL_IND_PEND *ind_pend);`

Parameters:

`ind_pend` This is the same parameter that is passed to all user defined Indication functions. It contains a union of request and/or response parameters that is used for several different services. The request parameters are set by MVL before calling this function. The response parameters must be set by the user before calling the response function (i.e., **`mplas_getvar_resp`**). The parameters to be used for this service are as follows:

Request parameters: `ind_pend->u.getvar.req_info`
See **`GETVAR_REQ_INFO`** for more information.

Response parameters: `ind_pend->u.getvar.resp_info`
See **`GETVAR_RESP_INFO`** for more information.

Return Value: `ST_VOID`

mvlas_getvar_resp

Usage: This is a Virtual Machine response function for handling a previously received GetVariableAccessAttributes indication. It completely processes the indication, fills in the response parameters in the **MVL_IND_PEND** structure, and then sends the response by calling **mplas_getvar_resp**. The (**MVL_IND_PEND ***) argument passed to this function must be the same as the (**MVL_IND_PEND ***) argument passed to the user defined function **u_mvl_getvar_ind** when the indication was received.

Function Prototype: `ST_VOID mvlas_getvar_resp (MVL_IND_PEND *ind_pend);`

Parameters:

`ind_pend` This is the same parameter that is passed to all user defined Indication functions. It contains a union of request and/or response parameters that is used for several different services. The request parameters are set by MVL before calling this function. The parameters to be used for this service are as follows:

Request parameters: `ind_pend->u.getvar.req_info`
See **GETVAR_REQ_INFO** for more information.

Response parameters: `ind_pend->u.getvar.resp_info`
See **GETVAR_RESP_INFO** for more information.

Return Value: `ST_VOID`

DefineNamedVariableList Service

This service is used by a Client application to request that a Server VMD create a Named Variable List object. This allows access through a list of Named Variable objects, Unnamed Variable objects, or Scattered Access objects, or any combination.

DefineNamedVariableList Data Structures

The following is the DefinedNamedVariableList Indication Control Structure:

```
typedef struct
  {
  DEFVLIST_REQ_INFO        *req_info;
  } MVLAS_DEFVLIST_CTRL;
```

defvlist_req_info

The operation-specific data structure described below is used by the Client in issuing a DefineNamedVariableList request. It is received by the Server when a DefineNamedVariableList indication is received.

```
struct defvlist_req_info
  {
  OBJECT_NAME       vl_name;
  ST_INT            num_of_variables;
/*VARIABLE_LIST     var_list [num_of_variables];                   */
  SD_END_STRUCT
  };
typedef struct defvlist_req_info DEFVLIST_REQ_INFO;
```

`vl_name`	This structure of type **`OBJECT_NAME`** contains the name of the variable list to be defined.
`num_of_variables`	This indicates the number of variables in this list.
`var_list`	This array of structures of type **`VARIABLE_LIST`** contains the variable descriptions for the list of variables to be accessed.

Note: *FOR REQUEST ONLY, when allocating Operation-Specific data structures containing a structure of type **`VARIABLE_LIST`**, make sure that sufficient memory is allocated to hold the list of variables contained in **`var_list`**. The following C Statement can be used:*

```
info = (DEFVLIST_REQ_INFO *) chk_malloc (sizeof(DEFVLIST_REQ_INFO) +
       (num_of_variables * (sizeof(VARIABLE_LIST))));
```

DefineNamedVariableList Functions

u_mvl_defvlist_ind

Usage: This is a user defined function called when a DefineNamedVariableList indication is received. The user must examine the request parameters contained in the **`MVL_IND_PEND`** structure, do whatever is necessary to process the request, and then call **`mplas_defvlist_resp`** or **`mvlas_defvlist_resp`** to send the response (or **`mplas_err_resp`** to send an error response).

Function Prototype: `ST_VOID u_mvl_defvlist_ind (MVL_IND_PEND *ind_pend);`

Parameters:

`ind_pend` This is the same parameter that is passed to all user defined Indication functions. It contains a union of request and/or response parameters that is used for several different services. The request parameters are set by MVL before calling this function. The parameters to be used for this service are as follows:

Request parameters: `ind_pend->u.defvlist.req_info`
See **`DEFVLIST_REQ_INFO`** for more information.

Response parameters: NONE

Return Value: `ST_VOID`

mplas_defvlist_resp

Usage: This function encodes and sends the Response for a previously received DefineNamedVariableList indication. The (**`MVL_IND_PEND *`**) argument passed to this function must be the same as the (**`MVL_IND_PEND *`**) argument passed to the user defined function **`u_mvl_defvlist_ind`** when the indication was received.

Function Prototype: `ST_VOID mplas_defvlist_resp (MVL_IND_PEND *ind_pend);`

Parameters:

`ind_pend` This is the same parameter that is passed to all user defined Indication functions. It contains a union of request and/or response parameters that is used for several different services. The request parameters are set by MVL before calling this function. The parameters to be used for this service are as follows:

Request parameters: `ind_pend->u.defvlist.req_info`
See **`DEFVLIST_REQ_INFO`** for more information.

Response parameters: NONE

Return Value: `ST_VOID`

mvlas_defvlist_resp

Usage: This is a Virtual Machine response function for handling a previously received DefineNamedVariableList indication. It completely processes the indication, fills in the response parameters in the **MVL_IND_PEND** structure, and then sends the response by calling **mplas_defvlist_resp**. The (**MVL_IND_PEND ***) argument passed to this function must be the same as the (**MVL_IND_PEND ***) argument passed to the user defined function **u_mvl_defvlist_ind** when the indication was received.

Function Prototype: `ST_VOID mvlas_defvlist_resp (MVL_IND_PEND *ind_pend);`

Parameters:

`ind_pend` This is the same parameter that is passed to all user defined Indication functions. It contains a union of request and/or response parameters that is used for several different services. The parameters to be used for this service are as follows:

Request parameters: `ind_pend->u.defvlist.req_info`
See **DEFVLIST_REQ_INFO** for more information.

Response parameters: NONE

Return Value: `ST_VOID`

DeleteNamedVariableList Service

This service is used by a Client application to request that a Server VMD delete one or more Named Variables List objects at a VMD. These must have a MMS Deletable attribute equal to true.

DeleteNamedVariableList Data Structures

The following is the DeleteNamedVariableList Indication Control Structure:

```
typedef struct
  {
  DELVLIST_REQ_INFO        *req_info;
  DELVLIST_RESP_INFO       *resp_info;
  } MVLAS_DELVLIST_CTRL;
```

delvlist_req_info

The operation-specific data structure described below is used by the Client in issuing a DeleteNamedVariableList request. It is received by the Server when a DeleteNamedVariableList indication is received.

```
struct delvlist_req_info
  {
  ST_INT16          scope;
  ST_BOOLEAN        dname_pres;
  ST_CHAR           dname [MAX_IDENT_LEN+1];
  ST_BOOLEAN        vnames_pres;
  ST_INT            num_of_vnames;
/*OBJECT_NAME       vname_list [num_of_vnames];                   */
  SD_END_STRUCT
  };
typedef struct delvlist_req_info DELVLIST_REQ_INFO;
```

`scope` This specifies the scope of the named variable definition(s) to be deleted:

DELVL_SPEC. Delete only those variables whose names are in **vname_list**.

DELVL_AA. The Named Variable List objects are specific to this association (aa-specific). Delete all AA-specific Named Variable List objects.

DELVL_DOM. Delete all domain-specific Named Variable List objects in the specified domain (**dname**).

DELVL_VMD. Delete all VMD-Specific Named Variable List objects.

`dname_pres` **SD_FALSE**. Do not include **dname** in the PDU.

SD_TRUE. Include **dname** in the PDU.

`dname` This contains the name of the domain for which all domain specific variables are to be deleted. Use if **scope = DELVL_DOM**.

`vnames_pres` **SD_FALSE**. Do not include **vname_list** in the PDU.

SD_TRUE. Include **vname_list** in the PDU.

`num_of_vnames` This indicates the number of variables to be deleted.

`vname_list` This array of structures of type **OBJECT_NAME** specifies the specific variables to be deleted.

Note: *FOR REQUEST ONLY, when allocating a data structure of type* ***DELVLIST_REQ_INFO****, enough memory must be allocated to hold the information for the* ***vnames_list*** *member of the structure. The following C statement can be used:*

```
info = (DELVLIST_REQ_INFO *) chk_malloc (sizeof (DELVLIST_REQ_INFO) +
             (num_of_vnames * (sizeof (OBJECT_NAME))));
```

delvlist_resp_info

The operation-specific data structure described below is used by the Server in issuing a DeleteNamedVariableList response. It is received by the Client when a DeleteNamedVariableList confirm is received.

```
struct delvlist_resp_info
  {
  ST_UINT32   num_matched;
  ST_UINT32   num_deleted;
  };
typedef struct delvlist_resp_info DELVLIST_RESP_INFO;
```

num_matched	This indicates the number of named variable list descriptions specified in the request that matched an existing variable.
num_deleted	This indicates the number of named variable lists actually deleted.

DeleteNamedVariableList Functions

u_mvl_delvlist_ind

Usage: This is a user defined function called when a DeleteNamedVariableList indication is received. The user must examine the request parameters contained in the **MVL_IND_PEND** structure, do whatever is necessary to process the request, and then call **mplas_delvlist_resp** or **mvlas_delvlist_resp** to send the response (or **mplas_err_resp** to send an error response).

Function Prototype: `ST_VOID u_mvl_delvlist_ind (MVL_IND_PEND *ind_pend);`

Parameters:

`ind_pend` This is the same parameter that is passed to all user defined Indication functions. It contains a union of request and/or response parameters that is used for several different services. The request parameters are set by MVL before calling this function. The response parameters must be set by the user before calling the response function (i.e., **mvlas_delvlist_resp** or **mplas_delvlist_resp**). The parameters to be used for this service are as follows:

Request parameters: `ind_pend->u.delvlist.req_info`
See **DELVLIST_REQ_INFO** for more information.

Response parameters: `ind_pend->u. delvlist.resp_info`
See **DELVLIST_RESP_INFO** for more information.

Return Value: `ST_VOID`

mplas_delvlist_resp

Usage: This function encodes and sends the Response for a previously received DeleteNamedVariableList indication. The Response parameters in the **MVL_IND_PEND** structure must be filled in before this function is called. The (**MVL_IND_PEND ***) argument passed to this function must be the same as the (**MVL_IND_PEND ***) argument passed to the user defined function **u_mvl_delvlist_ind** when the indication was received.

Function Prototype: `ST_VOID mplas_delvlist_resp (MVL_IND_PEND *ind_pend);`

Parameters:

`ind_pend` This is the same parameter that is passed to all user defined Indication functions. It contains a union of request and/or response parameters that is used for several different services. The request parameters are set by MVL before calling this function. The response parameters must be set by the user before calling the response function (i.e., **mvlas_delvlist_resp** or **mplas_delvlist_resp**). The parameters to be used for this service are as follows:

Request parameters: `ind_pend->u.delvlist.req_info`
See **DELVLIST_REQ_INFO** for more information.

Response parameters: `ind_pend->u. delvlist.resp_info`
See **DELVLIST_RESP_INFO** for more information.

Return Value: `ST_VOID`

mvlas_delvlist_resp

Usage: This is a Virtual Machine response function for handling a previously received DeleteNamedVariableList indication. It completely processes the indication, fills in the response parameters in the **`MVL_IND_PEND`** structure, and then sends the response by calling **`mplas_delvlist_resp`**. The (**`MVL_IND_PEND *`**) argument passed to this function must be the same as the (**`MVL_IND_PEND *`**) argument passed to the user defined function **`u_mvl_delvlist_ind`** when the indication was received.

Function Prototype: `ST_VOID mvlas_delvlist_resp (MVL_IND_PEND *ind_pend);`

Parameters:

`ind_pend` This is the same parameter that is passed to all user defined Indication functions. It contains a union of request and/or response parameters that is used for several different services. The request parameters are set by MVL before calling this function. The response parameters must be set by the user before calling the response function (i.e., **`mvlas_delvlist_resp`** or **`mplas_delvlist_resp`**). The parameters to be used for this service are as follows:

Request parameters: `ind_pend->u.delvlist.req_info`
See **`DELVLIST_REQ_INFO`** for more information.

Response parameters: `ind_pend->u. delvlist.resp_info`
See **`DELVLIST_RESP_INFO`** for more information.

Return Value: `ST_VOID`

GetNamedVariableListAttributes

This service is used by a Client application to request that a Server VMD return the attributes of a Named Variable List object defined at the VMD.

GetNamedVariableListAttributes Data Structures

The following is the GetNamedVariableListAttributes Indication Control Structure:

```
typedef struct
  {
  GETVLIST_REQ_INFO        *req_info;
  GETVLIST_RESP_INFO       *resp_info;  /* allocate appropriate size     */
  } MVLAS_GETVLIST_CTRL;
```

getvlist_req_info

The operation-specific data structure described below is used by the Client in issuing a GetNamedVariableList Attributes request. It is received by the Server when a GetNamedVariableListAttributes indication is received.

```
struct getvlist_req_info
  {
  OBJECT_NAME   vl_name;
  };
typedef struct getvlist_req_info GETVLIST_REQ_INFO;
```

`vl_name` This structure of type **`OBJECT_NAME`** contains the name of the variable list to be defined.

getvlist_resp_info

The operation-specific data structure described below is used by the Server in issuing a GetNamedVariableList Attributes response. It is received by the Client when a GetNamedVariableListAttributes confirm is received.

```
struct getvlist_resp_info
  {
  ST_BOOLEAN        mms_deletable;
  ST_INT            num_of_variables;
/*VARIABLE_LIST     var_list [num_of_variables];                         */
  SD_END_STRUCT
  };
typedef struct getvlist_resp_info GETVLIST_RESP_INFO;
```

`mms_deletable` **`SD_FALSE`**. The variable list definition is NOT deletable using a MMS service request.

`SD_TRUE`. The variable list definition is deletable using a MMS service request.

`num_of_variables` This indicates the number of variables in this named variable list.

`var_list` This array of structures of type **`VARIABLE_LIST`** contains the variable descriptions for variables in the NamedVariableList object. See note below on allocation exceptions.

Note: *FOR RESPONSE ONLY, when allocating a data structure of type* ***`GETVLIST_RESP_INFO`****, enough memory must be allocated to hold the information for the* ***`var_list`*** *member of the structure. The following C statement can be used:*

```
info = (GETVLIST_RESP_INFO*) chk_malloc (sizeof (GETVLIST_RESP_INFO) +
             (num_of_variables * (sizeof (VARIABLE_LIST))));
```

GetNamedVariableListAttributes Functions

u_mvl_getvlist_ind

Usage: This is a user defined function called when a GetNamedVariableListAttributes indication is received. The user must examine the request parameters contained in the **MVL_IND_PEND** structure, do whatever is necessary to process the request, and then call **mplas_getvlist_resp** or **mvlas_getvlist_resp** to send the response (or **mplas_err_resp** to send an error response).

Function Prototype: `ST_VOID u_mvl_getvlist_ind (MVL_IND_PEND *ind_pend);`

Parameters:

`ind_pend` This is the same parameter that is passed to all user defined Indication functions. It contains a union of request and/or response parameters that is used for several different services. The request parameters are set by MVL before calling this function. The response parameters must be set by the user before calling the response function (i.e., **mvlas_getvlist_resp** or **mplas_getvlist_resp**). The parameters to be used for this service are as follows:

Request parameters: `ind_pend->u.getvlist.req_info`
See **GETVLIST_REQ_INFO** for more information.

Response parameters: `ind_pend->u.getvlist.resp_info`
See **GETVLIST_RESP_INFO** for more information.

Return Value: `ST_VOID`

mplas_getvlist_resp

Usage: This function encodes and sends the Response for a previously received GetNamedVariableListAttributes indication. The Response parameters in the **MVL_IND_PEND** structure must be filled in before this function is called. The (**MVL_IND_PEND ***) argument passed to this function must be the same as the (**MVL_IND_PEND ***) argument passed to the user defined function **u_mvl_getvlist_ind** when the indication was received.

Function Prototype: `ST_VOID mplas_getvlist_resp (MVL_IND_PEND *ind_pend);`

Parameters:

`ind_pend` This is the same parameter that is passed to all user defined Indication functions. It contains a union of request and/or response parameters that is used for several different services. The request parameters are set by MVL before calling this function. The response parameters must be set by the user before calling the response function (i.e., **mvlas_getvlist_resp** or **mplas_getvlist_resp**). The parameters to be used for this service are as follows:

Request parameters: `ind_pend->u.getvlist.req_info`
See **GETVLIST_REQ_INFO** for more information.

Response parameters: `ind_pend->u.getvlist.resp_info`
See **GETVLIST_RESP_INFO** for more information.

Return Value: `ST_VOID`

mvlas_getvlist_resp

Usage: This is a Virtual Machine response function for handling a previously received GetNamedVariableListAttributes indication. It completely processes the indication, fills in the response parameters in the **`MVL_IND_PEND`** structure, and then sends the response by calling **`mplas_getvlist_resp`**. The (**`MVL_IND_PEND *`**) argument passed to this function must be the same as the (**`MVL_IND_PEND *`**) argument passed to the user defined function **`u_mvl_getvlist_ind`** when the indication was received.

Function Prototype: `ST_VOID mvlas_getvlist_resp (MVL_IND_PEND *ind_pend);`

Parameters:

`ind_pend` This is the same parameter that is passed to all user defined Indication functions. It contains a union of request and/or response parameters that is used for several different services. The request parameters are set by MVL before calling this function. The response parameters must be set by the user before calling the response function (i.e., **`mvlas_getvlist_resp`** or **`mplas_getvlist_resp`**). The parameters to be used for this service are as follows:

Request parameters: `ind_pend->u.getvlist.req_info`
See **`GETVLIST_REQ_INFO`** for more information.

Response parameters: `ind_pend->u.getvlist.resp_info`
See **`GETVLIST_RESP_INFO`** for more information.

Return Value: `ST_VOID`

GetDomainAttributes Service

This service is used to request that a Server return all the attributes associated with a specified domain.

GetDomainAttributes Data Structures

The following is the GetDomainAttributes Indication Control Structure:

```
typedef struct
  {
  GETDOM_REQ_INFO   *req_info;
  GETDOM_RESP_INFO  *resp_info;
  } MVLAS_GETDOM_CTRL;
```

getdom_req_info

The operation specific structure described below is used by the Client in issuing a GetDomainAttributes request. It is received by the Server when a GetDomainAttributes indication is received.

```
struct getdom_req_info
  {
  ST_CHAR           dname [MAX_IDENT_LEN +1];
  };
typedef struct getdom_req_info GETDOM_REQ_INFO;
```

`dname`	This contains the name of the domain for which the attributes are being requested.

getdom_resp_info

This operation specific data structure described below is used by the Server in issuing a GetDomainAttributes response. It is received by the Client when a GetDomainAttributes confirm is received.

```
struct getdom_resp_info
  {
  ST_INT     num_of_capab;
  ST_BOOLEAN mms_deletable;
  ST_BOOLEAN sharable;
  ST_INT     num_of_pinames;
  ST_INT16   state;
  ST_BOOLEAN upload_in_progress;
/*ST_CHAR    *capab_list [num_of_capab];                       */
/*ST_CHAR    *pinames_list [num_of_pinames];                   */
  SD_END_STRUCT
  };
typedef struct getdom_resp_info GETDOM_RESP_INFO;
```

`num_of_capab`	This indicates the number of pointers in the capabilities list **`capab_list`**.
`mms_deletable`	**`SD_FALSE`**. Domain is not deletable using a MMS service request. **`SD_TRUE`**. Domain is deletable using a MMS service request.
`sharable`	**`SD_TRUE`**. Domain is sharable among multiple program invocations. **`SD_FALSE`**. Domain is not sharable
`num_of_pinames`	This indicates the number of pointers in the program invocation list, **`pinames_list`**.
`state`	This indicates the state of the Domain: **`DOM_NON_EXISTENT`**. This state represents the domain before its creation. **`DOM_LOADING`**. This state represents an intermediate state that occurs during the loading process. **`DOM_READY`**. This state represents the state a domain enters in after a successful download.

DOM_IN_USE. This state differs from the Ready state in that one or more Program Invocations have been defined using this domain.

DOM_COMPLETE. This state represents an intermediate state that occurs after the last DownloadSegment has been received but before the DownloadSequence has been terminated.

DOM_INCOMPLETE. This state represents an intermediate state that when a DownloadSequence was terminated but before the loading process was complete.

DOM_D1 - DOM_D9. These states (D1 - D9) represent intermediate states per the IS specification. These are states between a request and a response.

upload_in_progress	This indicates the number of uploads currently in progress.
capab_list	This array of pointers to the list of capabilities contains information about the capabilities and the VMD resource limitations of this domain.
pinames_list	This is an array of pointers to a list of the names of the program invocations that reference this domain.

Note: *FOR RESPONSE ONLY, when allocating a data structure of type* ***GETDOM_RESP_INFO****, enough memory must be allocated to hold the information for list of capabilities,* ***capab_list****, and the list of the program invocation names,* ***pinames_list****, contained in this structure. The following C language statement can be used:*

```
info = (GETDOM_RESP_INFO *) chk_malloc (sizeof (GETDOM_RESP_INFO) +
                ((num_of_capab + num_of_pinames) * (sizeof(ST_CHAR *))));
```

GetDomainAttributes Functions

u_mvl_getdom_ind

Usage: This is a user defined function called when a GetDomainAttributes indication is received. The user must examine the request parameters contained in the **MVL_IND_PEND** structure, do whatever is necessary to process the request, and then call **mplas_getdom_resp** or **mvlas_getdom_resp** to send the response (or **mplas_err_resp** to send an error response).

Function Prototype: `ST_VOID u_mvl_getdom_ind (MVL_IND_PEND *ind_pend);`

Parameters:

`ind_pend` This is the same parameter that is passed to all user defined Indication functions. It contains a union of request and/or response parameters that is used for several different services. The request parameters are set by MVL before calling this function. The response parameters must be set by the user before calling the response function (i.e., **mplas_getdom_resp**). The parameters to be used for this service are as follows:

Request parameters: `ind_pend->u.getdom.req_info`
See **GETDOM_REQ_INFO** for more information.

Response parameters: `ind_pend->u.getdom.resp_info`
See **GETDOM_RESP_INFO** for more information.

Return Value: `ST_VOID`

mplas_getdom_resp

Usage: This function encodes and sends the Response for a previously received GetDomainAttributes indication. The Response parameters in the **MVL_IND_PEND** structure must be filled in before this function is called. The (**MVL_IND_PEND***) argument passed to this function must be the same as the (**MVL_IND_PEND***) argument passed to the user defined function **u_mvl_getdom_ind** when the indication was received.

Function Prototype: `ST_VOID mplas_getdom_resp (MVL_IND_PEND *ind_pend);`

Parameters:

`ind_pend` This is the same parameter that is passed to all user defined Indication functions. It contains a union of request and/or response parameters that is used for several different services. The request parameters are set by MVL before calling this function. The response parameters must be set by the user before calling the response function (i.e., **mplas_getdom_resp**). The parameters to be used for this service are as follows:

Request parameters: `ind_pend->u.getdom.req_info`
See **GETDOM_REQ_INFO** for more information.

Response parameters: `ind_pend->u.getdom.resp_info`
See **GETDOM_RESP_INFO** for more information.

Return Value: `ST_VOID`

mvlas_getdom_resp

Usage: This is a Virtual Machine response function for handling a previously received GetDomainAttributes indication. It completely processes the indication, fills in the response parameters in the **`MVL_IND_PEND`** structure, and then sends the response by calling **`mplas_getdom_resp`**. The (**`MVL_IND_PEND *`**) argument passed to this function must be the same as the (**`MVL_IND_PEND *`**) argument passed to the user defined function **`u_mvl_getdom_ind`** when the indication was received.

Function Prototype: `ST_VOID mvlas_getdom_resp (MVL_IND_PEND *ind_pend);`

Parameters:

`ind_pend` This is the same parameter that is passed to all user defined Indication functions. It contains a union of request and/or response parameters that is used for several different services. The request parameters are set by MVL before calling this function. The response parameters must be set by the user before calling the response function (i.e., **`mplas_getdom_resp`**). The parameters to be used for this service are as follows:

Request parameters: `ind_pend->u.getdom.req_info`
See **`GETDOM_REQ_INFO`** for more information.

Response parameters: `ind_pend->u.getdom.resp_info`
See **`GETDOM_RESP_INFO`** for more information.

Return Value: `ST_VOID`

InitializeJournal Service

This service is used by the client to request that a server initialize all or part of an existing Journal object by removing all or some of the journal entries.

InitializeJournal Data Structures

The following is the IntitializeJournal Indication Control Structure:

```
typedef struct
  {
  JINIT_REQ_INFO    *req_info;
  JINIT_RESP_INFO   *resp_info;
  } MVLAS_JINIT_CTRL;
```

jinit_req_info

The operation-specific structure described below is used by the client in issuing an InitializeJournal request. It is received by the server when an InitializeJournal indication is received.

```
struct jinit_req_info
  {
  OBJECT_NAME       jou_name;
  ST_BOOLEAN        limit_spec_pres;
  MMS_BTOD          limit_time;
  ST_BOOLEAN        limit_entry_pres;
  ST_INT            limit_entry_len;
  ST_UCHAR          *limit_entry;
  SD_END_STRUCT
  };
typedef struct jinit_req_info JINIT_REQ_INFO;
```

`jou_name`	This structure of type **`OBJECT_NAME`** contains the name of the journal to be initialized.	
`limit_spec_pres`	**`SD_FALSE`**.	Do NOT include **`limit_time`** or **`limit_entry`** in PDU. All Journal Entries will be cleared.
	`SD_TRUE`	Include at least **`limit_time`** in the PDU. Examine **`limit_entry_pres`** to determine whether to include **`limit_entry`** in the PDU.
`limit_time`	This structure of type **`MMS_BTOD`** specifies the time limit used to determine which Journal Entries are to be initialized. Only those Journal Entries that are older than the specified time will be initialized.	
`limit_entry_pres`	**`SD_FALSE`**. Do NOT include **`limit_entry`** in PDU. Journal Entries cleared will be based on **`limit_time`** only.	
	`SD_TRUE`. Include **`limit_entry`** in the PDU.	
`limit_entry_len`	This is the length, in bytes, of the data pointed to by **`limit_entry`**.	
`limit_entry`	This pointer to the Limiting Entry Specifier contains an entry identifier that is an octet string of no more than eight octets (bytes). It is used to resolve multiple entries that have the same occurrence time. The form of the entry specifier is dependent on the particular VMD. This contains the Journal and contains an octet string used to specify unique multiple journal entries that have the same time entry.	

jinit_resp_info

The operation-specific data structure described below is used by the server in issuing an InitializeJournal response. It is received by the client when an InitializeJournal confirm is received.

```
struct jinit_resp_info
  {
  ST_UINT32  del_entries;
  };
typedef struct jinit_resp_info JINIT_RESP_INFO;
```

`del_entries` This indicates the number of journal entries that were deleted as a successful result of the InitializeJournal service request.

InitializeJournal Functions

u_mvl_jinit_ind

Usage: This is a user defined function called when a InitializeJournal indication is received. The user must examine the request parameters contained in the **`MVL_IND_PEND`** structure, do whatever is necessary to process the request, fill in the response parameters in the **`MVL_IND_PEND`** structure, and then call **`mplas_jinit_resp`** to send the response (or **`mplas_err_resp`** to send an error response).

Function Prototype: `ST_VOID u_mvl_jinit_ind (MVL_IND_PEND *ind_pend);`

Parameters:

`ind_pend` This is the same parameter that is passed to all user defined Indication functions. It contains a union of request and/or response parameters that is used for several different services. The request parameters are set by MVL before calling this function. The response parameters must be set by the user before calling the response function (i.e., **`mplas_jinit_resp`**). The parameters to be used for this service are as follows:

Request parameters: `ind_pend->u.jinit.req_info`
See **`JINIT_REQ_INFO`** for more information.

Response parameters: `ind_pend->u.jinit.resp_info`
See **`JINIT_RESP_INFO`** for more information.

Return Value: `ST_VOID`

mplas_jinit_resp

Usage: This function encodes and sends the Response for a previously received InitializeJournal indication. The Response parameters in the **`MVL_IND_PEND`** structure must be filled in before this function is called. The (**`MVL_IND_PEND *`**) argument passed to this function must be the same as the (**`MVL_IND_PEND *`**) argument passed to the user defined function **`u_mvl_jinit_ind`** when the indication was received.

Function Prototype: `ST_VOID mplas_jinit_resp (MVL_IND_PEND *ind_pend);`

Parameters:

`ind_pend` This is the same parameter that is passed to all user defined Indication functions. It contains a union of request and/or response parameters that is used for several different services. The request parameters are set by MVL before calling this function. The response parameters must be set by the user before calling the response function (i.e., **`mplas_jinit_resp`**). The parameters to be used for this service are as follows:

Request parameters: `ind_pend->u.jinit.req_info`
See **`JINIT_REQ_INFO`** for more information.

Response parameters: `ind_pend->u.jinit.resp_info`
See **`JINIT_RESP_INFO`** for more information.

Return Value: `ST_VOID`

ReadJournal Service

This service is used by the client to request that a server retrieve information out of a specified Journal object, and return this information to the client. If the entire Journal object contents cannot be returned, the client may specify various filters that can be used. The contents of the Journal object is not affected by this service.

ReadJournal Data Structures

The following is the ReadJournal Indication Control Structure:

```
typedef struct
  {
  JREAD_REQ_INFO    *req_info;
  JREAD_RESP_INFO   *resp_info;
/* Variable size. User or mvlas_* must alloc.  */
  } MVLAS_JREAD_CTRL;
```

jread_req_info

The operation-specific structure described below is used by the client in issuing a ReadJournal request. It is received by the server when a ReadJournal indication is received.

```
struct jread_req_info
  {
  OBJECT_NAME       jou_name;
  ST_BOOLEAN        range_start_pres;
  ST_INT16          start_tag;
  MMS_BTOD          start_time;
  ST_INT            start_entry_len;
  ST_UCHAR          *start_entry;
  ST_BOOLEAN        range_stop_pres;
  ST_INT16          stop_tag;
  MMS_BTOD          end_time;
  ST_INT32          num_of_entries;
  ST_BOOLEAN        list_of_var_pres;
  ST_INT            num_of_var;
  ST_BOOLEAN        sa_entry_pres;
  MMS_BTOD          time_spec;
  ST_INT            entry_spec_len;
  ST_UCHAR          *entry_spec;
/*ST_CHAR           *list_of_var [num_of_var]; */
  SD_END_STRUCT
  };
typedef struct jread_req_info JREAD_REQ_INFO;
```

`jou_name`	This structure of type **`OBJECT_NAME`** contains the name of the journal to read.
`range_start_pres`	**`SD_FALSE`**. Do not include **`start_tag`**, **`start_time`**, **`start_entry_len`** or **`start_entry`** in the PDU. **`SD_TRUE`**. Include **`start_tag`**, **`start_time`**, **`start_entry_len`** and **`start_entry`** in the PDU.
`start_tag`	**0** Read Journal Entries that are younger than **`start_time`**. **1** Read Journal Entries after the first entry that matches **`start_entry`**.
`start_time`	This structure of type **`MMS_BTOD`** contains the time to start reading the Journal Entries.
`start_entry_len`	This is the length, in bytes, of the data pointed to by **`start_entry`**.
`start_entry`	This is a pointer to the entry identifier after which to start the read. This data contains an entry identifier, an octet string of no more than 8 octets (bytes), specific to the VMD. It contains the journal and is used to specify unique multiple journal entries having the same time entry.

range_stop_pres	**SD_FALSE**. Do not include **end_time** or **num_of_entries** in the PDU. **SD_TRUE**. Include **end_time** or **num_of_entries** in the PDU as specified by **stop_tag**.
stop_tag	**0** Use **end_time**. **1** Use **num_of_entries**.
end_time	This structure of type **MMS_BTOD** contains the end time. Do not read any entries younger than the specified time.
num_of_entries	This contains the number of entries to read. Read only the specified number of entries regardless of the end time.
list_of_var_pres	**SD_FALSE**. Do NOT include the **list_of_var** field in the PDU. **SD_TRUE**. Include the **list_of_var** field in the PDU.
num_of_var	This indicates the number of variable tags in the **list_of_var** array.
sa_entry_pres	**SD_FALSE**. Do NOT include **time_spec** or **entry_spec** in the PDU. This tells the remote node to begin the ReadJournal response with the first entry matching the start and stop specifications described above. **SD_TRUE** Include **time_spec** and **entry_spec** in the PDU. These specify where the remote node should begin its ReadJournal response for later requests when the entire list requested could not be returned in a single request. Use only if this is a subsequent ReadJournal request after a response has indicated **more_follows**.
time_spec	This structure of type **MMS_BTOD** specifies the entry time to start after for chained requests. This is used in subsequent ReadJournal requests if the entire list of journal entries could not be returned in the first request. Use only if this is a subsequent ReadJournal request after a response has indicated **more_follows**.
entry_spec_len	This is the length, in bytes, of the data pointed to by **entry_spec**.
entry_spec	This specifies the entry identifier after which to start the read. This data contains an entry identifier. This is an octet string of no more than eight octets (bytes) specific to the VMD that contains the journal. It is used to specify unique multiple journal entries having the same entry time. Use only if this is a later ReadJournal request after a response has indicated **more_follows**.
list_of_var	This specifies the variable tags (names) for which the journal entries are to be read. Only those journal entries containing these specified variables will be returned.

Note: *When allocating a structure of type **JREAD_REQ_INFO**, enough memory must be allocated to hold the list of variables member (**list_of_var**) of this structure and the variable tags themselves pointed to by **list_of_var**. The following C language statement can be used to allocate the memory needed by this structure. However, this will not allocate the memory to hold the actual variable tags themselves, only the pointers to the variable tags contained in **list_of_var**.*

```
info = (JREAD_REQ_INFO *) chk_malloc(sizeof(JREAD_REQ_INFO) + (num_of_var *
          sizeof(ST_CHAR *)));
```

jread_resp_info

The operation-specific data structure described below is used by the server in issuing a ReadJournal response. The client receives it when a ReadJournal confirm is received.

```
struct jread_resp_info
  {
  ST_INT            num_of_jou_entry;
  ST_BOOLEAN        more_follows;
/*JOURNAL_ENTRY     list_of_jou_entry [num_of_jou_entry];   */
  SD_END_STRUCT
  };
typedef struct jread_resp_info JREAD_RESP_INFO;
```

`num_of_jou_entry`	This indicates the number of Journal Entries in this Journal.
`more_follows`	**`SD_TRUE`**. There are more Journal Entries available.
	`SD_FALSE`. This is the end of the Journal Entries.
`list_of_jou_entry`	This array of structures of type **`JOURNAL_ENTRY`** contains information regarding each Journal Entry in the response or confirm.

Note: *When allocating a data structure of type **`JREAD_RESP_INFO`**, enough memory must be allocated to hold the information for the array of structures containing the Journal Entry list in the **`list_of_jou_entry[]`** member of this structure. The following C statement can be used:*

```
info = (JREAD_RESP_INFO *) chk_malloc(sizeof(JREAD_RESP_INFO)+ num_of_jou_entry
          * sizeof(JOURNAL_ENTRY);
```

ReadJournal Functions

u_mvl_jread_ind

Usage: This is a user defined function called when a ReadJournal indication is received. The user must examine the request parameters contained in the **`MVL_IND_PEND`** structure, do whatever is necessary to process the request, and then call **`mplas_jread_resp`** or **`mvlas_jread_resp`** to send the response (or **`mplas_err_resp`** to send an error response).

Function Prototype: `ST_VOID u_mvl_jread_ind (MVL_IND_PEND *ind_pend);`

Parameters:

`ind_pend` This is the same parameter that is passed to all user defined Indication functions. It contains a union of request and/or response parameters that is used for several different services. The request parameters are set by MVL before calling this function. The response parameters must be set by the user before calling the response function (i.e., **`mvlas_jread_resp`** or **`mplas_jread_resp`**). The parameters to be used for this service are as follows:

Request parameters: `ind_pend->u.jread.req_info`
See **`JREAD_REQ_INFO`** for more information.

Response parameters: `ind_pend->u.jread.resp_info`
See **`JREAD_RESP_INFO`** for more information.

Return Value: `ST_VOID`

mplas_jread_resp

Usage: This function encodes and sends the Response for a previously received ReadJournal indication. The Response parameters in the **`MVL_IND_PEND`** structure must be filled in before this function is called. The (**`MVL_IND_PEND *`**) argument passed to this function must be the same as the (**`MVL_IND_PEND *`**) argument passed to the user defined function **`u_mvl_jread_ind`** when the indication was received.

Function Prototype: `ST_VOID mplas_jread_resp (MVL_IND_PEND *ind_pend);`

Parameters:

`ind_pend` This is the same parameter that is passed to all user defined Indication functions. It contains a union of request and/or response parameters that is used for several different services. The request parameters are set by MVL before calling this function. The response parameters must be set by the user before calling the response function (i.e., **`mvlas_jread_resp`** or **`mplas_jread_resp`**). The parameters to be used for this service are as follows:

Request parameters: `ind_pend->u.jread.req_info`
See **`JREAD_REQ_INFO`** for more information.

Response parameters: `ind_pend->u.jread.resp_info`
See **`JREAD_RESP_INFO`** for more information.

Return Value: `ST_VOID`

mvlas_jread_resp

Usage: This is a Virtual Machine response function for handling a previously received ReadJournal indication. It completely processes the indication, fills in the response parameters in the **`MVL_IND_PEND`** structure, and then sends the response by calling **`mplas_jread_resp`**. The (**`MVL_IND_PEND *`**) argument passed to this function must be the same as the (**`MVL_IND_PEND *`**) argument passed to the user defined function **`u_mvl_jread_ind`** when the indication was received.

Function Prototype: `ST_VOID mvlas_jread_resp (MVL_IND_PEND *ind_pend);`

Parameters:

`ind_pend` This is the same parameter that is passed to all user defined Indication functions. It contains a union of request and/or response parameters that is used for several different services. The request parameters are set by MVL before calling this function. The response parameters must be set by the user before calling the response function (i.e., **`mvlas_jread_resp`** or **`mplas_jread_resp`**). The parameters to be used for this service are as follows:

Request parameters: `ind_pend->u.jread.req_info`
See **`JREAD_REQ_INFO`** for more information.

Response parameters: `ind_pend->u.jread.resp_info`
See **`JREAD_RESP_INFO`** for more information.

Return Value: `ST_VOID`

ReportJournalStatus Service

This service is used to determine the number of entries in a Journal object.

ReportJournalStatus Data Structures

The following is the ReportJournalStatus Indication Control Structure:

```
typedef struct
  {
  JSTAT_REQ_INFO    *req_info;
  JSTAT_RESP_INFO   *resp_info;
  } MVLAS_JSTAT_CTRL;
```

jstat_req_info

The operation-specific structure described below is used by the client in issuing a ReportJournalStatus request. It is received by the server when a ReportJournalStatus indication is received.

```
struct jstat_req_info
  {
  OBJECT_NAME       jou_name;
  };
typedef struct jstat_req_info JSTAT_REQ_INFO;
```

`jou_name`	This structure of type **`OBJECT_NAME`** contains the name of the Journal for which the status is to be obtained.

jstat_resp_info

The operation-specific data structure described below is used by the server in issuing a ReportJournalStatus response. It is received by the client when a ReportJournalStatus confirm is received.

```
struct jstat_resp_info
  {
  ST_UINT32         cur_entries;
  ST_BOOLEAN        mms_deletable;
  SD_END_STRUCT
  };
typedef struct jstat_resp_info JSTAT_RESP_INFO;
```

`cur_entries`	This indicates the number of current Journal Entries in this Journal.
`mms_deletable`	**`SD_FALSE`**. This Journal is NOT deletable using a service request. **`SD_TRUE`**. This Journal is deletable using a service request.

ReadJournalStatus Functions

u_mvl_jstat_ind

Usage: This is a user defined function called when a ReadJournalStatus indication is received. The user must examine the request parameters contained in the **MVL_IND_PEND** structure, do whatever is necessary to process the request, fill in the response parameters in the **MVL_IND_PEND** structure, and then call **mplas_jstat_resp** to send the response (or **mplas_err_resp** to send an error response).

Function Prototype: `ST_VOID u_mvl_jstat_ind (MVL_IND_PEND *ind_pend);`

Parameters:

`ind_pend` This is the same parameter that is passed to all user defined Indication functions. It contains a union of request and/or response parameters that is used for several different services. The request parameters are set by MVL before calling this function. The response parameters must be set by the user before calling the response function (i.e., **mplas_jstat_resp**). The parameters to be used for this service are as follows:

Request parameters: `ind_pend->u.jstat.req_info`
See **JSTAT_REQ_INFO** for more information.

Response parameters: `ind_pend->u.jstat.resp_info`
See **JSTAT_RESP_INFO** for more information.

Return Value: `ST_VOID`

mplas_jstat_resp

Usage: This function encodes and sends the Response for a previously received ReadJournalStatus indication. The Response parameters in the **MVL_IND_PEND** structure must be filled in before this function is called. The (**MVL_IND_PEND ***) argument passed to this function must be the same as the (**MVL_IND_PEND ***) argument passed to the user defined function **u_mvl_jstat_ind** when the indication was received.

Function Prototype: `ST_VOID mplas_jstat_resp (MVL_IND_PEND *ind_pend);`

Parameters:

`ind_pend` This is the same parameter that is passed to all user defined Indication functions. It contains a union of request and/or response parameters that is used for several different services. The request parameters are set by MVL before calling this function. The response parameters must be set by the user before calling the response function (i.e., **mplas_jstat_resp**). The parameters to be used for this service are as follows:

Request parameters: `ind_pend->u.jstat.req_info`
See **JSTAT_REQ_INFO** for more information.

Response parameters: `ind_pend->u.jstat.resp_info`
See **JSTAT_RESP_INFO** for more information.

Return Value: `ST_VOID`

ObtainFile Service

A MMS client uses this service to tell the VMD to obtain a file. When a VMD receives an ObtainFile request it would issue FileOpen, FileRead(s) and FileClose service requests to the client application that issued the ObtainFile request. The client would then have to support the server functions of the FileOpen, FileRead, and FileClose services.

ObtainFile Data Structures

The following is the ObtainFile Indication Control Structure:

```
typedef struct
  {
  ST_CHAR    srcfilename [MAX_FILE_NAME+1];
  ST_CHAR    destfilename [MAX_FILE_NAME+1];
  } MVLAS_OBTFILE_CTRL;
```

`srcfilename`	Name of the source file.
`destfilename`	Name of the destination file.

ObtainFile Functions

u_mvl_obtfile_ind

Usage: This is a user defined function called when an ObtainFile indication is received. The user must examine the request parameters contained in the **`MVL_IND_PEND`** structure, do whatever is necessary to process the request, and then call **`mplas_obtfile_resp`** or **`mvlas_obtfile_resp`** to send the response (or **`mplas_err_resp`** to send an error response). The application is responsible for issuing all the FileOpen, FileRead, and FileClose requests necessary to obtain the file before sending the ObtainFile response. **`mvlas_obtfile_resp`** takes care of the file transfer state machine and sending the response automatically.

Function Prototype: `ST_VOID u_mvl_obtfile_ind (MVL_IND_PEND *ind_pend);`

Parameters:

`ind_pend` This is the same parameter that is passed to all user defined Indication functions. It contains a union of request and/or response parameters that is used for several different services. The request parameters are set by MVL before calling this function. The parameters to be used for this service are as follows:

Request parameters: `ind_pend->u.optfile.srcfilename`
`ind_pend->u.optfile.destfilename`

Response parameters: NONE

Return Value: `ST_VOID`

mplas_obtfile_resp

Usage: This function encodes and sends the Response for a previously received ObtainFile indication. The (**MVL_IND_PEND ***) argument passed to this function must be the same as the (**MVL_IND_PEND ***) argument passed to the user defined function **u_mvl_obtfile_ind** when the indication was received.

Function Prototype: `ST_VOID mplas_obtfile_resp (MVL_IND_PEND *ind_pend);`

Parameters:

`ind_pend` This is the same parameter that is passed to all user defined Indication functions. It contains a union of request and/or response parameters that is used for several different services. The request parameters are set by MVL before calling this function. The parameters to be used for this service are as follows:

Request parameters: `ind_pend->u.optfile.srcfilename`
`ind_pend->u.optfile.destfilename`

Response parameters: NONE

Return Value: `ST_VOID`

mvlas_obtfile_resp

Usage: This function allows the user to respond to an ObtainFile indication without actually having to obtain the remote file directly, and without having to interact with the operating system to obtain the file. This function takes care of all the PDUs and operating system calls necessary to implement the ObtainFile.

Function Prototype: `ST_VOID mvlas_obtfile_resp (MVL_IND_PEND *ind_pend);`

Parameters:

`ind_pend` This is the same parameter that is passed to all user defined Indication functions. It contains a union of request and/or response parameters that is used for several different services. The request parameters are set by MVL before calling this function. The parameters to be used for this service are as follows:

Request parameters: `ind_pend->u.optfile.srcfilename`
`ind_pend->u.optfile.destfilename`

Response parameters: NONE

Return Value: `ST_VOID`

FileRename Service

This service is used to rename a file on the VMD.

FileRename Data Structures

The following is the FileRename Indication Control Structure:

```
typedef struct
  {
  ST_CHAR    curfilename [MAX_FILE_NAME+1];
  ST_CHAR    newfilename [MAX_FILE_NAME+1];
  } MVLAS_FRENAME_CTRL;
```

`curfilename` This is a NULL terminated ASCII string that represents the current file name.

`newfilename` This is a NULL terminated ASCII string that represents the new file name.

FileRename Functions

u_mvl_frename_ind

Usage: This is a user defined function called when a FileRename indication is received. The user must examine the request parameters contained in the **`MVL_IND_PEND`** structure, do whatever is necessary to process the request, fill in the response parameters in the **`MVL_IND_PEND`** structure, and then call **`mplas_frename_resp`** to send the response (or **`mplas_err_resp`** to send an error response).

Function Prototype: `ST_VOID u_mvl_frename_ind (MVL_IND_PEND *ind_pend);`

Parameters:

`ind_pend` This is the same parameter that is passed to all user defined Indication functions. It contains a union of request and/or response parameters that is used for several different services. The request parameters are set by MVL before calling this function. The parameters to be used for this service are as follows:

Request parameters: `ind_pend->u.frename.curfilename`
`ind_pend->u. frename.newfilename`

Response parameters: NONE

Return Value: `ST_VOID`

mplas_frename_resp

Usage: This function encodes and sends the Response for a previously received FileRename indication. There are no Response parameters in the **`MVL_IND_PEND`** structure to be filled in before this function is called but the application is responsible for renaming the file in the file store. The (**`MVL_IND_PEND *`**) argument passed to this function must be the same as the (**`MVL_IND_PEND *`**) argument passed to the user defined function **`u_mvl_frename_ind`** when the indication was received.

Function Prototype: `ST_VOID mplas_frename_resp (MVL_IND_PEND *ind);`

Parameters:

`ind_pend` This is the same parameter that is passed to all user defined Indication functions. It contains a union of request and/or response parameters that is used for several different services. The request parameters are set by MVL before calling this function. The parameters to be used for this service are as follows:

Request parameters: `ind_pend->u.frename.curfilename`
`ind_pend->u.frename.newfilename`

Response parameters: NONE

Return Value: `ST_VOID`

FileOpen Service

This service is used to identify a file to be read, and to establish the open state for the **F**ile **R**ead **S**tate **M**achine (**FRSM**). The client specifies the name of the file, and an initial read position.

FileOpen Data Structures

The following is the FileOpen Indication Control Structure:

```
typedef struct
  {
  ST_CHAR           filename [MAX_FILE_NAME+1];
  ST_INT            init_pos;
  FOPEN_RESP_INFO   *resp_info;
  } MVLAS_FOPEN_CTRL;
```

fopen_resp_info

The operation specific data structures described below are used by the server in issuing a FileOpen response. It is received by the client when a FileOpen confirm is received.

```
struct fopen_resp_info
  {
  ST_INT32   frsmid;
  FILE_ATTR  ent;
  };
typedef struct fopen_resp_info FOPEN_RESP_INFO;
```

`frsmid` This contains the **F**ile **R**ead **S**tate **M**achine **ID** assigned to this file. All future FileRead requests should reference this number.

`ent` This structure of type **`FILE_ATTR`** contains the file attributes for this file. See below for a description of this structure.

AND:

```
struct file_attr
  {
  ST_UINT32  fsize;
  ST_BOOLEAN mtimpres;
  time_t mtime;
  };
typedef struct file_attr FILE_ATTR;
```

`fsize` This contains the size of the file, in bytes.

`mtimpres` **`SD_FALSE`**. **`mtime`** is not included in the PDU.

`SD_TRUE`. **`mtime`** is included in the PDU.

`mtime` This contains the time, in the C language format, **`time_t`**, that the file was last modified.

FileOpen Functions

u_mvl_fopen_ind

Usage: This is a user defined function called when a FileOpen indication is received. The user must examine the request parameters contained in the **MVL_IND_PEND** structure, do whatever is necessary to process the request, fill in the response parameters in the **MVL_IND_PEND** structure, and then call **mplas_fopen_resp** to send the response (or **mplas_err_resp** to send an error response).

Function Prototype: `ST_VOID u_mvl_fopen_ind (MVL_IND_PEND *ind_pend);`

Parameters:

`ind_pend` This is the same parameter that is passed to all user defined Indication functions. It contains a union of request and/or response parameters that is used for several different services. The request parameters are set by MVL before calling this function. The response parameters must be set by the user before calling the response function (i.e., **mplas_fopen_resp**). The parameters to be used for this service are as follows:

Request parameters:	`ind_pend->u.fopen.filename`	Name of file to open.
	`ind_pend->u.fopen.init_pos`	Initial position in file.
Response parameters:	`ind_pend->u.fopen.resp_info` See **FOPEN_RESP_INFO** for more information.	

Return Value: `ST_VOID`

mplas_fopen_resp

Usage: This function encodes and sends the Response for a previously received FileOpen indication. The Response parameters in the **MVL_IND_PEND** structure must be filled in before this function is called. The (**MVL_IND_PEND ***) argument passed to this function must be the same as the (**MVL_IND_PEND ***) argument passed to the user defined function **u_mvl_fopen_ind** when the indication was received.

Function Prototype: `ST_VOID mplas_fopen_resp (MVL_IND_PEND *ind_pend);`

Parameters:

`ind_pend` This is the same parameter that is passed to all user defined Indication functions. It contains a union of request and/or response parameters that is used for several different services. The request parameters are set by MVL before calling this function. The response parameters must be set by the user before calling the response function (i.e., **mplas_fopen_resp**). The parameters to be used for this service are as follows:

Request parameters:	`ind_pend->u.fopen.filename`	Name of file to open.
	`ind_pend->u.fopen.init_pos`	Initial position in file.
Response parameters:	`ind_pend->u.fopen.resp_info` See **FOPEN_RESP_INFO** for more information.	

Return Value: `ST_VOID`

FileRead Service

This service is used to transfer all or part of the contents of an open file from a server to a client. It transfers data sequentially from the file position maintained by the **F**ile **R**ead **S**tate **M**achine (**FRSM**), and going to the end of the file.

FileRead Data Structures

The following is the FileRead Indication Control Structure:

```
typedef struct
  {
  FREAD_REQ_INFO    *req_info;
  ST_INT            max_size;
  FREAD_RESP_INFO   *resp_info;
  } MVLAS_FREAD_CTRL;
```

fread_req_info

The operation specific data structure described below is used by the client in issuing the FileRead request. It is received by the server when a FileRead indication is received.

```
struct fread_req_info
  {
  ST_INT32          frsmid;
  };
typedef struct fread_req_info FREAD_REQ_INFO;
```

`frsmid`	This contains the **F**ile **R**ead **S**tate **M**achine **ID** (**FRSMID**) of the file to be read. The FRSMID is obtained when the file is opened.

fread_resp_info

The operation specific data structure described below is used by the server in issuing a FileRead response. It is received by the client when a FileRead confirm is received.

```
struct fread_resp_info
  {
  ST_INT            fd_len;
  ST_UCHAR          *filedata;
  ST_BOOLEAN        more_follows;
  SD_END_STRUCT
  };
typedef struct fread_resp_info FREAD_RESP_INFO;
```

`fd_len`	This contains the length of file data, in bytes, pointed to by filedata.
`filedata`	This is a pointer to the file data to be read.
`more_follows`	**`SD_TRUE`**. Not the end of the file. More FileRead requests are necessary to complete the file transfer. This is the default. **`SD_FALSE`**. End-Of-File. No more data available.

FileRead Functions

u_mvl_fread_ind

Usage: This is a user defined function called when a FileRead indication is received. The user must examine the request parameters contained in the **MVL_IND_PEND** structure, do whatever is necessary to process the request, fill in the response parameters in the **MVL_IND_PEND** structure, and then call **mplas_fread_resp** to send the response (or **mplas_err_resp** to send an error response).

Function Prototype: `ST_VOID u_mvl_fread_ind (MVL_IND_PEND *ind_pend);`

Parameters:

`ind_pend` This is the same parameter that is passed to all user defined Indication functions. It contains a union of request and/or response parameters that is used for several different services. The request parameters are set by MVL before calling this function. The response parameters must be set by the user before calling the response function (i.e., **mplas_fread_resp**). The parameters to be used for this service are as follows:

Request parameters: `ind_pend->u.fread.req_info`
See **FREAD_REQ_INFO** for more information.

Response parameters: `ind_pend->u.fread.resp_info`
See **FREAD_RESP_INFO** for more information.

Return Value: `ST_VOID`

mplas_fread_resp

Usage: This function encodes and sends the Response for a previously received FileRead indication. The Response parameters in the **MVL_IND_PEND** structure must be filled in before this function is called. The (**MVL_IND_PEND ***) argument passed to this function must be the same as the (**MVL_IND_PEND ***) argument passed to the user defined function **u_mvl_fread_ind** when the indication was received.

Function Prototype: `ST_VOID mplas_fread_resp (MVL_IND_PEND *ind_pend);`

Parameters:

`ind_pend` This is the same parameter that is passed to all user defined Indication functions. It contains a union of request and/or response parameters that is used for several different services. The request parameters are set by MVL before calling this function. The response parameters must be set by the user before calling the response function (i.e., **mplas_fread_resp**). The parameters to be used for this service are as follows:

Request parameters: `ind_pend->u.fread.req_info`
See **FREAD_REQ_INFO** for more information.

Response parameters: `ind_pend->u.fread.resp_info`
See **FREAD_RESP_INFO** for more information.

Return Value: `ST_VOID`

FileClose Service

This service is used to request that a specified file be closed, and all resources associated with the file transfer be released. A successful FileClose causes the corresponding **F**ile **R**ead **S**tate **M**achine (**FRSM**) to be deleted, and the FRSMID is available for reassignment.

FileClose Data Structures

The following is the FileClose Indication Control Structure:

```
typedef struct
  {
  FCLOSE_REQ_INFO   *req_info;
  } MVLAS_FCLOSE_CTRL;
```

fclose_req_info

The operation specific data structure described below is used by the client in issuing the FileClose request. It is received by the server when a FileClose indication is received.

```
struct fclose_req_info
  {
  ST_INT32          frsmid;
  };
typedef struct fclose_req_info FCLOSE_REQ_INFO;
```

`frsmid`	This contains the **F**ile **R**ead **S**tate **M**achine **ID** (FRSMID) obtained when the file was opened using a call to **`mp_fopen`**.

FileClose Functions

u_mvl_fclose_ind

Usage: This is a user defined function called when a FileClose indication is received. The user must examine the request parameters contained in the **MVL_IND_PEND** structure, do whatever is necessary to process the request, fill in the response parameters in the **MVL_IND_PEND** structure, and then call **mplas_fclose_resp** to send the response (or **mplas_err_resp** to send an error response).

Function Prototype: `ST_VOID u_mvl_fclose_ind (MVL_IND_PEND *ind_pend);`

Parameters:

`ind_pend` This is the same parameter that is passed to all user defined Indication functions. It contains a union of request and/or response parameters that is used for several different services. The request parameters are set by MVL before calling this function. The parameters to be used for this service are as follows:

Request parameters: `ind_pend->u.fclose.req_info`
See **FCLOSE_REQ_INFO** for more information.

Response parameters: NONE

Return Value: `ST_VOID`

mplas_fclose_resp

Usage: This function encodes and sends the Response for a previously received FileClose indication. The (**MVL_IND_PEND ***) argument passed to this function must be the same as the (**MVL_IND_PEND ***) argument passed to the user defined function **u_mvl_fclose_ind** when the indication was received.

Function Prototype: `ST_VOID mplas_fclose_resp (MVL_IND_PEND *ind_pend);`

Parameters:

`ind_pend` This is the same parameter that is passed to all user defined Indication functions. It contains a union of request and/or response parameters that is used for several different services. The request parameters are set by MVL before calling this function. The parameters to be used for this service are as follows:

Request parameters: `ind_pend->u.fclose.req_info`
See **FCLOSE_REQ_INFO** for more information.

Response parameters: NONE

Return Value: `ST_VOID`

FileDelete Service

This service is used by a client to delete a file from the virtual filestore of a server.

FileDelete Data Structures

The following is the FileDelete Indication Control Structure:

```
typedef struct
  {
  ST_CHAR    filename [MAX_FILE_NAME+1];
  } MVLAS_FDELETE_CTRL;
```

FileDelete Functions

u_mvl_fdelete_ind

Usage: This is a user defined function called when a FileDelete indication is received. The user must examine the request parameters contained in the **`MVL_IND_PEND`** structure, do whatever is necessary to process the request, and then call **`mplas_fdelete_resp`** to send the response (or **`mplas_err_resp`** to send an error response).

Function Prototype: `ST_VOID u_mvl_fdelete_ind (MVL_IND_PEND *ind_pend);`

Parameters:

`ind_pend` This is the same parameter that is passed to all user defined Indication functions. It contains a union of request and/or response parameters that is used for several different services. The request parameters are set by MVL before calling this function. The parameters to be used for this service are as follows:

Request parameters:	`ind_pend->u.fdelete.filename`	Name of file to open.
Response parameters:	NONE	

Return Value: `ST_VOID`

mplas_fdelete_resp

Usage: This function encodes and sends the Response for a previously received FileDelete indication. The (**`MVL_IND_PEND *`**) argument passed to this function must be the same as the (**`MVL_IND_PEND *`**) argument passed to the user defined function **`u_mvl_fdelete_ind`** when the indication was received.

Function Prototype: `ST_VOID mplas_fdelete_resp (MVL_IND_PEND *ind_pend);`

Parameters:

`ind_pend` This is the same parameter that is passed to all user defined Indication functions. It contains a union of request and/or response parameters that is used for several different services. The request parameters are set by MVL before calling this function. The parameters to be used for this service are as follows:

Request parameters:	`ind_pend->u.fdelete.filename`	Name of file to open.
Response parameters:	NONE	

Return Value: `ST_VOID`

FileDirectory Service

This service is used by a client to obtain the name and attributes of a file or group of files in the server's filestore. The attributes returned by this service are the same as those returned in the FileOpen service.

FileDirectory Data Structures

The following is the FileDirectory Indication Control Structure:

```
typedef struct
  {
  ST_CHAR                  fs_filename[MAX_FILE_NAME+1];
  ST_CHAR                  ca_filename[MAX_FILE_NAME+1];
  MVL_FDIR_RESP_INFO       *resp_info;
  } MVLAS_FDIR_CTRL;
```

MVL_DIR_ENT

```
typedef struct
  {
  ST_UINT32  fsize;                    /* file size (# bytes)          */
  ST_BOOLEAN mtimpres;                 /* last modified time present   */
  time_t     mtime;                    /* last modified time           */
  ST_CHAR    filename [MAX_FILE_NAME+1];
  } MVL_DIR_ENT;
```

MVL_FDIR_RESP_INFO

```
typedef struct
  {
  ST_INT            num_dir_ent;       /* number of directory entries   */
  ST_BOOLEAN        more_follows;      /* more dir entries follow       */
                                       /* default: SD_FALSE             */
  MVL_DIR_ENT       *dir_ent;          /* ptr to array of dir entries   */
  } MVL_FDIR_RESP_INFO;
```

FileDirectory Functions

u_mvl_fdir_ind

Usage: This is a user defined function called when a FileDirectory indication is received. The user must examine the request parameters contained in the **`MVL_IND_PEND`** structure, do whatever is necessary to process the request, fill in the response parameters in the **`MVL_IND_PEND`** structure, and then call **`mplas_fdir_resp`** to send the response (or **`mplas_err_resp`** to send an error response).

Function Prototype: `ST_VOID u_mvl_fdir_ind (MVL_IND_PEND *ind_pend);`

Parameters:

`ind_pend` This is the same parameter that is passed to all user defined Indication functions. It contains a union of request and/or response parameters that is used for several different services. The request parameters are set by MVL before calling this function. The response parameters must be set by the user before calling the response function (i.e., **`mplas_fdir_resp`**). The parameters to be used for this service are as follows:

Request parameters:	`ind_pend->u.fdir.fs_filename`	File Specification.
	`ind_pend->u.fdir.ca_filename`	File name to continue after.
Response parameters:	`ind_pend->u.fdir.resp_info` See **`MVL_FDIR_RESP_INFO`** for more information.	

Return Value: `ST_VOID`

mplas_fdir_resp

Usage: This function encodes and sends the Response for a previously received FileDirectory indication. The Response parameters in the **`MVL_IND_PEND`** structure must be filled in before this function is called. The (**`MVL_IND_PEND *`**) argument passed to this function must be the same as the (**`MVL_IND_PEND *`**) argument passed to the user defined function **`u_mvl_fdir_ind`** when the indication was received.

Function Prototype: `ST_VOID mplas_fdir_resp (MVL_IND_PEND *ind_pend);`

Parameters:

`ind_pend` This is the same parameter that is passed to all user defined Indication functions. It contains a union of request and/or response parameters that is used for several different services. The request parameters are set by MVL before calling this function. The response parameters must be set by the user before calling the response function (i.e., **`mplas_fdir_resp`**). The parameters to be used for this service are as follows:

Request parameters:	`ind_pend->u.fdir.fs_filename`	File Specification.
	`ind_pend->u.fdir.ca_filename`	File name to continue after.
Response parameters:	`ind_pend->u.fdir.resp_info` See **`MVL_FDIR_RESP_INFO`** for more information.	

Return Value: `ST_VOID`

MVL MMS Client Facilities

MVL provides high-level client functions for many MMS services. Both synchronous (with timeout) and asynchronous versions of all client services are available. Please see the MVL sample client source code in **client.c** for more detail.

MVL has an outstanding request control system that keeps track of requests and matches up responses. The maximum number of outstanding request control elements that it will allocate is set by the global variable **`mvl_max_req_pend`** (default value is 10).

Note: *This is a list based system designed to handle multiple outstanding requests.*

Also, note that MVL allows the user to configure the remote node's variables, variable lists, and domains as well. This information is then used to handle Information Reports, and pre/post processing is available for these objects as well.

If the user application makes use of asynchronous client request functions (such as **`mvla_read_variables`**), the **`u_req_done`** callback function from the **`MMS_REQ_PEND`** structure will be invoked (if not **`NULL`**) from within the **`mvl_comm_serve`** function.

General Data Structure

MVL_REQ_PEND

The Client uses this structure for tracking any outstanding request. It contains all the information needed to match up a response with a request. When a response is received, it also contains all the necessary Response information.

```
typedef struct mvl_req_pend
  {
  DBL_LNK           l;                          /* For linked list         */
  ST_UINT32         invoke_id;
  time_t            request_time;
  MVL_NET_INFO      *net_info;                  /* Who it was sent to      */
  ST_INT            op;                         /* MMS Opcode              */
  union
    {
    struct
      {
      MVL_READ_RESP_PARSE_INFO   *parse_info;
      ST_INT                     num_data;
      } rd;
    struct
      {
      MVL_WRITE_REQ_INFO         *w_info;
      ST_INT                     num_data;
      } wr;
    struct
      {
      IDENT_RESP_INFO            *resp_info;
      } ident;
    struct
      {
      INIT_INFO                  *resp_info;
      } init;
```

```
    struct
      {
      FOPEN_RESP_INFO            *resp_info;
      } fopen;
    struct
      {
      FREAD_RESP_INFO            *resp_info;
      } fread;
    struct
      {
      MVL_FDIR_RESP_INFO         *resp_info;
      } fdir;
    struct
      {
      JINIT_RESP_INFO            *resp_info;
      } jinit;
    struct
      {
      JSTAT_RESP_INFO            *resp_info;
      } jstat;
    struct
      {
      MVL_JREAD_RESP_INFO        *resp_info;
      } jread;
    struct
      {
      GETVLIST_RESP_INFO         *resp_info;
      } getvlist;
    struct
      {
      DELVLIST_RESP_INFO         *resp_info;
      } delvlist;
    } u;
  MVL_COMM_EVENT    *event;      /* Save event ptr to free later          */
  ST_BOOLEAN        done;
  ST_RET            result;      /* SD_SUCCESS or error code              */
                                 /* User done function for async functions */
  ST_VOID           (*u_req_done) (struct mvl_req_pend *req);

  ST_VOID           *v;          /* For MVL user's use                     */
  } MVL_REQ_PEND;
```

Client Support Functions

The following functions are used for all Client services.

mvl_free_req_ctrl

Usage: Every Client request function allocates a **`MVL_REQ_PEND`** structure for tracking the request and to hold the response information. This function must be called to free the structure sometime after the response is received and processed.

***IMPORTANT*:** After this function is called, the structure contents are no longer valid. The contents of the structure MUST NOT be used after this function is called. This applies to any pointers to response information (i.e., **`req_pend->u.ident.resp_info`**). If some of the response information is still needed after calling this function, it must be copied to a safe location before calling this function.

Function Prototype: `ST_VOID mvl_free_req_ctrl (MVL_REQ_PEND *req_pend);`

Parameters:

`req_pend` Pointer to request tracking structure returned from a call to a Client request function (i.e., If **`&req_pend`** was passed as the **`req_out`** parameter to the Client request function then **`req_pend`** should be passed to this function).

Return Value: `ST_VOID`

u_mvl_check_timeout

Usage: This function pointer may be set to point to a user-defined function called repetitively by synchronous MVL client request functions while waiting for a confirm. If this function returns **`SD_TRUE`**, the synchronous request function will stop waiting for the confirm, and will return immediately with an error code. The user-defined function can be used to perform other applications processing, but cannot be used to perform additional MMS-*Lite* communications activity.

Function Pointer Global Variable:

```
extern ST_BOOLEAN (*u_mvl_check_timeout)
                                (ST_VOID);
```

Parameters: NONE

Return Value: `ST_BOOLEAN`

	`SD_TRUE`	Stop waiting for Confirm.
	`SD_FALSE`	Continue waiting for Confirm.

Client Request Functions Overview

Each Client service is asynchronous. The response may be received any time after the request is sent. The response is received by one of the periodic calls to **`mvl_comm_serve`**.

Asynchronous Request Functions

All of the asynchronous request functions begin with the "**`mvla_`**" prefix. The asynchronous functions return immediately. To determine when the response has been received, the user can check the value of **`done`** in the **`MVL_REQ_PEND`** structure. If it is **`SD_FALSE`**, the response has NOT been received yet. Alternatively, the user can set the function pointer **`u_req_done`** in the **`MVL_REQ_PEND`** structure to point to a function that will be called when the response is received. In either case, when the response is received, the user must check the value of **`result`** in the **`MVL_REQ_PEND`** structure to determine if the request was successful or not.

Common Arguments to Request Functions

The following arguments are passed to all Client request functions.

`net_info` This argument indicates where to send the request (i.e., which network connection to use).

`req_out` Every request function includes an argument **`MVL_REQ_PEND *req_out`**. The user must pass the address of a variable of type (**`MVL_REQ_PEND *`**) to the function. The function allocates a **`MVL_REQ_PEND`** structure and sets the user's variable to the address of the allocated structure. For example, if the user has a variable **`MVL_REQ_PEND *req_pend`**, they should pass **`&req_pend`** to the function and it will set the value of **`req_pend`**. The user must free the structure sometime after the response is received and processed by calling **`mvl_free_req_ctrl`** (**`req_pend`**).

Variable Access Support Structures

This section illustrates the various data structures used for variable access at the PPI level in MMS-EASE. Normally the virtual machine provides a simpler mechanism for dealing with variables. These structures will not need to be used for most of the virtual machine functions. Regardless, in order to understand fully this section, you must be familiar with the MMS specification and how it describes variables. The various structure members are described by using descriptions corresponding to the MMS specification.

Address Structures

UNCONST_ADDR
VAR_ACC_ADDR

These structures are used to describe the address of variables. Addresses are always implementation-specific and are not standardized. There are three forms that MMS addresses can take on, but their meanings and use are left for the various vendors of MMS hardware and software to specify.

```
struct unconst_addr
  {
  ST_INT        unc_len;
  ST_UCHAR     *unc_ptr;
  SD_END_STRUCT
  };
typedef struct unconst_addr UNCONST_ADDR;
```

unc_len	This is the length of the unconstrained address pointed to by **unc_ptr**.
unc_ptr	This pointer to the unconstrained address is stored as an OctetString.

An unconstrained address is just as the name implies: the address can contain any information at all. An unconstrained address is used when a relative (numeric) or symbolic address is not suitable.

```
struct var_acc_addr
  {
  ST_INT16 addr_tag;
  union
    {
    ST_UINT32              num_addr;
    ST_CHAR                *sym_addr;
    UNCONST_ADDR           unc_addr;
    } addr;
  };
typedef struct var_acc_addr VAR_ACC_ADDR;
```

addr_tag — This is a tag indicating the type of address:

NUM_ADDR	This represents the numeric address. Used with the **num_addr** member of **addr**.
SYM_ADDR	This represents the symbolic address. Use the **sym_addr** member of **addr**.
UNCON_ADDR	This represents the unconstrained address. Use **unc_addr** member of **addr**.

num_addr	This contains the numeric address of the variable. Used if **addr_tag = NUM_ADDR**.
sym_addr	This pointer to the symbolic address of the variable is used if **addr_tag = SYM_ADDR**.
unc_addr	This structure of type **UNCONST_ADDR** contains the unconstrained address of the variable. Used if **addr_tag = UNCON_ADDR**.

Variable Access Result Structures

The following describes the data structures used to represent the results of a variable access including success or failure information and a variable's data.

VAR_ACC_DATA

This structure is used to hold the data that was the result of a successful variable access.

```
struct var_acc_data
  {
  ST_INT len;
  ST_UCHAR *data;
  };
typedef struct var_acc_data VAR_ACC_DATA;
```

`len` This is the length, in bytes, of the data pointed to by **`data`**.

`data` This is a pointer to the ASN.1 encoded data resulting from the successful variable access. The data contained in this buffer must conform to the ASN.1 encoding rules. It also must conform to the following ASN.1 syntax as specified by ISO 9506 (the MMS IS specification). This is explained below.

```
Data ::= CHOICE {
context tag 0 is reserved for access_result
   array             [1]  IMPLICIT SEQUENCE OF Data,
   structure   [2]  IMPLICIT SEQUENCE OF Data,
   boolean           [3]  IMPLICIT BOOLEAN,
   bit-string  [4]  IMPLICIT BIT STRING,
   integer           [5]  IMPLICIT INTEGER,
   unsigned          [6]  IMPLICIT INTEGER,
   floating-point     [7]  IMPLICIT FloatingPoint,
   real              [8]  IMPLICIT REAL,
   octet-string       [9]  IMPLICIT OCTETSTRING,
   visible-string     [10] IMPLICIT VisibleString,
   generalized-time [11] IMPLICIT GeneralizedTime,
   binary-time        [12] IMPLICIT TimeOfDay,
   bcd        [13] IMPLICIT INTEGER,
   booleanArray       [14] IMPLICIT BITSTRING,
   objid             [15] IMPLICIT OBJECT IDENTIFIER,
   utc-time         [17] IMPLICIT UtcTime
}
```

Refer to the MMS IS specification. The data found in this element must conform to a particular type found in the type specification for this variable. See the following description of **`VAR_ACC_TSPEC`**. The virtual machine should be used for variable access since it automatically performs the translation of this data into the appropriate local variables. This eliminates having to deal with the above.

ACCESS_RESULT

This structure specifies the results of a data access. It may contain the actual data resulting from a Read, the data to be written during a Write, or error information regarding the failure of the variable access.

```
struct access_result
  {
  ST_INT16          acc_rslt_tag;
  ST_INT16          failure;
  VAR_ACC_DATA      va_data;
  };
typedef struct access_result ACCESS_RESULT;
```

`acc_rslt_tag` This is a tag indicating the result of the variable access:

`ACC_RSLT_FAILURE` Access failed. See **`failure`** member below.
`ACC_RSLT_SUCCESS` Access Succeeded. See **`va_data`** member below.

`failure` This indicates the reason for failure of the access. Used if **`acc_rslt_tag = ACC_RSLT_FAILURE`**.

`ARE_OBJ_INVALIDATED`. An attempted access references a defined object that has an undefined reference attribute. This represents a permanent error for access attempts to that object.

`ARE_HW_FAULT`. An attempt to access the variable has failed due to a hardware fault.

`ARE_TEMP_UNAVAIL`. The requested variable is temporarily unavailable for the requested access.

`ARE_OBJ_ACCESS_DENIED`. The MMS Client has insufficient privilege to request this operation.

`ARE_OBJ_UNDEFINED`. The object with the desired name does not exist.

`ARE_INVAL_ADDR`. Reference to the unnamed variable object's specified address is invalid because the specified format is incorrect or is out of range.

ARE_TYPE_UNSUPPORTED. An inappropriate or unsupported type is specified for a variable.

ARE_TYPE_INCONSISTENT. A type is specified that is inconsistent with the service or referenced object.

ARE_OBJ_ATTR_INCONSISTENT. The object is specified with inconsistent attributes.

ARE_OBJ_ACC_UNSUPPORTED. The variable is not defined to allow requested access.

ARE_OBJ_NONEXISTENT. The variable is non-existent.

va_data — This structure of type **VAR_ACC_DATA** contains the data for this variable if **acc_rslt_tag = ACC_RSLT_SUCCESS**.

Variable Type Structure

VAR_ACC_TSPEC

This structure is used to define the type of a particular variable. This type definition is the same as what is used by the virtual machine.

```
struct var_acc_tspec
  {
  ST_INT          len;
  ST_UCHAR       *data;
  };
typedef struct var_acc_tspec VAR_ACC_TSPEC;
```

len — This is the length, in bytes, of the data pointed to by **data**.

data — This is a pointer to the ASN.1 encoded type definition for the variable being accessed. The data contained in this buffer must conform to the ASN.1 encoding rules and to the ASN.1 syntax as specified by the MMS specification.

Described Variable Structure

VARIABLE_DESCR

This structure is used when access is made to a described variable. Described variable access specifies the type and address of the variable each timze that variable is accessed. This is different from named variables where access can be made on the name alone, and other unnamed variables where access can be made on address alone.

```
struct variable_descr
  {
  VAR_ACC_ADDR      address;
  VAR_ACC_TSPEC     type;
  };
typedef struct variable_descr VARIABLE_DESCR;
```

address — This structure of type **VAR_ACC_ADDR** contains this variable's address.

type — This structure of type **VAR_ACC_TSPEC** contains this variable's type definition.

Variable Specification Structure

VARIABLE_SPEC

This structure is used to hold a variable specification. When this structure and all its sub-structures are filled out completely, it specifies the variable being accessed. It contains information about whether the variable is named, addressed, or described. It is used during PPI variable access operations. Please note that this structure calls out the use of several previously documented structures.

```
struct variable_spec
  {
  ST_INT16                var_spec_tag;
  union
    {
    OBJECT_NAME           name;
    VAR_ACC_ADDR          address;
    VARIABLE_DESCR        var_descr;
    SCATTERED_ACCESS      sa_descr;
    } vs;
  };
typedef struct variable_spec VARIABLE_SPEC;
```

`var_spec_tag` This is a value indicating the type of variable:

`VA_SPEC_NAMED`. Access variable by name only.

`VA_SPEC_ADDRESSED`. Access variable by address only.

`VA_SPEC_DESCRIBED`. Access variable by address and type.

`VA_SPEC_SCATTERED`. Scattered Access.

`VA_SPEC_INVALIDATED`. Invalidated Variable. Used during responses only when the specification of the variable is to be returned in the response to a variable access request. An invalidated variable object occurs when access to a scattered access object is attempted where one or more of the underlying objects (defined as a part of the accessed scattered access object) has been deleted.

`name` This structure of type **`OBJECT_NAME`** contains the name of the variable when the variable is to be accessed by name only. Used **`if var_spec_tag = VA_SPEC_NAMED`**.

`address` This structure of type **`VAR_ACC_ADDR`** contains the address of the variable when the variable is to be accessed by addressed only. Used if **`var_spec_tag = VA_SPEC_ADDRESSED`**.

`var_descr` This structure of type **`VARIABLE_DESCR`** contains the description of the variable if the variable is to be accessed by specifying the address and type. Used if **`var_spec_tag = VA_SPEC_DESCRIBED`**.

`sa_descr` This structure of type **`SCATTERED_ACCESS`** contains the scattered access description of the variable. Used if **`var_spec_tag = VA_SPEC_SCATTERED`**.

Variable List Structure

VARIABLE_LIST

This structure is used to specify a variable and any alternative access on that variable in the list of variables to be accessed.

```
struct variable_list
  {
  VARIABLE_SPEC     var_spec;
  ST_BOOLEAN        alt_access_pres;
  ALTERNATE_ACCESS  alt_access;
  };
typedef struct variable_list VARIABLE_LIST;
```

`var_spec` This structure of type **`VARIABLE_SPEC`** contains the variable specification for this element of the variable list.

alt_access_pres	**SD_TRUE**. **alt_access** is present. **SD_FALSE**. **alt_access** is not present.
alt_access	If used, this structure of type **ALTERNATE_ACCESS** contains the alternate access description. See the next page for more information on this structure.

Variable Access Specification Structure

VAR_ACC_SPEC

This structure is used to specify everything needed for a particular variable access operation. It is used in nearly all the operation-specific data structures for the variable access services of the PPI. Nearly all previously documented PPI variable access support structures are used in one way or another inside the sub-structures of this master structure.

```
struct var_acc_spec
  {
  ST_INT16                var_acc_tag;
  struct object_name      vl_name;
  ST_INT                  num_of_variables;
/*struct variable_list    var_list [num_of_variables];            */
  SD_END_STRUCT
  };
typedef struct var_acc_spec VAR_ACC_SPEC;
```

var_acc_tag	This is a value indicating the type of access. Options are: **VAR_ACC_VARLIST** List of Variables **VAR_ACC_NAMEDLIST** Named Variable List
vl_name	This structure of type **OBJECT_NAME** contains the name of this Named Variable List. Used if **var_acc_tag = VAR_ACC_NAMELIST**.
num_of_variables	This indicates the number of variables in this list if this access is for a list of of variables. Used if **var_acc_tag = VAR_ACC_VARLIST**.

Note: *To read a single variable, you would read a list of one (e.g.,* ***num_of_variables = 1****).*

var_list	This array of structures of type **VARIABLE_LIST** contains the variable descriptions for the list of variables to be accessed. Used if **var_acc_tag = VAR_ACC_VARLIST**.

Note: *When allocating Operation-Specific data structures containing a structure of type* ***VAR_ACC_SPEC****, make sure that sufficient memory is allocated to hold the list of variables contained in* ***var_list****.*

Scattered Access Structure

SCATTERED_ACCESS

This structure is used to hold the ASN.1 encoding for scattered access. Scattered access is currently not supported by the VMI. However, for those knowledgeable in ASN.1 and MMS, this option can be used by encoding the appropriate ASN.1 into this structure when using the PPI. Please refer to the MMS specification for more detail on the ASN.1 representation of the scattered access object.

```
struct scattered_access
  {
  ST_INT     len;
  ST_UCHAR   *data;
  };
typedef struct scattered_access SCATTERED_ACCESS;
```

len	This is the length, in bytes, of the scattered access description pointed to by **data**.
data	This is a pointer to data that contains the scattered access description.

Alternate Access Structure

ALTERNATE_ACCESS

This structure is used to hold the ASN.1 encoding for alternate access. Alternate access is supported for the VMI and it is recommended to use the VMI instead of the PPI. However, for those knowledgeable in ASN.1 and MMS, this option can be used by encoding the appropriate ASN.1 into this structure when using the PPI. Please refer to the MMS specification for more detail on the ASN.1 representation of alternate access objects.

An alternate Access description specifies an alternative view of a variable's type (the abstract syntax and the range of possible values of a real variable). It can be used to alter the perceived abstract syntax (using MMS services) or to restrict access to a subset of a range of possible values (partial access), or both.

```
struct alternate_access
  {
  ST_INT      len;
  ST_UCHAR    *data;
  };
typedef struct alternate_access ALTERNATE_ACCESS;
```

`len`	This is the length, in bytes, of the alternate access description pointed to by **`data`**.
`data`	This is a pointer to data that contains the alternate access description.

Read Service

This service is used by a Client application to request that a Server VMD return the value of one or more variables defined at the VMD.

Read Data Structures

read_req_info

The operation-specific data structure described below is used by the Client in issuing the variable read request function. It is received by the Server when a variable read indication function is received.

```
struct read_req_info
  {
  ST_BOOLEAN        spec_in_result;
  VAR_ACC_SPEC      va_spec;
/*VARIABLE_LIST     var_list [va_spec.num_of_variables];                 */
/*SD_END_STRUCT                               */
  };
typedef struct read_req_info READ_REQ_INFO;
```

`spec_in_result`	**`SD_FALSE`**. Do not include the access specification in the response. This is the default. **`SD_TRUE`**. Include the access specification (the type and address information) in the response.
`va_spec`	This structure of type **`VAR_ACC_SPEC`** contains the variable access specification.
`var_list`	This array of structures of type **`VARIABLE_LIST`** includes a list of variables to be read.

Note: *FOR REQUEST ONLY, when allocating a data structure of type* ***`READ_REQ_INFO`****, enough memory must be allocated to hold the information for the* ***`var_list`*** *member of the structure. The following C statement can be used:*

```
info = (READ_REQ_INFO *) chk_malloc(sizeof(READ_REQ_INFO) +
             (num_of_variables * sizeof(VARIABLE_LIST)));
```

MVL_READ_RESP_PARSE_INFO

This structure contains information for processing the Read Response Data.

```
typedef struct mvl_read_resp_parse_info
  {
  ST_RET     result;      /* SD_SUCCESS for OK                           */
  ST_VOID    *dest;      /* Where data is to be put                     */
  ST_INT     type_id;     /* type of variable                            */
  ST_INT     descr_arr;   /* for described read of array                 */
  ST_INT     arr_size;    /* number of elements in described array.      */
/* Used only if descr_arr != SD_FALSE                                    */
  } MVL_READ_RESP_PARSE_INFO;
```

Read Functions

mvla_read_variables

Usage: This function performs an asynchronous Read request.

Function Prototype:

```
ST_RET mvla_read_variables (MVL_NET_INFO              *net_info,
                            READ_REQ_INFO             *read_info,
                            ST_INT                    num_data,
                            MVL_READ_RESP_PARSE_INFO  *parse_info,
                            MVL_REQ_PEND              **req_out);
```

Parameters:

`net_info`	Network connection information
`read_info`	Read request information
`num_data`	Number of variables to read
`parse_info`	Pointer to array of structures, one for each variable. Each structure contains the information necessary for processing the response data for a single variable. The parameters **`dest`**, **`type_id`**, **`descr_arr`**, and optionally **`arr_size`** must be set before calling this function. The **`result`** parameter is set by MVL when the response is received.
`req_out`	See the description of **`req_out`** on page 152.

Response Data: If **`i`** is the index into the list of variables, then:

`parse_info [i].result`	Indicates if the variable was read successfully.
`parse_info [i].dest`	Contains the value of the variable.

Return Value: `ST_RET` `SD_SUCCESS` If request sent successfully, or error code.

Note: If the return value is **`SD_SUCCESS`**, you still need to wait for the response. See *Asynchronous Request Functions* on page 152 for information on how to wait.

Write Service

This service is used for a Client application to request that the Server VMD replace the contents of one or more variables at a remote node with supplied values.

Write Data Structures

write_req_info

This operation-specific data structure described below is used by the Client in issuing a variable write request. It is received by the Server when a variable write indication is received.

```
struct write_req_info
  {
  ST_INT             num_of_data;
  VAR_ACC_DATA       *va_data;
  VAR_ACC_SPEC       va_spec;
/*VARIABLE_LIST      var_list [va_spec.num_of_variables];                  */
/*VAR_ACC_DATA       var_data_list [num_of_data];                          */
  };
typedef struct write_req_info WRITE_REQ_INFO;
```

`num_of_data`	This indicates the number of structures in the array of structures pointed to by **`va_data`**.
`va_data`	This pointer to **`var_data_list`** is an array of structures of type **`VAR_ACC_DATA`** containing the data to be written.
`va_spec`	This structure of type **`VAR_ACC_SPEC`** contains the variable access specification information.
`var_list`	This array of structures of type **`VARIABLE_LIST`** contains the variable specifications for the list of variables to be written.
`var_data_list`	This array of structures of type **`VAR_ACC_DATA`** contains the data to be written into the specified variables.

Note: *FOR REQUEST ONLY, when allocating a data structure of type **`WRITE_REQ_INFO`**, enough memory must be allocated to hold the information for the **`var_data_list`** and **`var_list`** members of the structure. For example, the following C statement can be used for a list of variables.*

```
info = (WRITE_REQ_INFO *) chk_malloc(sizeof (WRITE_REQ_INFO) +
             (num_of_variables * sizeof(VARIABLE_LIST)) + (num_of_data *
             sizeof(VAR_ACC_DATA)));
```

MVL_WRITE_REQ_INFO

This structure contains request and response parameters. See the function description for how they are used.

```
typedef struct mvl_write_req_info
  {
  ST_RET             result;              /* SD_SUCCESS for OK              */
  ST_VOID            *local_data;         /* Source of local data           */
  ST_INT             local_data_size;     /* Size of local data             */
  ST_INT             type_id;             /* type of variable               */
  ST_BOOLEAN         arr;                 /* SD_TRUE if type is array and # */
  ST_INT             num_el;              /* the elements needs to be set   */
  } MVL_WRITE_REQ_INFO;
```

Write Functions

mvla_write_variables

Usage: This function performs an asynchronous Write request.

Function Prototype:

```
ST_RET mvla_write_variables (MVL_NET_INFO          *net_info,
                             WRITE_REQ_INFO        *write_info,
                             ST_INT                num_data,
                             MVL_WRITE_REQ_INFO    *w_info,
                             MVL_REQ_PEND          *req_out);
```

Parameters:

`net_info`	Network connection information.
`write_info`	Write request information.
`num_data`	Number of variables to write.
`w_info`	Pointer to array of structures, one for each variable. Each structure contains the information about the data to be written. The parameters **`local_data`**, **`local_data_size`**, **`type_id`**, **`arr`**, and optionally **`num_el`** must be set before calling this function. The **`result`** parameter is set by MVL when the response is received.
`req_out`	See the description of **`req_out`** on page 152.

Response Data: If **i** is the index into the list of variables, then:

`w_info [i].result`	Indicates if the variable was written successfully.

Return Value:

`ST_RET`	`SD_SUCCESS`	If request sent successfully, or error code.

Note: If the return value is **`SD_SUCCESS`**, you still need to wait for the response. See *Asynchronous Request Functions* on page 152 for information on how to wait.

InformationReport Service

This service is used to inform the other node of the value of one or more specified variables, as read by the issuing node.

InformationReport Functions

u_mvl_info_rpt_ind

Usage: This is a user defined function called when an InformationReport indication is received. The user may examine the data referenced by the **`MVL_COMM_EVENT`** structure. Because this is an unconfirmed service, there is no response to send.

Function Prototype:

```
ST_VOID u_mvl_info_rpt_ind (MVL_COMM_EVENT *event);
```

Parameters:

`event` This is a pointer to a structure containing all the information from the request. The structure **`MVL_COMM_EVENT`** is defined in **mvl_defs.h**.

Return Value: `ST_VOID`

Note: An example of this user defined function can be found in **client.c**. It may be convenient to make use of the **`mvl_info_data_to_local`** function to convert the data to local format.

mvl_info_data_to_local

Usage: This function converts InformationReport data to local format. The user must provide an array of pointers to Variable Association structures (**`MVL_VAR_ASSOC`**). If you are processing both received IEC 61850 and UCA reports, you must call this function more than once with different values in the **`num_va`** argument. This is documented in the client code, **cli_rpt.c**.

Function Prototype:

```
ST_VOID mvl_info_data_to_local (MVL_COMM_EVENT      *event,
                                ST_INT              num_va,
                                MVL_VAR_ASSOC       **info_va);
```

Parameters:

`event` This is a pointer to a structure containing all the information from the request. The structure **`MVL_COMM_EVENT`** is defined in **mvl_defs.h**.

`num_va` Number of variables to convert to local format.

`info_va` Pointer to array of pointers to Variable Association structures. These structures must contain valid data type information (i.e., **`info_va[i].type_id`**) to be used in the conversion to local format, and valid pointers to data buffers (i.e., **`info_va[i].data`**) where the data can be stored.

Return Value: `ST_VOID`

Status Service

This service is used to allow a client to determine the general condition or status of a server node.

Status Data Structures

STATUS_REQ_INFO

See page 84 for more information.

STATUS_RESP_INFO

See page 84 for more information.

Status Functions

mvla_status

Usage: This function performs an asynchronous Status request.

Function Prototype:

```
ST_RET mvla_status (MVL_NET_INFO        *net_info,
                    STATUS_REQ_INFO     *req_info,
                    MVL_REQ_PEND        **req_out);
```

Parameters:

`net_info`	Network connection information.
`req_info`	Status request information.
`req_out`	See the description of **`req_out`** on page 152.

Response Data: The response data is in the **`status`** parameter of the **`MVL_REQ_PEND`** structure. It may be referenced by the following statement (assuming **`&req_pend`** was passed as the **`req_out`** argument):

```
STATUS_RESP_INFO *resp_info = req_pend->u.status.resp_info;
```

Return Value: `ST_RET` `SD_SUCCESS` If request sent successfully, or error code.

Note: If the return value is **`SD_SUCCESS`**, you still need to wait for the response. See *Asynchronous Request Functions* on page 152 for information on how to wait.

Identify Service

This service is used to obtain identifying information such a vendor name, and model number, from a responding node.

Identify Data Structures

ident_resp_info

See page 86 for more information.

Identify Functions

mvla_identify

Usage: This function performs an asynchronous Identify request.

Function Prototype:

```
ST_RET mvla_identify (MVL_NET_INFO      *net_info,
                      MVL_REQ_PEND      **req_out);
```

`net_info`	Network connection information.
`req_out`	See the description of **`req_out`** on page 152.

Response Data: The response data is in the **`ident`** parameter of the **`MVL_REQ_PEND`** structure. It may be referenced by the following statement (assuming **`&req_pend`** was passed as the **`req_out`** argument):

```
IDENT_RESP_INFO *ident = req_pend->u.ident.resp_info;
```

Return Value: `ST_RET` `SD_SUCCESS` If request sent successfully, or error code.

Note: If the return value is **`SD_SUCCESS`**, you still need to wait for the response. See *Asynchronous Request Functions* on page 152 for information on how to wait.

GetNameList Service

This service is used to request that a responding node return a list (or part of a list) of object names that exist at the VMD.

GetNameList Data Structures

NAMELIST_REQ_INFO

See page 88 for more information.

NAMELIST_RESP_INFO

See page 89 for more information.

GetNameList Functions

mvla_getnam

Usage: This function performs an asynchronous GetNameList request.

Function Prototype:

```
ST_RET mvla_getnam (MVL_NET_INFO          *net_info,
                    NAMELIST_REQ_INFO     *req_info,
                    MVL_REQ_PEND          **req_out);
```

Parameters:

`net_info`	Network connection information.
`req_info`	GetNameList request information.
`req_out`	See the description of **`req_out`** on page 152.

Response Data: The response data is in the **`getnam`** parameter of the **`MVL_REQ_PEND`** structure. It may be referenced by the following statement (assuming **`&req_pend`** was passed as the **`req_out`** argument):

```
NAMELIST_RESP_INFO *resp_info = req_pend->u.getnam.resp_info;
```

Return Value: `ST_RET SD_SUCCESS` If request sent successfully, or error code.

Note: If the return value is **`SD_SUCCESS`**, you still need to wait for the response. See *Asynchronous Request Functions* on page 152 for information on how to wait.

FileOpen Service

This service is used to identify a file to be read, and to establish the open state for the **F**ile **R**ead **S**tate **M**achine (**FRSM**). The client specifies the name of the file, and an initial read position.

FileOpen Data Structures

fopen_resp_info

See page 140 for more information.

FileOpen Functions

mvla_fopen

Usage: This function performs an asynchronous FileOpen request.

Function Prototype:

```
ST_RET mvla_fopen (MVL_NET_INFO  *net_info,
                   ST_CHAR *filename,
                   ST_UINT32 init_pos,
                   MVL_REQ_PEND **req_out);
```

Parameters:

`net_info`	Network connection information.
`filename`	Name of file to open (NULL-terminated string).
`init_pos`	Initial position in file to begin reading (i.e., number of bytes to skip).
`req_out`	See the description of **`req_out`** on page 152.

Response Data: The response data is in the **`fopen`** parameter of the **`MVL_REQ_PEND`** structure. It may be referenced by the following statement (assuming **`&req_pend`** was passed as the **`req_out`** argument):

```
FOPEN_RESP_INFO *resp_info = req_pend->u.fopen.resp_info;
```

Return Value: `ST_RET` `SD_SUCCESS` If request sent successfully, or error code.

Note: If the return value is **`SD_SUCCESS`**, you still need to wait for the response. See *Asynchronous Request Functions* on page 152 for information on how to wait.

FileRead Service

This service is used to transfer all or part of the contents of an open file from a server to a client. It transfers data sequentially from the file position maintained by the **F**ile **R**ead **S**tate **M**achine (**FRSM**), and going to the end of the file.

FileRead Data Structures

FREAD_REQ_INFO

See page 142 for more information.

FREAD_RESP_INFO

See page 142 for more information.

FileRead Functions

mvla_fread

Usage: This function performs an asynchronous FileRead request.

Function Prototype:

```
ST_RET mvla_fread (MVL_NET_INFO        *net_info,
                   FREAD_REQ_INFO      *req_info,
                   MVL_REQ_PEND        **req_out);
```

Parameters:

`net_info`	Network connection information.
`req_info`	FileRead request information.
`req_out`	See the description of **`req_out`** on page 152.

Response Data: The response data is in the **`fread`** parameter of the **`MVL_REQ_PEND`** structure. It may be referenced by the following statement (assuming **`&req_pend`** was passed as the **`req_out`** argument):

```
FREAD_RESP_INFO *resp_info = req_pend->u.fread.resp_info;
```

Return Value: `ST_RET SD_SUCCESS` If request sent successfully, or error code.

Note: If the return value is **`SD_SUCCESS`**, you still need to wait for the response. See *Asynchronous Request Functions* on page 152 for information on how to wait.

FileClose Service

This service is used to request that a specified file be closed, and all resources associated with the file transfer be released. A successful FileClose causes the corresponding **F**ile **R**ead **S**tate **M**achine (**FRSM**) to be deleted, and the FRSMID is available for reassignment.

FileClose Data Structures

FCLOSE_REQ_INFO

See page 144 for more information.

FileClose Functions

mvla_fclose

Usage: This function performs an asynchronous FileClose request.

Function Prototype:

```
ST_RET mvla_fclose (MVL_NET_INFO        *net_info,
                    FCLOSE_REQ_INFO     *req_info,
                    MVL_REQ_PEND        **req_out);
```

Parameters:

`net_info`	Network connection information.
`req_info`	FileClose request information.
`req_out`	See the description of **`req_out`** on page 152.

Return Value: `ST_RET` `SD_SUCCESS` If request sent successfully, or error code.

Note: If the return value is **`SD_SUCCESS`**, you still need to wait for the response. See *Asynchronous Request Functions* on page 152 for information on how to wait.

FileDirectory Service

This service is used by a client to obtain the name and attributes of a file, or group of files, in the server's filestore. The attributes returned by this service are the same as those returned in the FileOpen service.

FileDirectory Data Structures

MVL_DIR_ENT

This structure contains data for a single **FileDirectory** entry (i.e., a single file).

```
typedef struct
  {
  ST_UINT32   fsize;                      /* file size (# bytes)           */
  ST_BOOLEAN  mtimpres;                   /* last modified time present    */
  time_t      mtime;                      /* last modified time            */
  ST_CHAR     filename [MAX_FILE_NAME+1];
  } MVL_DIR_ENT;
```

MVL_FDIR_RESP_INFO

This structure contains information for processing the **FileDirectory** response data.

```
typedef struct
  {
  ST_INT            num_dir_ent;          /* number of directory entries   */
  ST_BOOLEAN        more_follows;         /* more dir entries follow       */
                                          /*   default: SD_FALSE           */
  MVL_DIR_ENT       *dir_ent;             /* ptr to array of dir entries   */
  } MVL_FDIR_RESP_INFO;
```

FileDirectory Functions

mvla_fdir

Usage: This function performs an asynchronous FileDirectory request.

Function Prototype:

```
ST_RET mvla_fdir (MVL_NET_INFO    *net_info,
                  ST_CHAR         *filespec,
                  ST_CHAR         *ca_filename,
                  MVL_REQ_PEND    **req_out);
```

Parameters:

`net_info`	Network connection information.
`filespec`	File specification for directory entries of interest (NULL-terminated string).
`ca_filename`	Name of file to continue after (NULL-terminated string).
`req_out`	See the description of **`req_out`** on page 152.

Response Data: The response data is in the **`fdir`** parameter of the **`MVL_REQ_PEND`** structure. It may be referenced by the following statement (assuming **`&req_pend`** was passed as the **`req_out`** argument):

```
MVL_FDIR_RESP_INFO *resp_info = req_pend->u.fdir.resp_info;
```

Return Value: `ST_RET` `SD_SUCCESS` If request sent successfully, or error code.

Note: If the return value is **`SD_SUCCESS`**, you still need to wait for the response. See *Asynchronous Request Functions* on page 152 for information on how to wait.

FileDelete Service

This service is used by a client to delete a file from the virtual filestore of a server.

FileDelete Functions

mvla_fdelete

Usage: This function performs an asynchronous FileDelete request.

Function Prototype:

```
ST_RET mvla_fdelete (MVL_NET_INFO      *net_info,
                     ST_CHAR           *filename,
                     MVL_REQ_PEND      **req_out);
```

Parameters:

`net_info`	Network connection information.
`filename`	Name of file to delete (NULL-terminated string).
`req_out`	See the description of **`req_out`** on page 152.

Return Value: `ST_RET` `SD_SUCCESS` If request sent successfully, or error code.

Note: If the return value is **`SD_SUCCESS`**, you still need to wait for the response. See *Asynchronous Request Functions* on page 152 for information on how to wait.

ObtainFile Service

This service is used by a Client application to cause the remote device to obtain a file from the local virtual file store.

ObtainFile Functions

mvla_optfile

Usage: This function performs an asynchronous ObtainFile request.

Function Prototype:

```
ST_RET mvla_obtfile (MVL_NET_INFO      *net_info,
                     ST_CHAR           *srcfilename,
                     ST_CHAR           *destfilename,
                     MVL_REQ_PEND      **req_out);
```

Parameters:

`net_info`	Network connection information.
`srcfilename`	This is a NULL terminated ASCII string of the source file name on the local device.
`destfilename`	This is a NULL terminated ASCII string of the destination file name on the remote device.
`req_info`	ObtainFile request information.

Return Value:	`ST_RET`	`SD_SUCCESS`	If request sent and response received successfully.
		`<> 0`	Error code.

FileGet Service

FileGet is not a true MMS service. Rather it is a MMS-*Lite* service that automatically generates MMS FileOpen, FileRead, and FileClose PDUs. The FileGet service allows a client to request that a specified file be copied from the virtual filestore of a server to the virtual filestore of the client. It will overwrite any existing file with the same name that is already present in the client's filestore. If the file transfer is interupted or an error occurs during file transfer, no destination file will be created.

FileGet Data Structures

```
typedef struct mvl_fget_req_info
  {
  ST_BOOLEAN        fget_done;
  ST_INT            fget_error;
  /* pointer to user's fget confirm function                              */
  ST_VOID           (*fget_cnf_ptr)(struct mvl_fget_req_info *state);
  ST_CHAR           srcfilename[MAX_FILE_NAME+1];
  ST_CHAR           destfilename[MAX_FILE_NAME+1];
  ST_VOID           *v;           /* For MVL user's use                   */
  /* The rest of this structure is not normally accessed by the user.     */
  char              tempfilename[L_tmpnam];
  FILE              *fp;
  ST_INT32          frsmid;
  ST_UINT32         fsize;
  } MVL_FGET_REQ_INFO;
```

FileGet Functions

mvla_fget

Usage: This is an asynchronous virtual machine function which allows the user to copy a file from a remote node's file system to the local file system. This can be done without having to generate and manage the individual requests, confirmations, and responses required by the MMS file operations or the operating system calls necessary to create the file locally.

Function Prototype:

```
ST_RET mvla_fget (MVL_NET_INFO         *net_info,
                  ST_CHAR              *srcfilename,
                  ST_CHAR              *destfilename,
                  MVL_FGET_REQ_INFO    *fget_req_info);
```

Parameters:

`net_info`	Network connection information.
`srcfilename`	This is a NULL terminated ASCII string of the source file name on the remote device.
`destfilename`	This is a NULL terminated ASCII string of the destination file name on the local device.
`fget_req_info`	This is a pointer to a pending service specific structure. Please refer to FileGet Data Structures for further information.

Return Value: `ST_RET`

`SD_SUCCESS`	If request sent and response received successfully
`<> 0`	Error code.

FileRename Service

This service is used by a Client application to Rename or move a file in a remote Virtual File Store.

FileRename Functions

mvla_frename

Usage: This function performs an asynchronous FileRename request.

Function Prototype:

```
ST_RET mvla_frename (MVL_NET_INFO *net_info,
                     ST_CHAR *curfilename,
                     ST_CHAR *newfilename,
                     MVL_REQ_PEND **req_out);
```

Parameters:

`net_info`	Network connection information.
`curfilename`	This is the NULL terminated ASCII string of the current file name in the remote virtual file store.
`newfilename`	This is the `NULL` terminated ASCII string of the new file name in the remote virtual file store.
`req_out`	See the description of **`req_out`** on page 152.

Return Value:	`ST_RET`	`SD_SUCCESS`	If request sent successfully.
		`<> 0`	Error code.

DefineNamedVariableList Service

This service is used by a Client application to request that a Server VMD create a NamedVariableList object. This allows access through a list of Named Variable objects, Unnamed Variable objects, or Scattered Access objects, or any combination.

DefineNamedVariableList Data Structures

DEFVLIST_REQ_INFO

See page 112 for more information.

DefineNamedVariableList Functions

mvla_defvlist

Usage: This function performs an asynchronous DefineNamedVariableList request.

Function Prototype:

```
ST_RET mvla_defvlist (MVL_NET_INFO          *net_info,
                      DEFVLIST_REQ_INFO     *req_info,
                      MVL_REQ_PEND          **req_out);
```

Parameters:

`net_info`	Network connection information.
`req_info`	DefineNamedVariableList request information.
`req_out`	See the description of **`req_out`** on page 152.

Return Value: `ST_RET SD_SUCCESS` If request sent successfully, or error code.

Note: If the return value is **`SD_SUCCESS`**, you still need to wait for the response. See *Asynchronous Request Functions* on page 152 for information on how to wait.

GetVariableAccessAttributes Service

This service is used to request that a VMD return the attributes of a Named Variable or an Unnamed Variable object defined at the VMD. Also, it can be used to request that a VMD return the derived type description of a Scattered Access object defined at the VMD.

GetVariableAccessAttributes Data Structures

GETVAR_REQ_INFO

See page 109 for more information.

GETVAR_RESP_INFO

See page 109 for more information.

GetVariableAccessAttributes Functions

mvla_getvar

Usage: This function performs an asynchronous GetVariableAccessAttributes request.

Function Prototype:

```
ST_RET mvla_getvar (MVL_NET_INFO       *net_info,
                    GETVAR_REQ_INFO    *req_info,
                    MVL_REQ_PEND       **req_out);
```

Parameters:

`net_info`	Network connection information.
`req_info`	GetVariableAccessAttributes request information.
`req_out`	See the description of **`req_out`** on page 152.

Response Data: The response data is in the **`getvar`** parameter of the **`MVL_REQ_PEND`** structure. It may be referenced by the following statement (assuming **`&req_pend`** was passed as the **`req_out`** argument):

```
GETVAR_RESP_INFO *resp_info = req_pend->u.getvar.resp_info;
```

Return Value: `ST_RET` `SD_SUCCESS` If request sent successfully, or error code.

Note: If the return value is **`SD_SUCCESS`**, you still need to wait for the response. See *Asynchronous Request Functions* on page 152 for information on how to wait.

GetNamedVariableListAttributes Service

This service is used by a Client application to request that a Server VMD return the attributes of a NamedVariableList object defined at the VMD.

GetNamedVariableListAttributes Data Structures

GETVLIST_REQ_INFO

See page 119 for more information.

GETVLIST_RESP_INFO

See page 119 for more information.

GetNamedVariableListAttributes Functions

mvla_getvlist

Usage: This function performs an asynchronous GetNamedVariableListAttributes request.

Function Prototype:

```
ST_RET mvla_getvlist (MVL_NET_INFO      *net_info,
                      GETVLIST_REQ_INFO *req_info,
                      MVL_REQ_PEND      **req_out);
```

Parameters:

`net_info`	Network connection information.
`req_info`	GetNamedVariableListAttributes request information.
`req_out`	See the description of **`req_out`** on page 152.

Response Data: The response data is in the **`getvlist`** parameter of the **`MVL_REQ_PEND`** structure. It may be referenced by the following statement (assuming **`&req_pend`** was passed as the **`req_out`** argument):

```
GETVLIST_RESP_INFO *resp_info = req_pend->u.getvlist.resp_info;
```

Return Value:	`ST_RET`	`SD_SUCCESS`	If request sent successfully. Otherwise, there will be an error code.
	Note:	If the return value is **`SD_SUCCESS`**, you still need to wait for the response. See *Asynchronous Request Functions* on page 152 for information on how to wait.	

GetDomainAttributes Service

This service is used to request that a Server return all of the attributes associated with a specific domain.

GetDomainAttributes Data Structures

GETDOM_REQ_INFO

See page 122 for more information.

GETDOM_RESP_INFO

See page 122 for more information.

GetDomainAttributes Functions

mvla_getdom

Usage: This function performs an asynchronous GetDomainAttributes request.

Function Prototype:

```
ST_RET mvla_getdom (MVL_NET_INFO        *net_info,
                    GETDOM_REQ_INFO     *req_info,
                    MVL_REQ_PEND        **req_out);
```

Parameters:

`net_info`	Network connection information.
`req_info`	GetDomainAttributes request information.
`req_out`	See the description of **`req_out`** on page 152.

Response Data: The response data is in the **`getdom`** parameter of the **`MVL_REQ_PEND`** structure. It may be referenced by the following statement (assuming **`&req_pend`** was passed as the **`req_out`** argument):

```
GETDOM_RESP_INFO *resp_info = req_pend->u.getdom.resp_info;
```

Return Value: `ST_RET` `SD_SUCCESS` If request sent successfully, or error code.

Note: If the return value is **`SD_SUCCESS`**, you still need to wait for the response. See *Asynchronous Request Functions* on page 152 for information on how to wait.

DeleteNamedVariableList Service

This service is used by a Client application to request that a Server VMD delete one or more NamedVariablesList objects at a VMD. These must have a MMS Deletable attribute equal to true.

DeleteNamedVariableList Data Structures

DELVLIST_REQ_INFO

See page 115 for more information.

DELVLIST_RESP_INFO

See page 116 for more information.

DeleteNamedVariableList Functions

mvla_delvlist

Usage: This function performs an asynchronous DeleteNamedVariableList request.

Function Prototype:

```
ST_RET mvla_delvlist (MVL_NET_INFO      *net_info,
                      DELVLIST_REQ_INFO *req_info,
                      MVL_REQ_PEND      **req_out);
```

Parameters:

`net_info`	Network connection information.
`req_info`	DeleteNamedVariableList request information.
`req_out`	See the description of **`req_out`** on page 152.

Response Data: The response data is in the **`delvlist`** parameter of the **`MVL_REQ_PEND`** structure. It may be referenced by the following statement (assuming **`&req_pend`** was passed as the **`req_out`** argument):

```
DELVLIST_RESP_INFO *resp_info = req_pend->u.delvlist.resp_info;
```

Return Value: `ST_RET` `SD_SUCCESS` If request sent successfully, or error code.

Note: If the return value is **`SD_SUCCESS`**, you still need to wait for the response. See *Asynchronous Request Functions* on page 152 for information on how to wait.

InitializeJournal Service

This service is used by the client to request that a server initialize all or part of an existing Journal object by removing all or some of the journal entries.

InitializeJournal Data Structures

JINIT_REQ_INFO

See page 126 for more information.

JINIT_RESP_INFO

See page 127 for more information.

InitializeJournal Functions

mvla_jinit

Usage: This function performs an asynchronous InitializeJournal request.

Function Prototype:

```
ST_RET mvla_jinit (MVL_NET_INFO        *net_info,
                   JINIT_REQ_INFO      *req_info,
                   MVL_REQ_PEND        **req_out);
```

Parameters:

`net_info`	Network connection information.
`req_info`	InitializeJournal request information.
`req_out`	See the description of **`req_out`** on page 152.

Response Data: The response data is in the **`jinit`** parameter of the **`MVL_REQ_PEND`** structure. It may be referenced by the following statement (assuming **`&req_pend`** was passed as the **`req_out`** argument):

```
JINIT_RESP_INFO *resp_info = req_pend->u.jinit.resp_info;
```

Return Value: `ST_RET` `SD_SUCCESS` If request sent successfully, or error code.

Note: If the return value is **`SD_SUCCESS`**, you still need to wait for the response. See *Asynchronous Request Functions* on page 152 for information on how to wait.

ReadJournal Service

This service is used by the client to request that a server retrieve information out of a specified Journal object and return this information to the client. If the entire Journal object contents cannot be returned, the client may specify various filters that can be used. The contents of the Journal object is not affected by this service.

ReadJournal Data Structures

JREAD_REQ_INFO

See page 129 for more information.

MVL_JOURNAL_ENTRY

```
typedef struct
  {
  ST_INT            entry_id_len;       /* Octet string ID, size 1-8     */
  ST_UCHAR          *entry_id;

  APP_REF           orig_app;
  MMS_BTOD          occur_time;         /* occurrence time               */

  ST_INT16          entry_form_tag;     /* entry form tag                */
                                        /*  2 : data                     */
                                        /*  3 : annotation               */
  union
    {
    struct                              /* entry form is DATA            */
     {
      ST_BOOLEAN    event_pres;         /* event present                 */
      OBJECT_NAME   evcon_name;         /* event condition name          */
      ST_INT16      cur_state;          /* current state                 */
                                        /*  0 : disabled                 */
                                        /*  1 : idle                     */
                                        /*  2 : active                   */
      ST_BOOLEAN    list_of_var_pres;   /* list of variables present     */
      ST_INT        num_of_var;         /* number of variables           */
      VAR_INFO      *list_of_var;       /* ptr to array                  */
      } data;
    ST_CHAR         *annotation;        /* pointer to annotation         */
    }ef;
  } MVL_JOURNAL_ENTRY;
```

MVL_JREAD_RESP_INFO

```
typedef struct
  {
  ST_INT                  num_of_jou_entry;   /* number of journal entries */
  ST_BOOLEAN              more_follows;       /* default = false           */
  MVL_CLI_JOURNAL_ENTRY   *jou_entry;         /* ptr to array of entries   */
  } MVL_JREAD_RESP_INFO;
```

ReadJournal Functions

mvla_jread

Usage: This function performs an asynchronous ReadJournal request.

Function Prototype:

```
ST_RET mvla_jread (MVL_NET_INFO        *net_info,
                   JREAD_REQ_INFO      *req_info,
                   MVL_REQ_PEND        **req_out);
```

Parameters:

`net_info`	Network connection information.
`req_info`	ReadJournal request information.
`req_out`	See the description of **`req_out`** on page 152.

Response Data: The response data is in the **`jread`** parameter of the **`MVL_REQ_PEND`** structure. It may be referenced by the following statement (assuming **`&req_pend`** was passed as the **`req_out`** argument):

```
MVL_JREAD_RESP_INFO *resp_info = req_pend->u.jread.resp_info;
```

Return Value: `ST_RET` `SD_SUCCESS` If request sent successfully, or error code.

Note: If the return value is **`SD_SUCCESS`**, you still need to wait for the response. See *Asynchronous Request Functions* on page 152 for information on how to wait.

ReportJournalStatus Service

This service is used to determine the number of entries in a Journal object.

ReportJournalStatus Data Structures

JSTAT_REQ_INFO

See page 134 for more information.

JSTAT_RESP_INFO

See page 134 for more information.

ReadJournalStatus Functions

mvla_jstat

Usage: This function performs an asynchronous ReportJournalStatus request.

Function Prototype:

```
ST_RET mvla_jstat (MVL_NET_INFO        *net_info,
                   JSTAT_REQ_INFO      *req_info,
                   MVL_REQ_PEND        **req_out);
```

Parameters:

`net_info`	Network connection information.
`req_info`	ReportJournalStatus request information.
`req_out`	See the description of **`req_out`** on page 152.

Response Data: The response data is in the **`jstat`** parameter of the **`MVL_REQ_PEND`** structure. It may be referenced by the following statement (assuming **`&req_pend`** was passed as the **`req_out`** argument):

```
JSTAT_RESP_INFO *resp_info = req_pend->u.jstat.resp_info;
```

Return Value: `ST_RET` `SD_SUCCESS` If request sent successfully, or error code.

Note: If the return value is **`SD_SUCCESS`**, you still need to wait for the response. See *Asynchronous Request Functions* on page 152 for information on how to wait.

Chapter 6

Using the UCA Features of MVL

To provide UCA support, MVLU makes use of standard MVL features such as the Manufactured Object Handlers and Indication Handlers.

Read/Write Indication Functions

MMS Object Foundry generates code to allow the MVLU support library to invoke user provided functions to implement the MMS Read and Write services. This code makes use of the concept of Read/Write indication handing functions for all primitive data elements of a UCA type. Please note that these indication functions are NOT associated with a particular variable, but rather with a type. This means that if there is more than one variable of a type it is necessary to use the base Variable Association to determine which variable is being accessed.

Read Indication Functions

The Read Indication functions have prototypes of the following form:

```
ST_VOID u_xxx_yyy_zzz_rd_ind_fun (MVLU_RD_VA_CTRL *mvluRdVaCtrl)
```

where **xxx_yyy_zzz** is created by MMS Object Foundry and is based on the UCA name of the primitive level object. For instance, for the UCA Device Identity (DI) object, the following Read Indication Function names are used:

```
u_di_name_rd_ind_fun
u_di_own_rd_ind_fun
u_di_vndid_devmdls_rd_ind_fun
u_di_vndid_sftrev_rd_ind_fun
u_di_commid_pro_rd_ind_fun
u_di_class_rd_ind_fun
u_di_loc_rd_ind_fun
u_di_vndid_sernum_rd_ind_fun
u_di_commid_commadr_rd_ind_fun
u_di_commid_med_rd_ind_fun
u_di_d_rd_ind_fun
u_di_vndid_vnd_rd_ind_fun
u_di_vndid_hwrev_rd_ind_fun
u_di_commid_commrev_rd_ind_fun
u_di_commid_mac_rd_ind_fun
```

The **MVLU_RD_VA_CTRL** data structure is passed into the read indication handler functions. It is used to allow the user application to handle each primitive data element read separately and asynchronously. MVLU keeps track of the number of **MVLU_RD_VA_CTRL** outstanding for a READ or WRITE indication and sends the MMS response when all have been handled. See the figure on page 187.

```
typedef struct mvlu_rd_va_ctrl
 {
 MVL_IND_PEND       *indCtrl;
 MVLAS_RD_VA_CTRL   *rdVaCtrl;
 ST_CHAR            *primData;
 ST_RTREF           primRef;
 ST_UINT            prim_num;
 ST_UINT            prim_offset_base;
} MVLU_RD_VA_CTRL;
```

`indCtrl` This is a pointer to the MVL indication control structure for the MMS indication. This structure contains two user-controlled fields that can be used to manage indication wide user information.

`rdVaCtrl` This is a pointer to the MVL Variable Association structure for the MMS variable being accessed. In this data structure are several elements that are useful in processing the Read Indication such as a reference to the Base VA from which this VA was derived. This Base VA is the high level configured VA and is used to distinguish between variables of the same type.

Note that the **`rdVaCtrl`** structure is NOT unique to this particular Read Indication Function (i.e., single MMS Variable Specification can result in many primitive indication functions in the case of a structure type variable).

`primData` This is a pointer to data buffer for the primitive variable data for a Read Indication. This is where the data to be returned is to be placed. Note that there is a single data buffer for each MMS variable (MVL Variable Association) and the **`primData`** points somewhere into this buffer. The VA data buffer is normally allocated dynamically. Please refer to the *UCA Buffer Management* on page 194 for more information.

`primRef` This is the primitive element reference, which is controlled by the developer. MMS Object Foundry makes use of a MMS Object Foundry generated define to initialize the reference element for each primitive element. The developer can modify this define using a Template input file and then can use this reference to aid processing of the indication. This can be especially useful when the developer chooses to use a single Read Indication Function to support access to multiple primitive elements.

`prim_num` Index to data (0, 1, 2, 3, etc.). Unique for each primitive data element. Starts at 0 for the first primitive data element in the base variable.

`prim_offset_base` Memory offset (in bytes) of this primitive data element from start of base variable.

When the read response data has been put into the buffer selected by the **`primData`** element, the user application must call the MVLU function **`mvlu_rd_prim_done`** so that MVLU can send the read response. Note that this can be either within the Read Indication Function or asynchronously some time later.

```
ST_VOID mvlu_rd_prim_done (MVLU_RD_VA_CTRL *mvluRdVaCtrl, ST_RET rc);
```

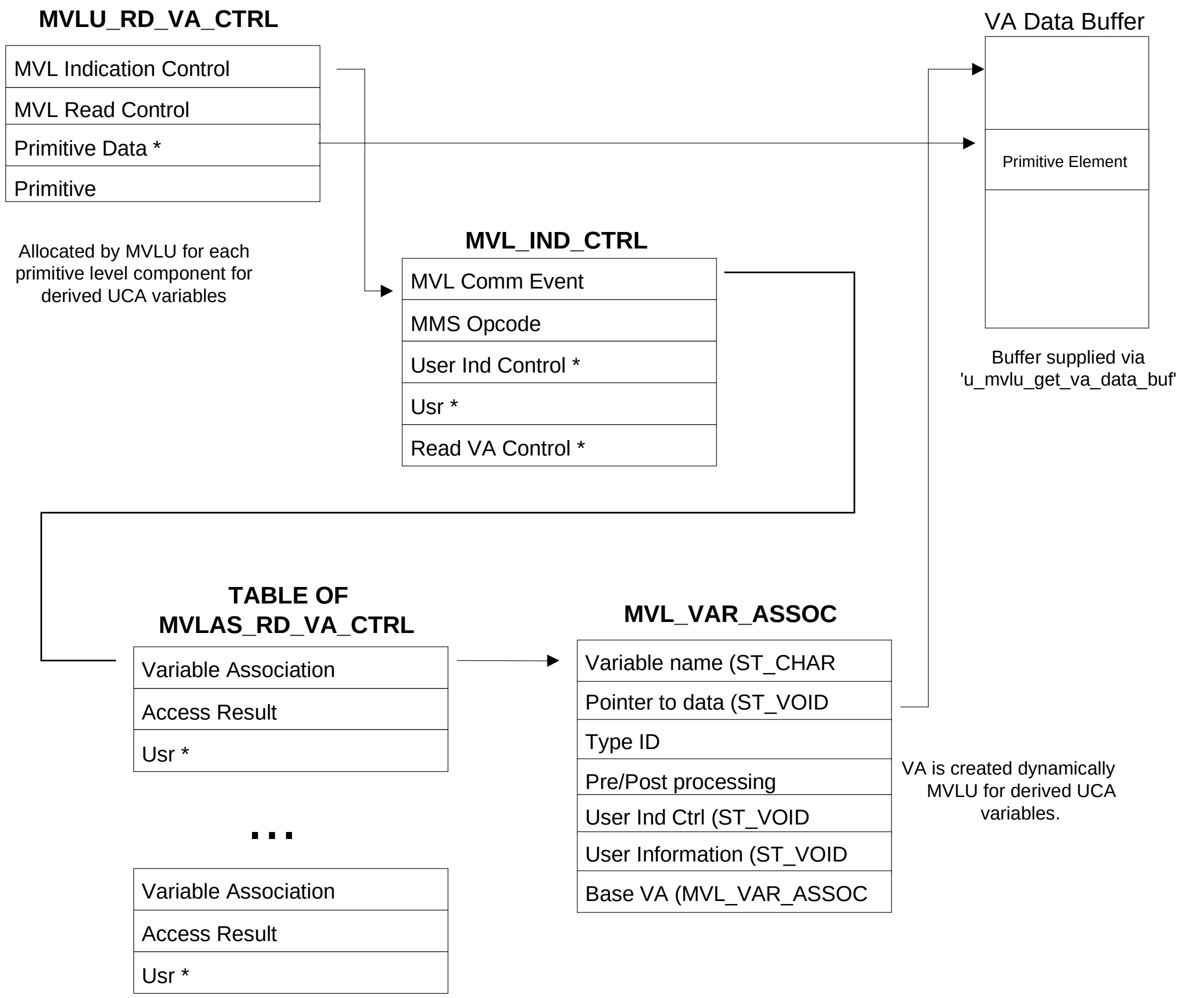


Figure 11: MVLU Read Control

Write Indication Functions

The Write Indication Function concepts are the same as those used in the Read Indication Functions. The differences are described below:

The Write Indication functions have prototypes of the following form:

```
ST_VOID u_xxx_yyy_zzz_wr_ind_fun (MVLU_WR_VA_CTRL *mvluWrVaCtrl)
```

The **`MVLU_WR_VA_CTRL`** structure is declared as shown below and provides all required context information to allow the Write Indication Function to process the primitive data effectively.

```
typedef struct mvlu_wr_va_ctrl
  {
  MVL_IND_PEND      *indCtrl;
  MVLAS_WR_VA_CTRL  *wrVaCtrl;
  ST_CHAR           *primData;
  ST_RTREF          primRef;
  ST_UINT           prim_num;
  ST_UINT           prim_offset_base;
  } MVLU_WR_VA_CTRL;
```

When the write data located in the buffer selected by the **`primData`** element has been processed by the application, the user application must call the MVLU function **`mvlu_wr_prim_done`** so that MVLU can send the write response. Note that this can be either within the Write Indication Function or asynchronously some time later.

```
ST_VOID mvlu_wr_prim_done (MVLU_WR_VA_CTRL *mvluWrVaCtrl, ST_RET rc);
```

Dynamic Type Creation for UCA and IEC 61850

NOTE: *This section uses the term "Leaf Access Parameters" (LAP) to refer to "leaf functions and references" used in the UCA and IEC 61850 Object modeling.*

Please refer to the next chapter for IEC 61850 specific information. Dynamic type creation for UCA and IEC 61850 devices requires extra code to set the "Leaf Acccess Parameters" (LAP) after the type is created. The functions in this section simplify the process by allowing the following:

- Programmatic access to Leaf Access Parameters (i.e., find leaf nodes by name, set leaf access parameters).
- Runtime loading of LAP information from XML file, or from any user source.

mvlu_set_leaf_param_name

Usage: This function is used to set the Leaf parameter name. Notice that the function names are passed as strings (not function pointers). This function looks up the function by name and sets the function pointer in the type definition. There is no need for the user to convert the function name to a function pointer.

NOTE: *This function is only available if **`MVLU_LEAF_FUN_LOOKUP_ENABLE`** is defined (preferably in **glbopt.h**).*

Function Prototype:

```
ST_RET mvlu_set_leaf_param_name (ST_INT        setFlags,
                                 ST_CHAR       *leafName,
                                 ST_CHAR       *rdIndFunName,
                                 ST_CHAR       *wrIndFunName,
                                 ST_CHAR       *refString);
```

Parameters:

`setFlags`	Indicates one or more of the following defines:
	`#define MVLU_SET_RD_FUN    0x01`
	`#define MVLU_SET_WR_FUN    0x02`
	`#define MVLU_SET_REF       0x04`
	`#define MVLU_SET_ALL (MVLU_SET_RD_FUN | MVLU_SET_WR_FUN | MVLU_SET_REF)`

`*leafName`	This is the name of the leaf.
`*rdIndFunName`	This is the read indication function name.
`*wrIndFunName`	This is the write indication function name.
`*refString`	This is the string to convert to the “reference.”

Return Value: `ST_RET`

`SD_SUCCESS`	No Error
`!= SD_SUCCESS`	Error

Example:

```
rc = mvlu_set_leaf_param_name (MVLU_SET_ALL, “DI$VndID$SerNum”,
                 “u_string_offset_rd_ind_fun”, “u_no_write_allowed”, “0”);
```

u_mvlu_resolve_leaf_ref

Usage: The **refString** argument to **mvlu_set_leaf_param_name** must be converted to **ST_RTREF** to be stored as the **reference** in the type definition. Because users may wish to store almost anything in the **reference**, a user callback function, **u_mvlu_resolve_leaf_ref**, is called to convert the string into a **ST_RTREF** value. In the simplest case, the string may contain an integer value, in which case this function may simply convert the string to an integer using **sscanf** or **atoi** and then cast the value to **ST_RTREF**. Examples of **u_mvlu_resolve_leaf_ref** are provided in the sample applications.

Function Prototype:

```
ST_RET u_mvlu_resolve_leaf_ref (ST_CHAR      *leafName,
                                ST_INT       *setFlagsIo,
                                ST_CHAR      *refString,
                                ST_RTREF     *refOut);
```

Parameters:

`*leafName` This is the same leaf name passed to **mvlu_set_leaf_param_name**.

`*setFlagsIo` Indicates one or more of the following defines:

```
#define MVLU_SET_RD_FUN    0x01
#define MVLU_SET_WR_FUN    0x02
#define MVLU_SET_REF       0x04
#define MVLU_SET_ALL (MVLU_SET_RD_FUN | MVLU_SET_WR_FUN |
MVLU_SET_REF)
```

`*refString` This is same string to convert to the "reference."

`*refOut` This is output value converted from **refString**.

Return Value:	ST_RET	SD_SUCCESS	No Error
		!= SD_SUCCESS	Error

mvlu_load_xml_leaf_file

Usage: This function loads text based LAP information from an XML file and calls **mvlu_set_leaf_param_name** to set the Leaf Access Parameters for each leaf. Below is a very simple example of an XML input file:

```
<Leafmap>
  <Leaf Name="DI$Name" RdIndFun="rdString" WrIndFun="noWrite" Ref="42"/>
  <Leaf Name="DI$Class" RdIndFun="rdString" WrIndFun="noWrite" Ref="43"/>
</Leafmap>
```

The function syntax is very simple. The only argument is the name of the XML file to use as input.

Note: *This function is only available if* ***MVLU_LEAF_FUN_LOOKUP_ENABLE*** *is defined (preferably in* ***glbopt.h****).*

Function Prototype:

```
ST_RET mvlu_load_xml_leaf_file (ST_CHAR *fileName);
```

Parameters:

`fileName` This is the ASCII name of the leaf file to Open.

Return Value:	ST_RET	SD_SUCCESS	No Error
		!= SD_SUCCESS	Error

mvlu_set_leaf_param

Usage: This lower level function may also be used to set one or more Leaf Access Parameters if function indices (**`rdIndFunIndex`**, **`wrIndFunIndex`**) can be determined by some other method.

Function Prototype:

```
ST_RET mvlu_set_leaf_param (ST_INT      setFlags,
                            ST_CHAR     *leafName,
                            ST_RTINT    rdIndFunIndex,
                            ST_RTINT    wrIndFunIndex,
                            ST_RTREF    ref);
```

Parameters:

`setFlags` Indicates one or more of the following defines:

```
#define MVLU_SET_RD_FUN    0x01
#define MVLU_SET_WR_FUN    0x02
#define MVLU_SET_REF       0x04
#define MVLU_SET_ALL (MVLU_SET_RD_FUN | MVLU_SET_WR_FUN |
MVLU_SET_REF)
```

`*leafName` This is the leaf name.

`rdIndFunIndex` This is the read indication function index.

`wrIndFunIndex` This is the write indication function index.

`ref` This is “reference.”

Return Value: `ST_RET`

`SD_SUCCESS`	No Error
`!= SD_SUCCESS`	Error

Example:

```
rc = mvlu_set_leaf_param (MVLU_SET_ALL, “DI$VndID$SerNum”,
         (ST_RTINT)42,(ST_RTINT)43,(ST_RTREF)44);
```

mvl_typname_to_typeid

Usage: This function can be used to find a Type by name, and return the TypeID.

Function Prototype:

```
ST_INT mvl_typename_to_typeid (ST_CHAR *typename);
```

Parameters:

`typename` This indicates the name of the Type.

Return Value: `ST_INT` The TypeID, or –1 in case of error.

Example:

```
di_typeid = mvl_typename_to_typeid (“DI”);
       if (di_typeid < 0)
       return (SD_FAILURE);
```

mvl_typeid_to_typename

Usage: This function can be used to find a TypeID, and return the Type Name.

Function Prototype:
```
ST_CHAR *mvl_typeid_to_typename (ST_INT type_id);
```

Parameters:

`type_id` This indicates the TypeID.

Return Value: `(ST_CHAR *)` Pointer to the name of the Type, or NULL in case of error.

mvlu_find_rt_leaf

Usage: This function is used to locate a particular leaf node within the selected type. This is useful if the developer wants to directly access the leaf's Runtime Type element.

Function Prototype:
```
RUNTIME_TYPE *mvlu_find_rt_leaf (ST_INT       type_id,
                                 ST_CHAR      *leafName);
```

Parameters:

`type_id` This indicates the TypeID.

`leafName` This is a pointer to the Leaf Name with the top level variable name removed (e.g., **`ST$Mod$stVal`** but NOT **`CSWI1$ST$Mod$stVal`**).

Return Value: `(RUNTIME_TYPE *)` Pointer to the Runtime Type element for this leaf.

Example:
```
rt = mvlu_find_rt_leaf (type_id, “ST$Mod$stVal”);
       if (rt == NULL)
       return (SD_FAILURE);
```

Array Handling

MVLU can handle single dimensional arrays of any support data type, including primitive and complex types. These are handled with multiple calls to the primitive leaf functions (one call per array element); Read/Write functions have access to the element index. As with UCA data structures, alternate access is handled transparently with the Read/Write function called for selected array elements only.

Foundry generates index use code for stub starter Read/Write functions in the following format:

```
{
...
ST_RTINT curr_index;
  curr_index = mvluRdVaCtrl->rdVaCtrl->va->arrCtrl.curr_index;
...
}
```

Template File (Obsolete)

This file should not be used when developing new applications. Use the "LAP XML Input File" instead. It is supported only for backward compatibility with previously developed applications.

When UCA processing is enabled, MMS Object Foundry can take a Template File as a source of Read/Write Indication Function and Reference information. When MMS Object Foundry needs to provide a Read or Write Indication Function, it searches the Template File in the following manner to resolve this required function.

1. MMS Object Foundry searches for a define for the function name. If it is found, the value is used as the name of the function to be used for that primitive element.
2. Assuming the define for the function name is not found, MMS Object Foundry then searches for an extern declaration for the function. If this is found, MMS Object Foundry assumes that the function will be supplied in a separate C module.
3. Assuming no define or extern is found for the function name, MMS Object Foundry then searches the Template for the function itself. If found, the code for the function is copied into the output C file.
4. If the function name is not found in any of the above forms, MMS Object Foundry generates a starter function and places it into the output C file and in the **lefttodo.txt** output file. These starter functions will allow the application to be compiled, linked and run, with simulated data supplied. Note that the starter functions are intended to be edited to provide real functionality and then moved into the input Template File.

In similar fashion, when MMS Object Foundry needs to provide a Reference define, it searches the Template File in the following manner to resolve this required define statement.

1. MMS Object Foundry searches for the define in the Template File. If it is found, it is extracted and placed in the output H file.
2. If the reference define is not found in the Template File, MMS Object Foundry generates a starter define and places it into the output H file and in the **lefttodo.txt** output file. These starter defines will allow the application to be compiled, linked and run. Note that the starter reference defines are intended to be edited to provide real functionality and then moved into the input Template File.

VA Processing Functions and UCA Variables

The standard MVL pre/post processing functions for Read/Write/Info Report services on Variable Associations are supported for UCA variables. However, they are not normally required. To use this feature, the Read/Write Indication Function must set the **`proc`** element of the derived Variable Association to select the desired processing functions.

Combining UCA and Non-UCA Variables

MVLU fully supports the standard non-UCA variables, with a few minor modifications. Since MVLU installs handlers for READ and WRITE indications, applications that also have non-UCA variables must consider the following:

1. By default, responses will be sent immediately for non-UCA variables per the normal UCA service mechanisms. Note that all pre/post processing functions will be called just as though MVLU was not installed.
2. To make use of the asynchronous response capability of MVL, the developer must set the function pointers below to a user defined function. If this is done, the application must call **`mvlu_rd_prim_done`** when the **`va->data`** is ready (READ), or **`mvlu_wr_prim_done`** when the **`va->data`** has been dealt with appropriately.

```
/* Function pointers for non-UCA variable handling */
ST_VOID(*mvluAsyncRdIndFun)(struct mvlu_rd_va_ctrl *mvluRdVaCtrl);
ST_VOID(*mvluAsyncWrIndFun)(struct mvlu_wr_va_ctrl *mvluWrVaCtrl);
```

UCA Buffer Management

When a Read/Write indication is received for a UCA variable, MVLU allocates a data buffer that is appropriately sized for the MMS variable and then calls primitive indication handler functions to handle the individual data elements. The VA data buffer is allocated and freed via these static functions.

```
static ST_VOID mvluDefGetVaDataBufFun (ST_INT        service,
                                       MVL_VAR_ASSOC *va,
                                       ST_INT        size);

static ST_VOID mvluDefFreeVaDataBufFun (ST_INT       service,
                                        MVL_VAR_ASSOC *va);
```

These functions check the **`use_static_data`** flag in the **`MVL_VAR_ASSOC`** structure for the base variable. If **`use_static_data`** is **`SD_FALSE`**, **`chk_calloc`** and **`chk_free`** are called to allocate and free the VA data buffer. If **`use_static_data`** is **`SD_TRUE`**, MVLU will assume that the configured (base) VA data element points to a user selected data buffer of the size of the base VA. MVLU will then set the derived VA data pointer to that base data pointer plus the calculated offset of the data element. This is useful when the application actually has the UCA object in memory.

When a MMS read or Write indication is received, functions selected by the function pointers shown below are invoked in order to allow the user to prepare for handling the indication. A typical use would be to use the **`indCtrl->usr_ind_ctrl`** to assist the buffer control subsystem to work effectively.

```
/* These function pointers are invoked to allow the user    */
/* application      to prepare for handling the indication. */
extern ST_RET (*u_mvl_rd_ind_start) (MVL_IND_PEND *indCtrl);
extern ST_RET (*u_mvl_wr_ind_start) (MVL_IND_PEND *indCtrl);
```

Please note that this feature and other buffer management issues are advanced options. The default MVLU buffer management will work well for most applications.

MVL UCA Report Handling

MVLU contains a set of functions and data structures that are useful in handling the UCA report control blocks and associated data sets. The MVL report handling system is based on the data structure **MVLU_RPT_CTRL**. This allows the application programmer to generate UCA reports easily.

The MVLU Report Control Element

The data structures below are used by MVLU to represent the BASRCB report control object.

```
typedef struct
  {
      /* Each connection get it's own view of this data                    */
  ST_BOOLEAN        RptEna;
  ST_CHAR           RptID[66];
  ST_CHAR           *DatSetNa[66];      /* Read only, get from Data Set NVL  */
  struct                                /* BVstring                           */
    {
    ST_INT16        len_1;
    ST_UCHAR        data_1[2];
    } OptFlds;
  ST_UINT32         BufTim;
  ST_UINT16         Trgs;
  ST_UINT8          SeqNum;
  ST_UCHAR          TrgOps[1];
  ST_UINT32         RBEPd;
  ST_UINT32         IntgPd;
  ST_UINT32         ConfRev;            /* Used only for IEC 61850 BRCB/URCB.*/
  ST_INT            EntryID;            /* Used only for IEC 61850 BRCB.     */
  } MVLU_BASRCB;

typedef struct mvlu_rpt_ctrl
  {
  DBL_LNK     l;                        /* Internal use                       */
/* Active clients                                                             */
  ST_INT      num_rpt_clients;
  MVLU_RPT_CLIENT   *rpt_client_list;
/* basrcb data for passive read clients                                       */
  MVLU_BASRCB       common_basrcb;
  ST_CHAR           *basrcb_name;
/* Used in read/write indication functions in finding the report ctrl        */
  RUNTIME_TYPE      *rcbRtHead;
  MVL_VAR_ASSOC     *base_va;
/* Used to support different different report schemes                        */
  ST_INT            rcb_type;           /* RCB_TYPE_UCA, RCB_TYPE_IEC_BRCB,  */
/* Action to be taken if var changes twice before buftim expires              */
  ST_INT            buftim_action;      /*MVLU_RPT_BUFTIM_REPLACE/SEND_NOW   */
/* Report Data Fields, used as data source when report is sent                */
  ST_UINT8          *inclusion_data;
/* The information below is used internally by MVLU                           */
  MVL_VAR_ASSOC     rptID_va;
  MVL_VAR_ASSOC     optFlds_va;
  MVL_VAR_ASSOC     sqNum_va;
  MVL_VAR_ASSOC     inclusion_va;
  MVL_VAR_ASSOC     *reasons_va;
  MVL_NVLIST_CTRL   *dsNvl;             /* The base dataSet for the report   */
  MVL_NVLIST_CTRL   rptNvl;             /* The NVL used to send the InfoRpt  */
  RUNTIME_TYPE      incRt;              /* Used in building the inclusion_va */
  ST_INT            maxNumRptVars;      /* Max vars used in report.          */
  MVLU_RPT_TYPEIDS  rpt_typeids;        /* Types needed for reports.         */
  MVL61850_BRCB_CTRL brcbCtrl;          /* Used only for 61850 BRCB.         */
  } MVLU_RPT_CTRL;
```

UCA Reporting Setup Sequence

The following steps should be followed to configure and enable UCA Reporting.

1. **Include the types required for UCA reporting.** To do this, include the following lines in your project's ODF file, which can be done by including the following line in the ODF file:
```
":CI", "gentypes.odf"
":CI", "rpt.odf"
```
2. **For each UCA report, create the dataset NVL.** To do this you must identify the variable(s) within the brick that contains the variables to be reported. For instance, the GLOBE brick contains the report control element **`GLOBE$RP$brcbST`**, which has a dataset that includes all ST variables from the logical device. For a logical device with a single PBRO brick, this means that the dataset includes variables in the **`PBRO$ST`** data structure. These variables are:
```
PBRO$ST$Out
PBRO$ST$Tar
PBRO$ST$FctDS
PBRO$ST$AuxIn1
PBRO$ST$PuGrp
```

Note: The MMS-*Lite* Reporting Subsystem is only going to serve a Report if the DataSet being referenced by the RCB is created programmatically at runtime. There are a few functions that work equally well to create a DataSet. They are: **`mvlu_derive_rpt_ds`**, **`mvlu_rpt_nvl_add`**, and **`mvl_nvl_add`** . If you use the function **`mvl_find_mvl`** and try to get a pointer to the nvl, you will not be able to use a NamedVariableList instanciated by the MMS Foundry.

The easiest way to create this dataset is to use the following function:

```
MVL_NVLIST_CTRL *mvlu_derive_rpt_ds (ST_CHAR      *domName,
                                     ST_CHAR      *nvlName,
                                     ST_INT       numNodes,
                                     ST_CHAR      **nodeNames);
```

An example of the use of this function is as follows:

```
ST_CHAR *nodeNames[1];
nodeNames[0] = "PBRO$ST";
nvl = mvlu_derive_rpt_ds ("pbroDev", "globeStRptDs", 1, nodeNames);
```

See page 198 for more information on this function.

Alternatively, you can use the function **`mvlu_rpt_nvl_add`** to create the report dataset NVL. This function takes the desired NVL name along with a table of MMS variable names to be included in the NVL.

```
MVL_NVLIST_CTRL * mvlu_rpt_nvl_add  (OBJECT_NAME  *nvl_obj,
                                     ST_INT       num_var,
                                     OBJECT_NAME  *var_obj);
```

An example of the use of this function is:

```
OBJECT_NAME nvlObjName;
OBJECT_NAME varObjNames[5];
ST_INT i;
  nvlObjName.object_tag = DOM_SPEC;
  nvlObjName.domain_id = "pbroDev";
  nvlObjName.obj_name.item_id = "LogDev$ST";
  for (i = 0; i < numRptVarNames; ++i)
    {
    varObjNames[i].object_tag = DOM_SPEC;
    varObjNames[i].domain_id = "pbroDev";
    varObjNames[i].obj_name.item_id = rptVarNames[i];
    }
  nvl = mvlu_rpt_nvl_add (&nvlObjName, 5, varObjNames);
```

See page 199 for more information on this function.

3. **Create the MVLU Report Control element**. To do this, you will need to know the variable name for the BASRCB, have created the dataset NVL, and located the Variable Association for the brick that contains the BASRCB variable. In addition, you will need to assign a unique report control ID (typically an integer).

   The function **`mvlu_creat_rpt_ctrl`** must be called to create the UCA report control. Note that this function does limited initialization of the common BASRCB data (**`DatSetNa`** is intialized, **`OptFlds`** bitstring length is set to 5, **`TrgOps`** is set to **`MVLU_TRGOPS_DATA`**). All other values are set to 0; any other desired initialization must be done in the application, or by the report client. See page 200 for more information on this function.

4. **Set the leaf functions for reading and writing each RCB primitive element.** The MVLU library contains leaf functions for each primitive element of the RCB. The type definition must contain pointers to these functions. The function pointers may be initialized using the Foundry input file **leafmap.xml**. The following is an example of how this may be done in **leafmap.xml**:

```
<Leaf Name="POPF$BR$brcbST$RptEna" RdIndFun="mvlu_rptena_rd_ind_fun" WrIndFun="mvlu_rptena_wr_ind_fun" Ref=""/>
<Leaf Name="POPF$BR$brcbST$RptID" RdIndFun="mvlu_rptid_rd_ind_fun" WrIndFun="mvlu_rptid_wr_ind_fun" Ref=""/>
<Leaf Name="POPF$BR$brcbST$DatSet" RdIndFun="mvlu_datsetna_rd_ind_fun" WrIndFun="u_no_write_allowed" Ref=""/>
<Leaf Name="POPF$BR$brcbST$ConfRev" RdIndFun="mvlu_confrev_rd_ind" WrIndFun="u_no_write_allowed" Ref=""/>
<Leaf Name="POPF$BR$brcbST$OptFlds" RdIndFun="mvlu_optflds_rd_ind_fun" WrIndFun="mvlu_optflds_wr_ind_fun" Ref=""/>
<Leaf Name="POPF$BR$brcbST$BufTm" RdIndFun="mvlu_buftim_rd_ind_fun" WrIndFun="mvlu_buftim_wr_ind_fun" Ref=""/>
<Leaf Name="POPF$BR$brcbST$SqNum" RdIndFun="mvlu_sqnum_int16u_rd_ind_fun" WrIndFun="u_no_write_allowed" Ref=""/>
<Leaf Name="POPF$BR$brcbST$TrgOps" RdIndFun="mvlu_trgops_rd_ind_fun" WrIndFun="mvlu_trgops_wr_ind_fun" Ref=""/>
<Leaf Name="POPF$BR$brcbST$IntgPd" RdIndFun="mvlu_intgpd_rd_ind_fun" WrIndFun="mvlu_intgpd_wr_ind_fun" Ref=""/>
<Leaf Name="POPF$BR$brcbST$GI" RdIndFun="mvlu_gi_rd_ind" WrIndFun="mvlu_gi_wr_ind" Ref=""/>
<Leaf Name="POPF$BR$brcbST$PurgeBuf" RdIndFun="mvlu_purgebuf_rd_ind" WrIndFun="mvlu_purgebuf_wr_ind" Ref=""/>
<Leaf Name="POPF$BR$brcbST$EntryID" RdIndFun="mvlu_entryid_rd_ind" WrIndFun="mvlu_entryid_wr_ind" Ref=""/>
<Leaf Name="POPF$BR$brcbST$TimeofEntry" RdIndFun="mvlu_timeofentry_rd_ind" WrIndFun="u_no_write_allowed" Ref=""/>
```

NOTE: In applications configured with SCL, these functions are mapped automatically to the RCB leafs by the library at runtime. The leafmap.xml file only needs entries like the following so that the function pointers are available for “dynamic” mapping:

```
<Leaf Name="$dynamic" RdIndFun="mvlu_rptena_rd_ind_fun" WrIndFun="mvlu_rptena_wr_ind_fun" Ref=""/>
<Leaf Name="$dynamic" RdIndFun="mvlu_rptid_rd_ind_fun" WrIndFun="mvlu_rptid_wr_ind_fun" Ref=""/>
```

5. **Create Report Scan Control Elements.** An application can choose to have MVLU scan report data, using the standard MVLU read/write indication functions. To do this, the application creates one or more **`MVLU_RPT_SCAN_CTRL`** elements using the function **`mvlu_rpt_create_scan_ctrl`**. Note that the MVLU report scan control elements are independent of the report control elements themselves, and consist primarily of the list of variables to be scanned and associated scan control information. That is, a variable may be used in one or more reports but need be present only once in a scan control element.

   The following is an example of how this is done, where a single scan control element is setup to scan all variables associated with a single UCA report dataset:

```
MVL_NVLIST_CTRL *dsNvl;
MVLU_RPT_SCAN_CTRL *scanCtrl;
ST_INT i;
scanCtrl = mvlu_rpt_create_scan_ctrl (dsNvl->num_of_entries);
for (i = 0; i < dsNvl->num_of_entries; ++i)
  scanCtrl->scan_va[i]= dsNvl->entries[i];
memcpy (scanCtrl->scan_va_scope, nvl->va_scope,
       nvl->num_of_entries * sizeof (MVL_SCOPE));
scanCtrl->enable = SD_TRUE;
```

   After the scan control is created, its control parameters (scan period, enable, etc.) may be modified as desired by the application.

6. **Report Service.** The MVLU function **`mvlu_rpt_service`** is used to provide MVLU with processing time. This report processing consists of servicing all MVLU Report Scan Control elements, servicing all MVLU Report Control elements (that is, for active clients), and sending UCA reports as appropriate.

7. The frequency at which **`mvlu_rpt_service`** must be called depends on the accuracy and timeliness required of the system, as well as the data change detection mechanisms selected (see below). For instance, if the application does not make use of the MVLU Report Scan mechanisms and reports changes directly, **`mvlu_rpt_service`** need only be called when data has changed, and at a period suitable for integrity/periodic reports. On the other hand, if the application relies on the scan mechanisms to detect changes, **`mvlu_rpt_service`** should be called frequently enough to not miss data changes that are to be reported.
8. **Data Change Detection.** The application may choose to make use of the MVLU Report Scan Control mechanism to detect data changes, or may report data changes asynchronously as they take place. To do this, the function **`mvlu_rpt_va_change`** is called, with the variable association, new data, and reason for change. MVLU will then buffer the data and track what data has changed.

Theory of Operation

BASRCB Handling

Each MVLU Report Control element has data storage for BASRCB data. This data is referred to as the "common" data. When a client establishes a connection it can read the BASRCB data, and the source of the data is the "common" BASRCB data. In this state the client is referred to as a "browsing" client; it does not participate in actual report activities.

When the client writes any element of the BASRCB, the client is given it's own BASRCB data storage. From that point on, the client is referred to as an "active" client, and it can control the UCA report mechanisms independent from other clients. An active client can set all BASRCB parameters as desired.

Report Dataset Named Variable List Handling

These functions are used to manage the Named Variable List control elements, which are used in setting up and managing the report control elements. Note that these functions are not necessarily UCA specific, but can also be used to create Named Variable Lists dynamically.

Named Variable List Functions

mvlu_derive_rpt_ds

Usage: This function is used to create the dataset NVL.

Function Prototype:

```
MVL_NVLIST_CTRL *mvlu_derive_rpt_ds (ST_CHAR   *domName,
                                     ST_CHAR   *nvlName,
                                     ST_INT    numNodes,
                                     ST_CHAR   **nodeNames);
```

Parameters:

`domName` This is the name of the domain where the node variables are found and also where the resulting NVL is to be located.

`nvlName` The name of the NVL to be created.

`numNodes` The number of structures from which to derive variable names.

`nodeNames` A table of [**`numNodes`**] pointers to the names of variable nodes from which report variable names will be derived. A typical name will be of the form **`PBRO$ST`**, which will cause all members of the structure variable **`PBRO$ST`** to be added as elements of the dataset.

Return Value: A pointer to the new Named Variable List object. **NULL** if the operation failed. The structure **`MVL_JOURNAL_CTRL`** is defined in **mvl_defs.h**.

mvlu_rpt_nvl_add

Usage: This function to used to create the report dataset NVL.

Function Prototype:

```
MVL_NVLIST_CTRL *mvlu_rpt_nvl_add (OBJECT_NAME       *obj,
                                   ST_INT            num_var,
                                   OBJECT_NAME       *var_obj);
```

Parameters:

`obj`	This is the MMS Named Variable List name to be used for the report NVL (dataset).
`num_var`	The number of variables to be included in the NVL (dataset).
`var_obj`	This is an array of MMS Named Variable names to be included in the NVL (dataset).

Return Value: A fully resolved and ready to use MVL Named Variable List control element. NULL will be returned if an error occurs.

mvlu_rpt_nvl_destroy

Usage: This function is used to free a NVL created by **`mvlu_derive_rpt_ds`** or **`mvlu_rpt_nvl_add`**.

Function Prototype:

```
ST_VOID mvlu_rpt_nvl_destroy (MVL_NVLIST_CTRL *nvl);
```

Parameters:

`nvl`	This is pointer to the **`MVL_NVLIST_CTRL`** structure to be freed.

Return Value: A fully resolved and ready to use MVL Named Variable List control element. NULL will be returned if an error occurs.

MVLU Report Control Creation Functions

These functions are used to create and free MVL report control elements. These report control elements are used in the sending of UCA reports and optionally for updating the data to be sent.

mvlu_create_rpt_ctrl

Usage: This function is used to create a MVL Report Control data structure for a UCA report. All report data elements are contained in the DataSet NVL and the **`MVLU_RPT_CTRL`** data structure. Note that **`MVLU_RPT_CTRL`** contains a connection oriented set of data structures to provide client applications with their own view of some report control data.

Function Prototype:

```
MVLU_RPT_CTRL *mvlu_create_rpt_ctrl (ST_CHAR          *basrcbName,
                                     MVL_NVLIST_CTRL  *dsNvl,
                                     MVL_VAR_ASSOC    *base_va,
                                     ST_INT           rcb_type,
                                     ST_INT           buftim_action,
                                     ST_INT           brcb_bufsize,
                                     ST_UINT32        ConfRev);
```

Parameters:

`basrcbName` This is the variable name for the BASRCB used to control the report. For example, in the GLOBE brick we have **`GLOBE$RP$brcbMX`** and **`GLOBE$RP$brcbST`**.

`dsNvl` This is the dataSet associated with the report control element. This must be a completely resolved Named Variable List. That is, all variable associations must be complete and valid. This will be the case when the dataSet NVL is created using **`mvlu_derive_rpt_ds`** or **`mvlu_rpt_nvl_add`**.

The data pointer input parameters are used to link the MVLU Report Control block with the associated MMS RCB. That is, these references are used as the data source to correspond with the UCA report elements and will typically map to the MMS visible RCB for the report.

`base_va` This is the MVL Variable Association for the brick to which the BASRCB belongs. This can be obtained as shown below:

```
OBJECT_NAME baseVarName;
MVL_VAR_ASSOC *baseVa;

baseVarName.object_tag = DOM_SPEC;
baseVarName.domain_id = "pbroDev";
baseVarName.obj_name.item_id = "GLOBE";
baseVa = mvl_vmd_find_var (&baseVarName);
```

`rcb_type` The Report Control Block type (must be **`RCB_TYPE_UCA`**).

`buftim_action` This is the action to be taken of a variable changes twice before the **`BufTim`** timer expires (one of the following):

```
MVLU_RPT_BUFTIM_REPLACE
MVLU_RPT_BUFTIM_SEND_NOW
```

`brcb_bufsize` Ignored.

`ConfRev` Ignored.

Return Value: This function returns the MVL report control element, **`MVLU_RPT_CTRL`**. NULL will be returned if an error occurs.

mvlu_free_rpt_ctrl

Usage: This function is used to free a MVLU Report Control element created via **`mvlu_create_rpt_ctrl`**.

Function Prototype: `ST_VOID mvlu_free_rpt_ctrl (MVLU_RPT_CTRL *rptCtrl);`

Parameters:

`rptCtrl` A pointer to a **`MVLU_RPT_CTRL`** structure to be freed.

Return Value: `ST_VOID`

Report Variable Scanning Functions

mvlu_rpt_create_scan_ctrl2

Usage: This function is used to create a **`MVLU_RPT_SCAN_CTRL`** element. Note that the MVLU report scan control elements are independent of the report control elements themselves and consist primarily of the list of variables to be scanned and associated scan control information. That is, a variable may be used in one or more reports but need be present only once in a scan control element.

Function Prototype:

```
MVLU_RPT_SCAN_CTRL *mvlu_rpt_create_scan_ctrl2 (MVL_NVLIST_CTRL    *nvl,
                                                ST_RET             (*scan_done_fun)
                                                (struct mvl_ind_pend      *ind_pend),
                                                ST_UINT            report_scan_rate);
```

Parameters:

`nvl`	Report DataSet (Named Variable List) to scan.
`scan_done_fun`	Pointer to optional user function to be called when each scan completes. NULL if user function not needed.
`report_scan_rate`	Report scan rate (in milliseconds).

Return Value:

`!= NULL`	Returns a pointer to a **`MVLU_RPT_SCAN_CTRL`** structure.
`= NULL`	An error has occurred.

mvlu_rpt_create_scan_ctrl

Usage: This function is used to create a **`MVLU_RPT_SCAN_CTRL`** element. Note that the MVLU report scan control elements are independent of the report control elements themselves and consist primarily of the list of variables to be scanned and associated scan control information. That is, a variable may be used in one or more reports but need be present only once in a scan control element.

Note: **`mvlu_rpt_create_scan_ctrl2`** performs more initialization of the **`MVLU_RPT_SCAN_CTRL`** structure, so it should be easier to use in most cases.

Function Prototype: `MVLU_RPT_SCAN_CTRL *mvlu_rpt_create_scan_ctrl (ST_INT numScanVa);`

Parameters:

`numScanVa`	The number of variables to scan.

Return Value:

`!= NULL`	Returns a pointer to a **`MVLU_RPT_SCAN_CTRL`** structure.
`= NULL`	An error has occurred.

mvlu_rpt_destroy_scan_ctrl

Usage: This function destroys a **MVLU_RPT_SCAN_CTRL** structure created by the **mvlu_rpt_create_scan_ctrl** function or the **mvlu_rpt_create_scan_ctrl2** function.

Function Prototype: `ST_VOID mvlu_rpt_destroy_scan_ctrl (MVLU_RPT_SCAN_CTRL *scanCtrl);`

Parameters:

`scanCtrl` Indicates a pointer the **MVLU_RPT_SCAN_CTRL** structure to be destroyed.

Return Value: `ST VOID` (Ignored)

Report Service Functions

mvlu_rpt_service

Usage: This function is used to provide MVLU with processing time. This report processing consists of servicing all MVLU Report Scan Control elements, servicing all MVLU Report Control elements (that is, for active clients), and sending UCA reports as appropriate.

Function Prototype: `ST_VOID mvlu_rpt_service (ST_VOID);`

Parameters: NONE

Return Value: `ST_VOID`

Asynchronous Change Reporting Functions

mvlu_rpt_va_change

Usage: This function is used to make use of the MVLU Report Scan Control mechanism to detect data changes, or may report data changes asynchronously as they take place. To do this, it is called with the variable association, new data, and reason for change. MVLU will then buffer the data and track what data has changed.

Function Prototype:

```
ST_VOID mvlu_rpt_va_change (MVL_VAR_ASSOC      *va,
                            ST_UCHAR           reason,
                            ST_VOID            *new_data);
```

Parameters:

`va` This is a pointer to a **MVL_VAR_ASSOC** structure containing the variable association information.

`reason` This contains the reason for the change.

`new_data` This contains the newly changed data.

Return Value: `ST_VOID`

Lower Level Functions

These functions may be used to take direct control of the scanning process. For usage information refer to the MVL source code.

mvlu_rpt_va_scan

Usage: This function is called by **`mvl_rpt_service`** to scan all UCA Report variables.

Function Prototype: `ST_VOID mvlu_rpt_va_scan (ST_VOID);`

Parameters: NONE

Return Value: `ST_VOID`

mvlu_rpt_scan_read

Usage: This function is called by **`mvlu_rpt_va_scan`** to scan an individual group of variables.

Function Prototype: `ST_VOID mvlu_rpt_scan_read (MVLU_RPT_SCAN_CTRL *scanCtrl);`

Parameters:

`scanCtrl` Pointer to the scanning control structure that was created by **`mvlu_rpt_create_scan_ctrl`**.

Return Value: `ST_VOID`

MVL UCA SBO Handling

MVLU contains a set of functions and data structures that are useful in handling the UCA Select Before Operate (SBO) features. This support comes in the form of common UCA Read/Write Indication functions that are attached to the SBO element and the protected object, and a SBO control data structure.

```
typedef struct
  {
  ST_BOOLEAN        in_use;                    /* control element management */
  ST_CHAR           sbo_var[MAX_SBO_NAME_SIZE+1];
  MVL_NET_INFO      *net_info;                /* Connection ID              */
  time_t            expire_time;               /* SELECT expiration time     */
  } MVL_SBO_CTRL;
```

The following user defined function is called to operate the protected element.

```
ST_VOID u_mvl_sbo_operate (MVL_SBO_CTRL *sboSelect,
                           MVLU_WR_VA_CTRL *mvluWrVaCtrl);
```

The following function is used to terminate any pending SBO operations on the selected connection and is typically called when a connection is terminated.

```
ST_VOID mvlu_clr_pend_sbo (MVL_NET_INFO *net_info);
```

UCA SBO Read/Write Indication Handler Functions

These Read/Write indication handler functions are to be attached to the appropriate SBO objects via the Foundry template input file.

```
ST_VOID mvlu_sbo_operate_wr_ind (MVLU_WR_VA_CTRL *mvluWrVaCtrl);
ST_VOID mvlu_sbo_select_rd_ind (MVLU_RD_VA_CTRL *mvluRdVaCtrl);
```

MVL_UCA Compilation Options

To make use of the MMS-*Lite* UCA extensions, **MVL_UCA** must be defined during compilation of the core MMS libraries, MVL libraries, and all user code. This define works to enable the enhanced **RUNTIME_TYPE** features required for handling the UCA object models effectively.

Note that by default this is defined automatically when **MMS_LITE** is defined, and is fully compatible with non-UCA applications.

To implement the UCA support subsystem, MVLU creates Runtime Types dynamically and the MVL type control table is allocated at initialization time. As a result, MVL must know the maximum number of active “dynamic” types at any given time. This is done via the following define:

```
#define MVLU_NUM_DYN_TYPES 100
```

This define controls the number of “dynamic” MVL type control elements available for use by MVLU. This should be set to the max number of variables per read * the number of indications pending.

SBO Control Defines

```
#define SBO_SELECT_TIMEOUT      30    /* seconds                      */
#define MAX_NUM_SBO_PEND        10    /* Number of SBOs to be pending */
```

Chapter 7

Using the IEC 61850 Features of MVL

Data structures and functions common to both IEC 61850 and UCA are documented in the previous section.

IEC 61850 Reporting Functions

mvl61850_brcb_entryid_init

Usage: This function sets the initial value of the EntryID attribute in an IEC 61850 BRCB.

Function Prototype:

```
ST_VOID mvl61850_brcb_entryid_init (MVLU_RPT_CTRL    *rptCtrl,
                                    ST_UINT8         *EntryID);
```

Parameters:

`rptCtrl` Pointer of type **`MVLU_RPT_CTRL`** to the Report Control data structure for the BRCB.

`EntryID` Pointer to an array of 8 bytes containing the initial **`EntryID`** value.

Return Value: `ST_VOID`

mvl61850_create_rpt_ctrl

Usage: This function is used to create an MVL Report Control data structure for an IEC 61850 report.

Function Prototype:

```
MVLU_RPT_CTRL *mvl61850_create_rpt_ctrl (ST_CHAR              *basrcbName,
                                        MVL_NVLIST_CTRL      *dsNvl,
                                        MVL_VAR_ASSOC        *base_va,
                                        ST_INT               rcb_type,
                                        ST_INT               buftim_action,
                                        ST_INT               brcb_bufsize,
                                        ST_UINT32            ConfRev);
```

Parameters:

`basrcbName` This is the variable name for the BASRCB used to control the report (e.g., **`POPF$BR$brcbST01`** or **`POPF$RP$urcbMX01`**).

`dsNvl` This is the data set associated with the report control element. This must be a completely resolved Named Variable List. That is, all variable associations must be complete and valid. This will be the case when the data set NVL is created using **`mvlu_derive_rpt_ds`** or **`mvlu_rpt_nvl_add`**.

`base_va` This is the MVL Variable Association for the Logical Node to which the BASRCB belongs.

`rcb_type` The Report Control Block type (one of the following):

```
RCB_TYPE_IEC_BRCB
RBC_TYPE_IEC_URCB
```

`buftim_action` This is the action to be taken of a variable changes twice before the **`BufTim`** timer expires (one of the following):

```
MVLU_RPT_BUFTIM_REPLACE
MVLU_RPT_BUFTIM_SEND_NOW
```

`brcb_bufsize` This is the maximum amount of memory (in bytes) to allow for storing IEC 61850 Buffered Reports. It is used only if **`rcb_type = RCB_TYPE_IEC_BRCB`**.

`ConfRev` This is the value to be stored in the **`ConfRev`** attribute of the RCB.

Return Value: This function returns a pointer to the **`MVLU_RPT_CTRL`** structure. NULL will be returned if an error occurs.

mvl61850_free_rpt_ctrl

Usage: This function is used to free a MVL Report Control element created via **`mvl61850_create_rpt_ctrl`**.

Function Prototype: `ST_VOID mvl61850_free_rpt_ctrl (MVLU_RPT_CTRL *rptCtrl);`

Parameters:

`rptCtrl` A pointer to a **`MVLU_RPT_CTRL`** structure to be freed.

Return Value: `ST_VOID`

mvl61850_rpt_service

Usage: This function is used to provide MVL with report processing time. This processing consists of scanning for changes in any data included in the data set, and generating IEC 61850 reports as necessary. It should be called frequently.

Function Prototype: `ST_VOID mvl61850_rpt_service (ST_VOID);`

Parameters: None

Return Value: `ST_VOID`

mvl61850_ctl_chk_sbo

Usage: This function should be called from the “leaf” function when the IEC 61850 “SBO” attribute is being read (i.e., performing Control Model ‘Select’ Service when **ctlModel = sbo-with-normal-security**). It checks if the client is allowed to perform ‘Select’. If ‘Select’ is allowed, it reserves a **`MVL_SBO_CTRL`** structure and returns a pointer to it.

Function Prototype:

```
MVL_SBO_CTRL *mvl61850_ctl_chk_sbo (MVLU_RD_VA_CTRL *mvluRdVaCtrl);
```

Parameters:

`mvluRdVaCtrl` This is a pointer to a **`MVLU_RD_VA_CTRL`** structure. The caller should use the same pointer that was passed to the “leaf” function.

Return Value: If successful, a pointer to the **`MVL_SBO_CTRL`** structure (**`sbo_var`** member of the structure contains the name to send in the read response)
If failed, returns NULL.

CRITICAL NOTE: If the return is NOT NULL and the caller decides not to allow the ‘Select” for some other reason, the caller must free the structure by calling **`mvlu_sbo_ctrl_free`** and passing this pointer as the argument.

mvl61850_ctl_chk_sbow

Usage: This function should be called from a “leaf” function when the IEC 61850 **SBOw** attribute is being written (i.e., performing Control Model ‘Select’ Service when **ctlModel = sbo-with-enhanced-security**). It checks if the client is allowed to perform ‘Select’. If ‘Select’ is allowed, it reserves a **`MVL_SBO_CTRL`** structure and returns a pointer to it.

Function Prototype:

```
MVL_SBO_CTRL *mvl61850_ctl_chk_sbow (MVLU_WR_VA_CTRL *mvluWrVaCtrl);
```

Parameters:

`mvluWrVaCtrl` This is a pointer to a **`MVLU_WR_VA_CTRL`** structure. The caller should use the same pointer that was passed to the “leaf” function.

Return Value: If successful, a pointer is returned to the **`MVL_SBO_CTRL`** structure. If failed, returns NULL.

***CRITICAL NOTE*:** If the return is NOT NULL and the caller decides not to allow the ‘Select’ for some other reason, the caller MUST free the structure by calling **`mvlu_sbo_ctrl_free`** and passing this pointer as the argument.

Additional Note: The **SBOw** is a structure, so several leaf functions are called when it is written. It is most efficient if this function is only called from one of those leaf functions. The sample code in **userleaf.c** calls it only when the mandatory **Check** attribute is being written.

mvl61850_ctl_chk_state

Usage: This function checks the value of **`ctlModel`**, etc. to determine if the control is the right type and in the right state to allow writing of the **`Oper`** structure. It should be called from the user "leaf" function for writing components of the **`Oper`** structure.

Function Prototype: `ST_RET mvl61850_ctl_chk_state (MVLU_WR_VA_CTRL *mvluWrVaCtrl);`

Parameters:

`mvluWrVaCtrl` This is a pointer to a **`MVLU_WR_VA_CTRL`** structure. The caller should use the same pointer that was passed to the "leaf" function.

Return Value: `ST_RET`

`SD_SUCCESS` if **`Oper`** may be written.

`SD_FAILURE` if **`Oper`** may not be written. In this case, this function also sets the appropriate **`Error`** and **`AddCause`** members of **`mvluWrVaCtrl ->wrVaCtrl->LastApplError`**. These values are used to automatically send the LastApplError InformationReport required by IEC 61850.

mvl61850_beh_stval_rd_ind

Usage: This function may be used as the "leaf" function for reading the **`stVal`** component of the **`Beh`** attribute in an IEC 61850 server application. It computes the value of **`stVal`** based on the values of **`Mod$stVal`** according to the rules in IEC 61850-7-4.

Note: See **userleaf.c** for an example of how to use this function in an IEC 61850 application.

Function Prototype: `ST_VOID mvl61850_beh_stval_rd_ind (MVLU_RD_VA_CTRL *mvluRdVaCtrl);`

Parameters:

`mvluRDVaCtrl` This is a pointer to a **`MVLU_RD_VA_CTRL`** structure.

Return Value: `ST_VOID` (Ignored)

mvl61850_ctl_command_termination

Usage: This function sends an IEC 61850 Command Termination request to implement controls with “enhanced security”.

Note: See **scl_srvr.c** for an example of how to use this function in an IEC 61850 application.

Function Prototype:

```
ST_RET mvl61850_ctl_command_termination (MVL_NET_INFO              *net_info,
                                          ST_CHAR                   *oper_ref,
                                          ST_RET                    status,
                                          MVL61850_LAST_APPL_ERROR  *last_appl_error);
```

Parameters:

`net_info`	This is a pointer to a **`MVL_NET_INFO`** structure identifies the connection on which to send the message.
`oper_ref`	This is the ObjectReference for the **`Oper`** attribute being controlled.
`status`	Indicates the completion status for the control (**`SD_SUCCESS`** or **`SD_FAILURE`**)
`last_appl_error`	This is a pointer to a **`MVL61850_LAST_APPL_ERROR`** structure containing the data to be sent in the **`LastApplError`** variable of the CommandTermination request if the completion status is **`SD_FAILURE`**. If the completion status is **`SD_SUCCESS`**, this data is not used.

Return Value: `ST_RET` `SD_SUCCESS` if CommandTermination was sent, or Error.

mvl61850_rpt_ctrl_destroy_all

Usage: This function destroys all IEC 61850 report controls.

Note: See **scl_srvr.c** for an example of how to use this function in an IEC 61850 application.

Function Prototype: `ST_VOID mvl61850_rpt_ctrl_destroy_all ( );`

Parameters: None

Return Value: None

mvlu_rpt_ctrl_destroy_all

Usage: This function destroys all UCA report controls.

Function Prototype: `ST_VOID mvlu_rpt_ctrl_destroy_all ( );`

Parameters: None

Return Value: None

u_mvl61850_ctl_oper_begin

Usage: This call back function must be supplied by the user. It is called from MVL when the **`Oper`** structure is being written. It is called before any "leaf" functions are called for the **`Oper`** attributes.

Note: See **scl_srvr.c** for an example of how to use this function in an IEC 61850 application.

Function Prototype:
```
ST_VOID u_mvl61850_ctl_oper_begin (ST_CHAR *oper_ref);
```

Parameters:

`oper_ref` This is the ObjectReference for the **`Oper`** attribute being controlled.

Return Value: `ST_VOID` (Ignored)

u_mvl61850_ctl_oper_end

Usage: This call back function must be supplied by the user. It is called from MVL when the **`Oper`** structure is being written. It is called after all "leaf" functions are called for the **`Oper`** attributes.

Note: See **scl_srvr.c** for an example of how to use this function in an IEC 61850 application.

Function Prototype:
```
ST_VOID u_mvl61850_ctl_oper_end (MVL_NET_INFO *net_info,
                                 ST_CHAR *oper_ref,
                                 MVL_VAR_ASSOC *base_var);
```

Parameters:

`net_info` This is a pointer to a **`MVL_NET_INFO`** structure that identifies the connection on which to end control.

`oper_ref` This is the ObjectReference for the **`Oper`** attribute being controlled.

`base_var` This is a pointer to a **`MVL_VAR_ASSOC`** structure for the Logical Node that contains the **`Oper`** attribute.

Return Value: `ST_VOID` (Ignored)

Sampled Value Support

Sampled Value ASDU Data Structure (message contains multiple ASDU)

```
typedef struct
  {
  ST_UINT8          *SamplePtr;   /* pointer to "Sample" data           */
  ST_INT            SampleLen;    /* length of "Sample" data in bytes   */
  ST_CHAR           svID [MAX_SMPVAL_SVID_LEN+1]; /* MsvID or UsvID-Vstring65*/
  ST_BOOLEAN        DatSetPres;   /* is "DatSet" present in ASDU?       */
  ST_CHAR           DatSet [MAX_SMPVAL_OBJREF_LEN+1];
                                  /* Vstring129 ObjectReference)        */
                                  /* (Optional)                         */
  ST_UINT16         SmpCnt;
  ST_UINT32         ConfRev;
  ST_BOOLEAN        SmpSynch;
  ST_BOOLEAN        RefrTmPres;   /* is "RefrTm" present in ASDU?       */
  MMS_UTC_TIME      RefrTm;       /* Optional                           */
  ST_BOOLEAN        SmpRatePres;  /* is "SmpRate" present in ASDU?      */
  ST_UINT16         SmpRate;      /* Optional                           */
  } SMPVAL_ASDU;
```

Sampled Value Message Data Structure

```
typedef struct
  {
  ST_UINT16         numASDU;      /* Num ASDU concatenated into one  APDU */
  SMPVAL_ASDU       *asduArray;   /* array of "numASDU" structs          */
                                  /* allocated by smpval_msg_create OR   */
                                  /* allocated during decode             */
  ST_UCHAR          securityBuf [MAX_SMPVAL_SECURITY_LEN]; /* security info */
  ST_UINT           securityLen;  /* len of security info                */
  }SMPVAL_MSG;
```

Functions for sending Sampled Value Messages

smpval_msg_create

Usage: This function allocates and initializes a Sampled Value message structure to store all message data.

Function Prototype: `SMPVAL_MSG *smpval_msg_create (ST_UINT numASDU);`

Parameters:

`numASDU` Number of ASDUs concatenated into one APDU.

Return Value: The function returns a pointer to a **`SMPVAL_MSG`** structure where all message data may be stored.

smpval_msg_destroy

Usage: This function frees up all memory associated with a **SMPVAL_MSG** structure.

Function Prototype: `ST_VOID smpval_msg_destroy (SMPVAL_MSG *smpvalMsg);`

Parameters:

`smpvalMsg` This is a pointer to a **SMPVAL_MSG** structure returned from the **smpval_msg_create** function.

Return Value: This function does not return a value.

smpval_asdu_data_update

Usage: This function updates data stored for one ASDU to be sent in a SMPVAL message.

Function Prototype:

```
ST_RET smpval_asdu_data_update (SMPVAL_MSG      *smpvalMsg,
                                ST_INT          asduIdx,
                                ST_UINT8        *SamplePtr,
                                ST_INT          SampleLen,
                                ST_CHAR         *svID,
                                ST_INT          SmpCnt,
                                ST_BOOLEAN      DatSetPres,
                                ST_CHAR         *DatSet,
                                ST_UINT32       ConfRev,
                                ST_BOOLEAN      SmpSynch,
                                ST_BOOLEAN      RefrTmPres,
                                MMS_UTC_TIME    *RefrTm,
                                ST_BOOLEAN      SmpRatePres,
                                ST_UINT16       SmpRate);
```

Parameters:

`smpvalMsg`	Pointer to a SMPVAL message info structure.
`asduIdx`	Index into array of ASDU for this SMPVAL message.
`SamplePtr`	Pointer to the actual sample data.
`SampleLen`	Length of the sample data in bytes.
`svID`	Pointer to the svID string (system-wide unique identifier) to send in this ASDU.
`SmpCnt`	Sample count value to send in this ASDU. This is incremented each time a new sampling value is taken.
`DatSetPres`	This flag is set to **`SD_TRUE`**, if the optional Data Set should be sent.
`DatSet`	Contains the optional Data Set if the **`DatSetPres`** argument is set to **`SD_TRUE`**.
`ConfRev`	Configuration Revision value to send in this ASDU.
`SmpSynch`	This is the value to send in this ASDU. If this is true, Sampled Values are resynchronized by a clock signal.
`RefrTmPres`	This flag is set to **`SD_TRUE`** if the optional Reference Time should be sent.
`RefrTm`	Contains the optional Reference Time if the **`RefrTmPres`** is set to **`SD_TRUE`**.
`SmpRatePres`	This flag is set to **`SD_TRUE`** if the optional Sample Rate should be sent.
`SmpRate`	Contains the optional Sample Rate is the **`SmpRatePres`** argument is set to **`SD_TRUE`**.

Return Value: `ST_RET` `SD_SUCCESS` If OK, or an error code.

smpval_msg_send

Usage: This function encodes and sends a complete SMPVAL message (APDU plus Ethertype header).

Function Prototype:
```
ST_RET smpval_msg_send (SMPVAL_MSG   *smpvalMsg,
                        ETYPE_INFO   *etypeInfo,
                        ST_UCHAR     *dstMac);
```

Parameters:

`smpvalMsg`	Pointer to a SMPVAL message info structure.
`etypeInfo`	Pointer to the ethertype info.
`dstMac`	Pointer to the destination (Multicast) MAC address.

Return Value: **`SD_SUCCESS`** or an error code.

Functions for Receiving SMPVAL Messages

smpval_msg_decode

Usage: This function decodes a received SMPVAL message and fills in the **SMPVAL_MSG** structure.

Function Prototype:
```
SMPVAL_MSG *smpval_msg_decode (SN_UNITDATA       *sn_req,
                               ETYPE_INFO        *etypeInfo);
```

Parameters:

`sn_req` Pointer to the message to decode.

`etypeInfo` Pointer to an **ETYPE_INFO** structure of where to store decoded Ethertype info.

Return Value: Returns a pointer of type **SMPVAL_MSG**.

smpval_msg_free

Usage: This function must be called to free the **SMPVAL_MSG** structure returned from **smpval_msg_decode**.

Function Prototype:
```
ST_VOID smpval_msg_free (SMPVAL_MSG *smpvalMsg);
```

Parameters:

`smpvalMsg` Pointer to a SMPVAL message info structure to be freed.

Return Value: Ignored

Chapter 8

Configuring IEC 61850 Devices Using SCL

The IEC 61850-6 standard defines a configuration language specifically for electrical substation IEDs (Intelligent Electronic Devices). The configuration language is called Substation Configuration description Language (SCL) and it is based on XML. This chapter explains how to configure IEC 61850 devices using MMS-*Lite* and SCL.

Dynamically Creating IEC 61850 Types from Input Obtained from the SCL File

When using SCL to configure an IEC 61850 Server application, some of the options of the SCL language are not useful. Therefore, the following restrictions are placed on the SCL file used to configure the "IEC 61850 Server:"

- It must contain at least one ***IED*** section and, within that, at least one ***AccessPoint*** section. There must be one ***IED*** element whose "name" attribute matches the **`iedName`** argument passed to **`scl_parse`**. Within that *IED* element, there must be an ***AccessPoint*** element whose "name" attribute matches the **`accessPointName`** argument passed to **`scl_parse`**.

  Note: In the scl_srvr sample application , the ***IEDName*** and ***AccessPointName*** parameters are extracted from **startup.cfg**.

- The ***AccessPoint*** section may contain only the ***Server*** element. The SCL language allows for one ***Server*** element or multiple ***LN*** elements. The ***LN*** element is not well defined, and it may not contain all the information needed to configure a IEC 61850 Server, so it is not allowed.

  Note: Only the necessary information is extracted from the SCL file. The SCL parser skips over large sections of the file.

The following functions allow dynamic creation of IEC 61850 types, Logical Devices, Logical Nodes and Report Control Blocks from input obtained from the SCL file (the SCL file format is defined by IEC 61850-6. The typical user does not need to know anything about the **`SCL_INFO`** structure used to store information extracted from the SCL file, but if needed, it is defined in **scl.h**.

SCL Data Structures

SCL_INFO

This is the main structure for SCL processing. It contains all information extracted from the SCL file to be used for MMS-EASE Lite initialization. This structure may periodically change as more information is extracted from the SCL file to implement new features (e.g. Edition 2 support). This file changes often so please refer to **scl.h** for details.

SCL_OPTIONS

This structure is used to pass optional parameters to the SCL parsing functions (**scl_parse_cid**, **scl_parse_scd_all**, and **scl_parse_scd_filtered**). It allows the user to easily change the parser behavior.

```
typedef struct
  {
  ST_INT forceEdition;           /* 0 = use edition detected in SCL file */
                                 /* 1 = force Edition 1 parsing          */
                                 /* 2 = force Edition 2 parsing          */
  /* NOTE: "includeOwner" should NOT be used if Tissue 807 is approved.  */
  /*       It should only be used as an alternative way to control       */
  /*       inclusion of "Owner" until Tissue 807 is resolved.            */
  ST_BOOLEAN includeOwner;       /* control inclusion of "Owner" in RCBs.*/
  } SCL_OPTIONS;
```

This structure is used to configure options for a Server (NOT configured by SCL).

```
typedef struct
  {
  /* Report configuration parameters.                                    */
  ST_UINT    reportScanRateMs;    /* Report scan rate (millisec)         */
  ST_INT     brcb_bufsize;        /* BRCB buffer size                    */
  /* Log configuration parameters.                                       */
  ST_UINT    logScanRateMs;      /* Log scan rate (millisec)             */
  ST_UINT    logMaxEntries;      /* Max number of Log entries allowed    */
  } SCL_SERV_OPT;
```

This structure is used only by **scl_parse_scd_filtered** to identify a Server to configure.

```
typedef struct
  {
  ST_CHAR    iedName [MAX_IDENT_LEN+1];       /* IED name to find       */
  ST_CHAR    apName  [MAX_IDENT_LEN+1];       /* AccessPoint name to find*/
  } SCL_SERV_CFG;                             /* Config info for 1 Server*/
```

scl_parse

Usage: Completely parses an SCL file and stores all information extracted for a single **AccessPoint** element within a single **IED** element into a single structure.

Function Prototype:

```
ST_RET scl_parse (ST_CHAR     *xmlFileName,
                  ST_CHAR     *iedName,
                  ST_CHAR     *accessPointName,
                  SCL_INFO    *sclInfo);
```

Parameters:

`xmlFileName` Name of SCL file to parse (e.g., sisco_sample.cid).

`iedName` Extract information from the SCL file **ONLY** from the **IED** element whose "name" attribute matches this name. All other **IED** elements are ignored.

`accessPointName` Extract information from the SCL file **ONLY** from the **AccessPoint** element whose "name" attribute matches this name. All other **AccessPoint** elements are ignored. **The AccessPoint element must be contained within the IED element.**

`sclInfo` Pointer to structure in which to store all information extracted from the SCL file. This must point to a previously allocated structure (or possibly a local or global variable). This function completely initializes the structure, so there is no need to calloc or memset the structure before calling this function.

Return Value:

	`ST_RET`	`SD_SUCCESS`	No Error
		`!= SD_SUCCESS`	Error

scl_parse_cid

Usage: Completely parses an SCL file and stores all information extracted for a single **AccessPoint** element within a single **IED** element into a single structure. Basically, this function assumes the input is a CID file (i.e. it only contains one IED). If the input file contains other IEDs, they are ignored. This function is essentially the same as the older **`scl_parse`** function except it includes the **`options`** argument for more flexibility.

Function Prototype:

```
ST_RET scl_parse_cid (ST_CHAR       *xmlFileName,
                      ST_CHAR       *iedName,
                      ST_CHAR       *accessPointName,
                      SCL_OPTIONS   *options,
                      SCL_INFO      *sclInfo);
```

Parameters:

`xmlFileName` Name of SCL file to parse (e.g., **sisco_sample.cid**).

`iedName` Extract information from the SCL file **ONLY** from the **IED** element whose “name” attribute matches this name. All other **IED** elements are ignored.

`accessPointName` Extract information from the SCL file **ONLY** from the **AccessPoint** element whose “name” attribute matches this name. All other **AccessPoint** elements are ignored. **The <u>AccessPoint</u> element must be contained within the <u>IED</u> element.**

`options` Miscellaneous parser options. This may be NULL if no options needed. Please refer to the definition of the **`SCL_OPTIONS`** structure for details.

`sclInfo` Pointer to structure in which to store all information extracted from the SCL file. This must point to a previously allocated structure (or possibly a local or global variable). This function completely initializes the structure, so there is no need to calloc or memset the structure before calling this function.

Return Value:			
	`ST_RET`	`SD_SUCCESS`	No Error
		`!= SD_SUCCESS`	Error

scl_parse_scd_all

Usage: Completely parses an SCL file and stores all information extracted for ALL **AccessPoint** elements and ALL **IED** elements. Basically, this function assumes the input is a SCD file (i.e., it contains multiple IEDs). The information for each IED/AccessPoint "pair" is stored in a **`SCL_SERVER`** structure. The **`SCL_INFO`** structure now contains a pointer to a linked list of **`SCL_SERVER`** structures.

Function Prototype:

```
ST_RET scl_parse_scd_all (ST_CHAR        *xmlFileName,
                          SCL_OPTIONS    *options,
                          SCL_INFO       *sclInfo);
```

Parameters:

`xmlFileName` Name of SCL file to parse (e.g., **sisco_sample_ed2.scd**).

`options` Miscellaneous parser options. This may be NULL if no options needed. Please refer to the definition of the **`SCL_OPTIONS`** structure for details.

`sclInfo` Pointer to structure in which to store all information extracted from the SCL file. This must point to a previously allocated structure (or possibly a local or global variable). This function completely initializes the structure, so there is no need to calloc or memset the structure before calling this function.

Return Value:			
	`ST_RET`	`SD_SUCCESS`	No Error
		`!= SD_SUCCESS`	Error

scl_parse_scd_filtered

Usage: Completely parses an SCL file and stores information extracted for a "**filtered**" set of **IED** and **AccessPoint** elements. This is like **`scl_parse_scd_all`** but it only stores the specified IED/AccessPoint pairs. Also, it only stores the selected types. This function assumes the input is a SCD file (i.e., it contains multiple IEDs). The information for each IED/AccessPoint "pair" is stored in a **`SCL_SERVER`** structure.

Function Prototype:

```
ST_RET scl_parse_scd_filtered (ST_CHAR         *xmlFileName,
                               SCL_OPTIONS     *options,
                               SCL_INFO        *sclInfo,
                               SCL_SERV_CFG    *scl_serv_cfg_arr,
                               ST_UINT         scl_serv_cfg_num,
                               ST_CHAR         **scl_iedtype_cfg_arr,
                               ST_UINT         scl_iedtype_cfg_num);
```

Parameters:

`xmlFileName`	Name of SCL file to parse (e.g., **sisco_sample_ed2.scd**).
`options`	Miscellaneous parser options. This may be NULL if no options needed. Please refer to the definition of the **`SCL_OPTIONS`** structure for details.
`sclInfo`	Pointer to structure in which to store all information extracted from the SCL file. This must point to a previously allocated structure (or possibly a local or global variable). This function completely initializes the structure, so there is no need to calloc or memset the structure before calling this function.
`scl_serv_cfg_arr`	Pointer to an array of Servers to configure. Each Server is identified by an IED/AccessPoint pair. Other Servers will be ignored.
`scl_serv_cfg_num`	Number of elements in **`scl_serv_cfg_arr`**.
`scl_iedtype_cfg_arr`	Pointer to an array of **`iedType`** attributes to configure. If the elements in the **`DataTypeTemplates`** section contain the **`iedType`** attribute, only elements with these **`iedType`** attributes will be used.
`scl_iedtype_cfg_num`	Number of **`iedType`** attributes in the **`scl_iedtype_cfg_arr`**.

Return Value:			
	`ST_RET`	`SD_SUCCESS`	No Error
		`!= SD_SUCCESS`	Error

Comment: You must be very careful with the last 4 arguments. If one of the Servers or **`iedTypes`** can't be found, or if a Server depends on an **`iedType`** that was not specified, this function will fail.

scl_info_destroy

Usage: This function destroys all the info stored in the **SCL_INFO** structure by **scl_parse**, and frees up the associated memory.

Function Prototype: `ST_VOID scl_info_destroy (SCL_INFO *scl_info);`

Parameters:

`scl_info`	This is a pointer to a **SCL_INFO** structure to be destroyed.

Return Value: `ST_VOID` (Ignored)

scl2_datatype_create_all

Usage: Creates MMS Data types for all Logical Node Types (LNodeType) defined in SCL.

Function Prototype:

```
ST_RET scl2_datatype_create_all (MVL_VMD_CTRL  *vmd_ctrl,
                                 SCL_INFO      *sclInfo,
                                 ST_INT        max_rt_num,
                                 ST_BOOLEAN    use_names,
                                 ST_CHAR       *name_prefix);
```

Parameters:

`vmd_ctrl`	A pointer to an **MVL_VMD_CTRL** structure in which to add types.
`sclInfo`	This is the main **SCL_INFO** structure where all the SCL info is stored.
`max_rt_num`	Indicates the maximum number of **RUNTIME_TYPE** for each LNodeType.
`use_names`	This flag if **SD_TRUE**, will generate a name for each type.
`name_prefix`	This is a pointer to unique prefix to add to each type name. This is only used if **use_names==SD_TRUE**.

Return Value: `SD_SUCCESS` or error code

scl2_ld_create_all

Usage: Creates all Logical Devices from information extracted from the SCL file (stored in the **`SCL_INFO`** structure). This includes creating the Logical Device (MMS Domain), and within the Logical Device: all Logical Nodes (MMS variables), all Data Sets (MMS NamedVariableLists), and all ReportControlBlocks.

Note: The functions **`scl_parse`** and **`scl2_datatype_create_all`** must be called first to read the SCL file and initialize the **`SCL_INFO`** structure passed to this function, and to create all MMS Data Types needed by the Logical Device.

Function Prototype:

```
ST_RET scl2_ld_create_all (MVL_VMD_CTRL      *vmd_ctrl,
                           SCL_INFO          *sclInfo,
                           ST_UINT           reportScanRate,

                           ST_INT            brcb_bufsize,
                           ST_BOOLEAN        is_client);
```

Parameters:

`vmd_ctrl`	Pointer to a **`MVL_VMD_CTRL`** structure in which to add Logical Devices.
`sclInfo`	Pointer to structure containing all information extracted from the SCL file (filled in by **`scl_parse`**).
`reportScanRate`	Report Scan Rate (in milliseconds). If this value is not 0 (zero) and Report Control Blocks (RCB) are configured in the SCL file, all members of the Report Data Set will automatically be scanned for data changes at this rate. If this value is 0 (zero), scanning will take place every time **`mvl61850_rpt_service`** is called.
`brcb_bufsize`	Buffer size to use for each buffered report (if configured).
`is_client`	If this flag is set, Client model is created (i.e., Control Blocks NOT created).

Return Value: `SD_SUCCESS` or error code

scl2_ld_create_all_scd

Usage: Creates all Logical Devices from information extracted from the SCL file (stored in the **SCL_INFO** structure). This includes creating the Logical Device (MMS Domain), and within the Logical Device: all Logical Nodes (MMS variables), all Data Sets (MMS NamedVariableLists), and all ReportControlBlocks.

Note: One of the **scl_parse_*** functions and **scl2_datatype_create_all** must be called first to read the SCL file and initialize the **SCL_INFO** structure passed to this function, and to create all MMS Data Types needed by the Logical Device.

Function Prototype:

```
ST_RET scl2_ld_create_all_scd (MVL_VMD_CTRL    vmd_ctrl,
                               SCL_INFO        *scl_info,
                               SCL_SERVER      *scl_server,
                               SCL_SERV_OPT    *serv_opt,
                               ST_BOOLEAN      is_client);
```

Parameters:

vmd_ctrl	Pointer to a **MVL_VMD_CTRL** structure in which to add Logical Devices.
sclInfo	Pointer to structure containing all information extracted from the SCL file (filled in by **scl_parse_cid** or **scl_parse_scd_all**, etc.).
scl_server	Pointer to the server information used to create all MMS Objects.
serv_opt	Pointer to the options for this server. See the definition of **SCL_SERV_OPT** for details. These options were not configurable in the past.
is_client	If this flag is set, Client model is created (i.e., Control Blocks NOT created).

Return Value: SD_SUCCESS or error code

scl2_vmd_create_all

Usage: This function simply automates several SCL initialization steps into one simple function to create ONE Server VMD and multiple Client VMDs. You must first call **`scl_parse_scd_all`** to initialize the **`SCL_INFO`** structure. For each "**Server**" found in the SCD file, it creates a VMD. One "**Server**" must match the **`iedName`** and **`apName`** passed here. It is stored in the global VMD (**`mvl_vmd`**). All other Servers are stored in Client VMDs.

Function Prototype:

```
MVL_VMD_CTRL **scl2_vmd_create_all (SCL_INFO        *sclInfo,
                                    ST_CHAR         *iedName,
                                    ST_CHAR         *apName,
                                    SCL_SERV_OPT    *serv_opt,
                                    ST_UINT         *vmd_count);
```

Parameters:

`sclInfo`	Pointer to structure containing all information extracted from the SCL file (filled in by **`scl_parse_scd_all`**).
`iedName`	Pointer to the IED name of the Server (all other IEDs are configured as Clients).
`apName`	Indicates the AccessPoint name of the Server. If NULL, no Server is configured.
`serv_opt`	The options to use for ALL Servers. See the **`SCL_SERV_OPT`** definition for details.
`vmd_count`	Pointer to the number of VMDs created (i.e., size of array returned).

Return Value: `MVL_VMD_CTRL **` Pointer to an array of VMDs created. These VMDs must be freed by calling **`mvl_vmd_destroy`** before exit (see, for example, **`all_obj_destroy_scd`** in **scl_srvr.c**).

SCL Server Sample Application

The **SCL Server** sample application reads an SCL file (i.e., an input file conforming to the "**S**ubstation **C**onfiguration description **L**anguage" defined in IEC 61850-6). The SCL input is used to dynamically create all MMS objects. All source code and sample configuration files are found in the directory **\mmslite\mvl\usr\scl_srvr**.

This sample application reads the SCL file and creates MMS objects by calling the functions **`scl_parse`**, **`scl2_datatype_create_all`**, and **`scl2_ld_create_all`**. The configuration file, **startup.cfg** is read to get information to pass to **`scl_parse`** (see **startup.c**). This same information could be obtained in many different ways in a real application.

After all MMS objects are created, data mapping is done by calling **`datamap_cfg_read`** to read the file **datamap.cfg** (see **usermap.c**). The user should create this file to contain information to map "leafnames" to "user-defined text". The user-defined text" may then be used in leaf functions. A **`DATA_MAP`** structure (see **usermap.h)** is allocated for each entry (one line of this file) and the entry information is stored in the **`DATA_MAP`** structure. This structure may be accessed in the "read and write leaf functions" as demonstrated in **`u_custom_rd_ind`** and **`u_custom_wr_ind`** (see **userleaf.c**). These two example leaf functions may be customized by the developer to use the **`DATA_MAP`** information to control data access in any way appropriate for the user application. The expected format of this file is three columns separated by tabs. One line of the file is used to store information for one "leaf" by allocating one **`DATA_MAP`** structure and copying the information to it. The columns must contain the following:

COLUMN #1: Domain name
COLUMN #2: Leaf name
COLUMN #3: User text to be used by leaf function

To help to create the **datamap.cfg** file, every time the "SCL Server" application is executed, an output file **datamapout.cfg** is generated that contains all valid entries from this file plus "sample entries" for any "leaf" that is NOT configured in this file. The "sample entries" in **datamapout.cfg** may be copied to this input file and modified to contain the appropriate "User Text" in COLUMN #3.

***IMPORTANT*:** Any time objects are added, deleted, or changed in the SCL Configuration file (**scl.xml**), this file should be updated with the appropriate data mapping.

Note: The use of the **datamap.cfg** input file is only one method to provide data mapping. The user is free to use other data mapping methods if necessary.

datamap_cfg_read

Usage: This optional function reads a data mapping configuration file and maps the data for all variables in the global VMD, **`mvl_vmd`**.

Function Prototype:

```
ST_RET datamap_cfg_read (ST_CHAR       *in_filename
                         ST_CHAR       *out_filename);
```

Parameters:

`in_filename` This is a pointer to the input configuration file name.

`out_filename` This is a pointer to the output configuration file name

Return Value: `ST_RET` `SD_SUCCESS` or an error code.

Comments: The input configuration file is a simple ASCII text file. Each line contains the mapping for a single "leaf" in three columns, as follows:

COLUMN #1: Domain name
COLUMN #2: Leaf name
COLUMN #3: User text to be passed to leaf function

Notes: All the mapping information is passed to every leaf function in a **`DATA_MAP`** structure. See **`u_custom_rd_ind`** in **userleaf.c** to see how this structure may be accessed.

If the user's leaf functions do not need the information configured by this function, then this function need not be called.

datamap_cfg_destroy

Usage: This function removes all mappings created by the **`datamap_cfg_read`** function and frees the associated buffers.

Function Prototype: `ST_VOID datamap_cfg_destroy ();`

Parameters: None

Return Value: `ST_VOID` (Ignored)

CRITICAL NOTE: This must be called ***BEFORE*** the variables are removed, or it will be impossible to remove the mapping.

Chapter 9

IEC 61850 GOOSE Support

General GOOSE Information

The Generic Object Oriented Substation Event (GOOSE), as defined by IEC 61850, is a special message sent to multiple destinations using the multicast capability of the Ethernet MAC layer. The data to be sent in the GOOSE message, as well as the timing is defined in IEC 61850.

Subnetwork functions used for IEC 61850 GOOSE Support

The following Subnetwork functions are used for supporting IEC 61850 GOOSE. Please refer to *H: Subnetwork API* for detailed information on these functions.

`clnp_snet_read` - this function reads a PDU from the subnetwork.

`clnp_snet_free` - this function frees up subnetwork resources associated with a received PDU.

`clnp_snet_write_raw` - this function writes a PDU to the subnetwork.

`clnp_snet_set_multicast_filter` (or **`gse_set_multicast_filter`**) - This function enables the reception of multicast packets (including GOOSE messages) by the Ethernet driver.

`etype_hdr_decode` - Decodes the header of a “Tagged MAC Frame”, as defined in IEEE 802.3. The “Tagged MAC Frame” is commonly referred to as an “Ethertype frame”.

`etype_hdr_encode` -Encodes the header of a “Tagged MAC Frame” (i.e., Ethertype frame).

The following two functions may be used to assist in finding all available sources of GOOSE messages on a sub-network (i.e., “GOOSE Discovery Mode”). These functions may be very useful in applications where the user dynamically chooses the GOOSE messages to accept.

`clnp_snet_rx_all_multicast_start` (or **`gse_discovery_start`**) - This function enables the reception of “ALL multicast” packets by the Ethernet driver so that ALL incoming multicast packets (including GOOSE messages) are accepted. The driver remains in this mode until **`clnp_snet_rx_all_multicast_stop`** is called. When a GOOSE message is received, an application may check the destination MAC address, GoCBRef, or other parameters and decide whether to subscribe for that GOOSE. To subscribe, it should add the destination MAC to the list of addresses passed later to **`clnp_snet_set_multicast_filter`**.

`clnp_snet_rx_all_multicast_stop` (or **`gse_discovery_stop`**) - This function disables the reception of “ALL multicast” packets by the Ethernet driver.

The following macros are provided for more consistent naming:

```
#define gse_set_multicast_filter        clnp_snet_set_multicast_filter
#define gse_discovery_start             clnp_snet_rx_all_multicast_start
#define gse_discovery_stop              clnp_snet_rx_all_multicast_stop
```

IEC GOOSE

IEC GOOSE Decode Data Structures

```
typedef struct
  {
  ST_CHAR            *dataRef;
  ST_INT32           elementId;
  ST_UINT8           *asn1Ptr;
  ST_INT             asn1Len;
  } GSE_IEC_DATA_ENTRY_RX;

typedef struct
  {
  ST_CHAR            *gcRef;
  ST_UINT32          timeToLive;
  ST_CHAR            *dataSetRef;
  ST_CHAR            *appID;
  MMS_UTC_TIME       utcTime;
  ST_UINT32          stNum;
  ST_UINT32          sqNum;
  ST_BOOLEAN         test;
  ST_INT32           confRev;
  ST_BOOLEAN         needsCommissioning;
  ST_INT8            sendMode;
  ST_INT32           numDataEntries;
  ST_INT             tmpIndex; /*index to current entry in "dataEntries" array*/
                            /* Used during decode when filling in"dataEntries".*/
  GSE_IEC_DATA_ENTRY_RX    *dataEntries;       /* ptr array data entry structs*/
  } GSE_IEC_HDR;
```

IEC GOOSE Decode Functions

The IEC GOOSE decode is invoked by the user application. The complete decode requires calling at least three functions, **`gse_iec_hdr_decode`**, **`ms_asn1_to_local`**, and **`gse_iec_decode_done`**.

Header Decode Function

gse_iec_hdr_decode

Usage: This function decodes the header of a IEC GOOSE message, but not the data.

Function Prototype: `GSE_IEC_HDR *gse_iec_hdr_decode (SN_UNITDATA *sn_udt);`

Parameters:

`sn_udt` A pointer to a **`SN_UNITDATA`** structure containing the input IEC GOOSE message.

Return Value: `(GSE_IEC_HDR *)` A pointer to a structure allocated by the function, containing the output (i.e., decoded) IEC GOOSE header data. This pointer must be freed when it is no longer in use, by calling **`gse_iec_decode_done.`**

Data Decode Function

The function **ms_asn1_to_local** may be called to convert data from the ASN.1 representation to the "local" representation (i.e., the format expected by the "C" compiler). Information from the **dataEntries** element of the **GSE_IEC_HDR** structure may be used as the **asn1Ptr** and **asn1Len** arguments to this function.

ms_asn1_to_local

Usage: This function converts data from the ASN.1 representation to the "local" representation (i.e. the format expected by the "C" compiler). This function may safely be called from multiple threads simultaneously.

Function Prototype:

```
ST_RET ms_asn1_to_local (RUNTIME_TYPE   *runtimeTypeHead,
                         ST_INT         numRuntimeTypes,
                         ST_UCHAR       *asn1Ptr,
                         ST_INT         asn1Len,
                         ST_CHAR        *localData);
```

Parameters:

runtimeTypeHead	Pointer to array of Runtime Type structures.
numRuntimeTypes	Number of Runtime Type structures in array.
asn1Ptr	Pointer to the ASN1 encoding of this data value.
asn1Len	Length of the ASN1 encoding of this data value.
localData	Pointer to local data. The decoded results are placed here.

Return Value:

ST_RET	SD_SUCCESS	No Error
	= SD_SUCCESS	Error

Decode Done Function

gse_iec_decode_done

Usage: This function frees up all resources for the received IEC GOOSE message. This function should not be called until the message has been completely processed and the resources are no longer needed.

Function Prototype:

```
ST_RET gse_iec_decode_done (GSE_IEC_HDR *hdr);
```

Parameters:

hdr	A pointer to the structure allocated by a previous call to the **gse_iec_hdr_decode** function. This pointer must be freed when it is no longer in use, by calling **gse_iec_decode_done**.

Return Value:

ST_RET	SD_SUCCESS	No Error
	!= SD_SUCCESS	Error

IEC GOOSE Encode Data Structures

```
typedef struct
  {
  ST_CHAR                  *dataRef;
  ST_INT                   elementId;
  struct runtime_type      *runtimeTypeHead;   /* Array of Runtime Types  */
  ST_INT                   numRuntimeTypes;    /*# Runtime Types in array */
  ST_CHAR                  *dataBuf;           /* ptr to local data       */
  ST_VOID                  *userInfo;   /* store anything user wants.     */
                                        /* GSE code does not use it.      */
  } GSE_IEC_DATA_ENTRY;


typedef struct
  {
  ST_CHAR                  *gcRef;
  ST_UINT32                timeToLive;
  ST_CHAR                  *dataSetRef;
  ST_CHAR                  *appID;
  MMS_UTC_TIME             utcTime;
  ST_UINT32                stNum;
  ST_UINT32                sqNum;
  ST_BOOLEAN               test;
  ST_INT                   confRev;
  ST_BOOLEAN               needsCommissioning;
  ST_INT8                  sendMode;
  ST_INT                   numDataEntries;
  GSE_IEC_DATA_ENTRY       *dataEntries;/* array of data entry structs    */
  } GSE_IEC_CTRL;
```

IEC GOOSE Encode Functions

gse_iec_control_create

Usage: This function creates a IEC GOOSE control block and initializes the **gcRef**, **dataSetRef**, **appId**, and **numDataEntries** elements. It also allocates an array of "data entry" control structures for the number of data entries requested (i.e., numDataEntries). It also stores a pointer to the "data entry" array in the **dataEntries** element of **GSE_IEC_CTRL**.

Function Prototype:

```
GSE_IEC_CTRL *gse_iec_control_create (ST_CHAR  *gcRef,
                                      ST_CHAR  *dataSetRef,
                                      ST_CHAR  *appId,
                                      ST_INT   numDataEntry);
```

Parameters:

`gcRef`	String to encode as gcRef in the IEC GOOSE message.
`dataSetRef`	String to encode as dataSetRef in the IEC GOOSE message.
`appId`	String to encode as appId in the IEC GOOSE message.
`numDataEntries`	Number of Data Entries to be included in the IEC GOOSE message.

Return Value:

`(GSE_IEC_CTRL *)`	`!=NULL`	Pointer to control block created.
	`NULL`	Control block could NOT be created.

Comments: The **dataEntries** array in **GSE_IEC_CTRL** is NOT initialized. The function **gse_iec_data_init** must be called for each element of the **dataEntries** array to initialize each data entry.

gse_iec_control_destroy

Usage: This function destroys the resources reserved through the **gse_iec_control_create** function.

Function Prototype: `ST_RET gse_iec_control_destroy (GSE_IEC_CTRL *gptr);`

Parameters:

`gptr` Pointer to IEC GOOSE control structure returned by **gse_iec_control_create**.

Return Value:

`ST_RET`	`SD_SUCCESS`	Success
	`!= SD_SUCCESS`	Error

gse_iec_data_init

Usage: This function initializes a Data Entry in an existing IEC GOOSE control block.

Function Prototype:

```
ST_RET gse_iec_data_init (GSE_IEC_CTRL          *ctrl,
                          ST_INT                index,
                          struct runtime_type   *runtimeTypeHead,
                          ST_INT                numRuntimeTypes);
```

Parameters:

`ctrl` Pointer to the IEC GOOSE control structure containing the Data Entry. This must point to a control structure created by **`gse_iec_control_create`**.

`index` Index into array of Data Entry control structures. This value must be less than **`numDataEntries`** passed to **`gse_iec_control_create`**.

`runtimeTypeHead` Pointer to array of Runtime types describing this dataEntry.

`numRuntimeTypes` Number of Runtime Types in array.

Return Value: `ST_RET`

`SD_SUCCESS`	Data entry initialized successfully.
`!= SD_SUCCESS`	Error code.

gse_iec_data_update

Usage: This function may be used to update the data stored for a single data entry in the IEC GOOSE control structure. Repeated calls are allowed in order to change multiple Data Entries, or to change a single data entry many times. This mechanism allows the Application to determine which values have changed and to update those values only.

Before calling this function, **`gse_iec_data_init`** must be called for this Data Entry.

Function Prototype:

```
ST_RET gse_iec_data_update (GSE_IEC_CTRL    *ctrl,
                            ST_INT          index,
                            ST_VOID         *dataPtr);
```

Parameters:

`ctrl` A pointer to a structure containing IEC GOOSE control information. This must point to a control structure created by **`gse_iec_control_create`**.

`index` Index into array of Data Entries.

`dataPtr` Pointer to “local data” (i.e., normal “C” data) to be saved for this Data Entry.

Return Value: `ST_RET`

`SD_SUCCESS`	Data entry updated successfully.
`<>SD_SUCCESS`	Error code.

Comments: This function does not convert the data to ASN.1 (that is done by **`gse_iec_encode`**). Therefore, it may be called many times to update the data as it changes, with very little overhead. The size of the data to be saved is determined from the **`runtime_type`** passed to **`gse_iec_data_init`**. Therefore, it is critical that the **`runtime_type`** must correctly define the data format.

Encoding a IEC GOOSE

gse_iec_encode

Usage: This function encodes an IEC 61850 GOOSE based upon a previously created and initialized control block.

Function Prototype:

```
ST_UCHAR *gse_iec_encode (GSE_IEC_CTRL  *ctrl,
                          ST_UCHAR      *EncBuf,
                          ST_INT        EncBufLen,
                          ST_INT        *pEncPduLen,
                          ETYPE_INFO    *etype_info);
```

Parameters:

`ctrl`	A pointer to a structure containing IEC GOOSE control information. This must point to a control structure created by **`gse_iec_control_create`**.
`EncBuf`	A pointer to a buffer into which the GOOSE message will be encoded.
`EncBufLen`	The size of the encode buffer.
`pEncPduLen`	Pointer to length of ASN.1 encoded IEC GOOSE PDU. This is an “output” parameter. The function saves the encoded length at this address.
`etype_info`	Pointer to a structure to contain the Ethertype header information to be encoded.

Return Value:	`(ST_UCHAR*)`	`NULL`	Encode error
		`!= NULL`	Pointer to encoded GOOSE PDU.

Comments: If the data cannot be encoded according to the **`RUNTIME_TYPE`** passed to **`gse_iec_data_init`**, this function will fail.

The encoded GOOSE message may be sent by simply calling **`clnp_snet_write_raw`**.

Chapter 10

IEC 61850 GSSE (same as UCA 2.0 GOOSE)

The IEC 61850 GSSE message, as defined by IEC 61850 (same as UCA Version 2.0 GOOSE) is sent over the Connectionless OSI stack to multiple destinations using the multicast capability of the Ethernet MAC layer. The data to be sent in the message, as well as the timing is defined in IEC 61850 and UCA 2.0. This section describes how to send and receive GSSE messages using the functions of MMS-*Lite*.

Receiving GSSE Messages

The sub-network interface function **`clnp_snet_set_multicast_filter`** must be called to enable the reception of multicast GSSE packets. It must be called during initialization, after calling **`mvl_start_acse`**. If the Ethernet driver is already set to promiscuous mode, this function does not need to be written or called.

When a multicast packet (not destined for “ALL-ES” or “ALL-IS”) is received, it is assumed to be a GSSE message. It is passed to the Connectionless OSI stack. The stack decodes the packet, but does not validate any of the addressing information (i.e., PSEL, SSEL, TSEL, NSAP, and MAC). When decoding is complete, the user function **`u_mmsl_goose_received`** is called.Incoming GSSE messages are received and processed as follows:

1. The user application must periodically call subnet_serve to receive incoming packets. This may be done from any thread.
2. The file **subnet.c** must be compiled with **`GSSE_RX_SUPP`** defined to enable the GSSE reception code.
3. If a GSSE Packet is received and successfully decoded, the user callback function **`u_mmsl_goose_received`** is called. This function is passed the decoded GSSE information, which is valid only during the function call (the user must copy the data if required for later processing).

Sending GSSE Messages

To send a GSSE message, simply call the function **`mmsl_send_goose`**. This can be done from the “main” thread or from any other thread. If this is done from another thread, however, the “stack” library must be compiled with **`S_MT_SUPPORT`** defined. This is necessary to make sure the eventual call to **`clnp_write`** is threadsafe.

Porting Issues

Complete the instructions in each of the following sections for successful porting.

GSSE Source Code

The source file **goose.c** in the directory **\mmslite\uca\goose**, must be included in the “stack” makefile (i.e., **ositpxs.mak**).

GSSE Header File

The header file **goose.h** in the directory **\mmslite\inc**, must be included in any user source modules that will be performing GSSE processing.

GLBSEM subsystem

If the multi-threading features are to be used, the source file **glbsem.c** must be ported to the target operating system.

Makefile changes

If multiple threads are used, the following changes must be made to makefiles (or “vcproj” files for Windows):

mem.mak	Add **`-D S_MT_SUPPORT`**
slog.mak	Add **`-D S_MT_SUPPORT`**
util.mak	Add **`-D S_MT_SUPPORT`**. Add **glbsem.c**.

Application changes

- **`clnp_snet_set_multicast_filter`** must be called AFTER **`mvl_start_acse`** to receive multicast packets.
- The user callback function **`u_mmsl_goose_received`** must be written to examine the GSSE packets received. A very simple example is included.
- **`mmsl_send_goose`** must be called to send a GSSE packet.

GSSE Data Structures

```
typedef struct
  {
  ST_UCHAR   loc_mac [CLNP_MAX_LEN_MAC];/* local MAC address            */
  ST_UCHAR   rem_mac [CLNP_MAX_LEN_MAC];/* remote MAC address           */
  ST_UINT16  lpdu_len;                  /* Length of LPDU.              */
  ST_UCHAR  *lpdu;                      /* Pointer to LPDU buffer to send*/
  }SN_UNITDATA;

typedef struct tagAUDT_APDU
  {
  /* The following entries passed to peer in AUDT-apdu.                 */
  /* ACSE sets and checks "protocol-version".  Must be "version1".      */
  ST_BOOLEAN ASO_context_name_pres;
  MMS_OBJ_ID ASO_context_name;
  AE_TITLE   called_ae_title;
  AE_TITLE   calling_ae_title;
  BUFFER     user_info;                 /* User must encode/decode      */

  /* The following entries passed to or received from presentation.     */
  PRES_ADDR  calling_paddr;
  PRES_ADDR  called_paddr;

  /* User doesn't need to set loc_mac before calling a_unit_data_req    */
  /* Decode process fills in loc_mac before calling u_a_unit_data_ind   */
  ST_UCHAR   loc_mac  [CLNP_MAX_LEN_MAC];     /* Local MAC addr         */
  ST_BOOLEAN rem_mac_valid;                   /* SD_TRUE ifMAC addr valid*/
  ST_UCHAR   rem_mac  [CLNP_MAX_LEN_MAC];     /* Remote MAC addr        */
  } AUDT_APDU;

typedef struct
  {
/* GSSE Stack addressing information                                    */
  AUDT_APDU audtApdu;
```

```
/* GSSE MMS values                                                     */
  ST_CHAR    SendingIED[66];
  MMS_BTOD   t;
  ST_UINT32  SqNum;
  ST_UINT32  StNum;
  ST_UINT32  HoldTim;
  ST_UINT32  BackTim;
  ST_UINT16  PhsID;

  ST_INT num_dna_bits;
  ST_UCHAR   DNA[GOOSE_MAX_NUM_DNA_BITS/8];

  ST_INT     num_usr_bits;
  ST_UCHAR   UserSt[GOOSE_MAX_NUM_USR_BITS/8];
  } GOOSE_INFO;
```

`SendingIED` The SendingIED uniquely names the device reporting to GSSE. A given reporting IED may handle several devices.

`t` The time in milliseconds of the substation event. This time changes each time a substation event occurs.

`SqNum` This sequence number is incremented by one each time a message is sent. It rolls over after the max count is reached.

`StNum` This state number is incremented by one each time an IED sends information that is new.

`HoldTim` Hold time. The time that a particular message (status) is held before it is canceled. Cancellation, depending on the status reported, may result in an automatic reset of the conditions (i.e., a BFI timer is canceled or the removal of a "block" condition). In order for the status conditions within the message to remain valid, a repeat of the message must be received before the hold time expires. The hold time is incremented each time the message is sent and may follow geometric progression (e.g., 10, 20, 30, 40, 50 .... up to a maximum of one minute). The timers and progressions are parameterized. The progression timers reset when a new GSSE is created.

`BackTim` This is the microsecond offset beteen the time **`t`** and the actual time of the substation event.

`PhsID` This integer value defines which Phases are involved. GOMSFE defines these as follows.

Value	**Name**
0	*None*
1	*Phase*
2	*Phase B*
3	*Phase C*
4	*Ground Only*
5	*A to Ground*
6	*B to Ground*
7	*C to Ground*
8	AB
10	*CA*
11	*AB to Ground*
12	*BC to Ground*
13	*CA to Ground*
14	*ABC*
15	*ABC to Ground*

`num_dna_bits` This is the number **n** of bits to send in the DNA bitstring numbered 0 to n.

`DNA`	DNA is a single message that conveys all genetically required protection scheme information regarding an individual IED. This message uniquely reports the status of the described elements resident in the ***transmitting*** IED to its peers per the enrollment list. Please refer to the GOOSE Message Section of GOMSFE for values of bit pairs.
`num_usr_bits`	This is the number **n** of bits to send in the User Status bitstring numbered 0 to n.
`UserSt`	These bit pairs are user defined and are available for statuses not covered in the DNA. Their meaning is assumed to be known and understood between applications exchanging them.

GSSE Handling Functions

mvl_init_audt_addr

Usage: This function is used to get connectionless addressing information for later use when sending GSSE messages. The calling and called AE Title and P-Address information are copied to the **`AUDT_APDU`** structure from local and remote DIB entry information. The MMS AP context of {1,0,9506,2,3} is assigned to the **`ASO_context_name`** of the **`AUDT_APDU`**.

Function Prototype:

```
ST_RET mvl_init_audt_addr (AUDT_APDU     *audt,
                           ST_CHAR       *localArName,
                           ST_CHAR       *remoteArName)
```

Parameters:

`audt`	This output parameter contains **`AUDT_APDU`** information useful for copying to the **`audtApdu`** field of the **`GOOSE_INFO`** before sending a GSSE message.
`locArName`	This is the ASCII character string of a local DIB entry used for the *calling* **`AUDT_APDU`** information.
`remARName`	This is the ASCII character string of a remote DIB entry sed for the *called* **`AUDT_APDU`** information.

Return Value:

`ST_INT`	`SD_SUCCESS`	Initialization was OK.
	`MVLE_LOCAL_NAME`	**`locArName`** not found in local DIB.
	`MVLE_REMOTE_NAME`	**`remArName`** not found in local DIB.

mmsl_send_goose

Usage: This function is called to broadcast a GSSE message. It may be called from any thread, but due to the critical nature of PACT, it is recommended to call this function from a separate thread as soon as the substation event occurs.

Function Prototype:

```
ST_RET mmsl_send_goose (GOOSE_INFO *gi);
```

Parameters:

`gi`	A pointer to a **`GOOSE_INFO`** structure that is the source information for the GSSE message. The **`GOOSE_INFO`** structure is defined in **goose.h**.

Return Value:

`ST_RET`	`SD_SUCCESS`	The GSSE message was sent OK.
	`<>0`	Error code.

u_mmsl_goose_received

Usage: This user function is called when a GSSE message is received. This function must be written by the user to examine and/or process the information received in the GSSE message.

Function Prototype: `ST_VOID u_mmsl_goose_received (GOOSE_INFO *goose_info);`

Parameters:

`goose_info` A pointer to a **`GOOSE_INFO`** structure that contains the GSSE information received from the network.

Return Value: `ST_VOID`

Alternate GSSE Reception Mode

Applications that need to receive GSSE messages, but do not need to support the 7-layer OSI stack, may be able to use the following method to receive the GSSE messages. This method allows the programmer more direct control of the reception and decoding of subnetwork packets containing GSSE messages.

Receiving GSSE Messages

1. The sub-network interface function **`clnp_snet_set_multicast_filter`** must be called to specify a list of multicast MAC addresses to be accepted. This function enables the reception of multicast packets addressed to a set of multicast MAC addresses selected by the user.
2. The function **`clnp_snet_read`** must be called periodically to receive packets from the network.
3. The destination MAC address and the LLC LSAP in the packet may be examined to determine if the packet contains a GSSE message. The user may choose to process any packets of interest. The packets may be stored for later processing (e.g., on a queue or a linked list) or they may be processed immediately.
4. If a received packet contains a GSSE message, the function **`gse_uca_decode`** may be called to decode the packet. This function places the decoded information in a **`GOOSE_INFO`** structure to be examined by the user.
5. If desired, the user code may perform additional processing on the GSSE data contained in the **`GOOSE_INFO`** structure.
6. The function **`clnp_snet_free`** must be called to free the Ethernet packet after all processing is complete.

Additional Functions for Alternate GSSE Reception Mode

gse_uca_decode

Usage: This function decodes the received GSSE packet from the subnetwork layer up through the application layer.

Function Prototype:

```
ST_RET gse_uca_decode (SN_UNITDATA      *sn_udt,
                       GOOSE_INFO       *goose_info);
```

Parameters:

`sn_udt`	This is a packet received from the subnetwork interface.
`goose_info`	This is a pointer to a **`GOOSE_INFO`** structure to contain the result of the decode.

Return Value:	`ST_RET`	`SD_SUCCESS`	The GSSE message was decoded correctly.
		`<>0`	Error code.

Chapter 11

IEC 61850 GSE Management

GSE Request Data Structures

GSE Offset Request Structure

The “GSE Offset” request functions pass a pointer to this structure.

```
typedef struct
   {
    ST_UINT32    stateID;                    /* Reference ID assign by client.*/
    ST_CHAR      ident [MAX_VSTRING_BUF+1]; /* Description string.          */
    ST_INT       numVStrings;                /* No of strings in references   */
                                             /* array.                        */
    ST_CHAR      **references;               /* References array.             */
    } GSE_OFFSET_REQ;
```

GSE Reference Request Structure

The “GSE Reference” request functions pass a pointer to this structure.

```
typedef struct
   {
   ST_UINT32    stateID;                    /* ReferenceID assign by client.  */
   ST_CHAR      ident [MAX_VSTRING_BUF+1]; /* Description string.            */
   ST_INT       numIntegers;                /* No integers in offset array.   */
   ST_UINT32    *offset;                    /* Array of offsets.              */
   } GSE_REF_REQ;
```

GSE Response Structures

GSE Global Error Response Structure

The “GSE Global Error” response functions pass a pointer to this structure.

```
typedef struct
   {
   ST_UINT32 stateID;                       /* ReferenceID assign by client. */
   ST_CHAR   ident [MAX_VSTRING_BUF+1];     /* Description string.           */
   ST_UINT32 confRev;                       /* Configuration revision.       */
   ST_UINT32 glbError;                      /* This var can be GLB_ERR_OTHER */
                    /* GLB_ERR_UNKNOWN_CTRL_BLK, GLB_ERR_RSP_TOO_LARGE,   */
                    /* or GLB_ERR_CTRL_BLK_CONFIG_ERR.                    */
   } GSE_GLB_ERR_RSP;
```

GSE Offset Response Structure

This structure is used in the **GSE_OFFSET_RSP** structure.

```
typedef struct
   {
   ST_INT       rsp_type;    /* SD_SUCCESS if offset,or SD_FAILURE if error.*/
   ST_UINT32    offset;      /* offset is set if rsp_type = SD_SUCCESS.    */
   ST_UINT32    error;       /* error is set if rsp_type = SD_FAILURE.     */
   } OFFSET_REQ_RESULTS;
```

The “GSE Offset” response functions pass a pointer to this structure.

```
typedef struct
   {
   ST_UINT32           stateID;     /* Reference ID assigned by client.     */
   ST_CHAR             ident [MAX_VSTRING_BUF+1]; /* Description string.    */
   ST_UINT32           confRev;     /* Configuration revision.              */
   ST_CHAR             datSet [MAX_VSTRING_BUF+1]; /* Data set description. */
   ST_INT              numResults;  /* Number of results in result array.   */
   OFFSET_REQ_RESULTS  *result;     /* Request result array.                */
   } GSE_OFFSET_RSP;
```

GSE Reference Response Structure

Used in the **GSE_REF_RSP** structure.

```
typedef struct
   {
   ST_INT       rsp_type;    /* SD_SUCCESS if reference,SD_FAILURE if error */
   ST_CHAR      reference [MAX_VSTRING_BUF+1];  /* Set for ref response.    */
   ST_UINT32    error;       /* error is set if rsp_type = SD_FAILURE.      */
   } REF_REQ_RESULTS;
```

The “GSE Reference” response functions pass a pointer to this structure.

```
typedef struct
   {
   ST_UINT32    stateID;            /* Reference ID assigned by client.     */
   ST_CHAR      ident [MAX_VSTRING_BUF+1];       /* Description string.     */
   ST_UINT32    confRev;                         /* Configuration revision. */
   ST_CHAR      datSet [MAX_VSTRING_BUF+1];      /* Data set description.   */
   ST_INT       numResults;        /* Number of results in result array.    */
   REF_REQ_RESULTS *result;         /* Request result array.                */
   } GSE_REF_RSP;
```

GSE Management Message Data Structure

This structure contains all information decoded from a received GSE Management message.

```
typedef struct
   {
   ST_UINT32    stateID;      /* Reference ID assign by client.            */
   ST_INT       msgType;      /* Set to following values when message      */
                              /* is decoded.  Used to free memory          */
                              /* allocated for various msg structs.        */
                              /* Valid message types are:                  */
                              /* GSE_MSG_TYPE_GOOSE_ELE_REQ,               */
                              /* GSE_MSG_TYPE_GS_REF_REQ,                  */
                              /* GSE_MSG_TYPE_GSSE_DATA_OFF_REQ,           */
                              /* GSE_MSG_TYPE_GO_REF_RSP,                  */
                              /* GSE_MSG_TYPE_GOOSE_ELE_RSP,               */
                              /* GSE_MSG_TYPE_GS_REF_RSP,                  */
                              /* GSE_MSG_TYPE_GSSE_DATA_OFF_RSP, or        */
                              /* GSE_MSG_TYPE_GLOBAL_ERROR_RSP.            */

     union GSE_MSG {          /* Union of all GSE messages.                */
       GSE_REF_REQ     refReq;      /*msgType = GSE_MSG_TYPE_GO_REF_REQ or  */
                                    /* GSE_MSG_TYPE_GS_REF_REQ.             */
       GSE_OFFSET_REQ  offReq;      /*msgType=GSE_MSG_TYPE_GOOSE_ELE_REQ or */
                                    /* GSE_MSG_TYPE_GSSE_DATA_OFF_REQ.      */
       GSE_OFFSET_RSP  offRsp;      /*msgType=GSE_MSG_TYPE_GOOSE_ELE_RSP or */
                                    /* GSE_MSG_TYPE_GSSE_DATA_OFF_RSP.      */
       GSE_REF_RSP     refRsp;      /*msgType = GSE_MSG_TYPE_GO_REF_RSP or  */
                                    /* GSE_MSG_TYPE_GS_REF_RSP.             */
       GSE_GLB_ERR_RSP glbErrRsp;   /*msgType=GSE_MSG_TYPE_GLOBAL_ERROR_RSP.*/
       } msg;
   } GSE_MGMT_MSG;
```

GSE Management Message Encode Functions

getGlbErrorRspEncode

Usage: This function encodes the GSE Management Global Error response, including the 14 byte Ethertype header. The parameters in the **(GSE_GLB_ERR_RSP *)** and **(ETYPE_INFO *)** structures must be filled in before this function is called. The (**ST_UCHAR ***) argument passed to this function points to the encode buffer and **asn1DataBufLen** parameter contains the length of the buffer. The function returns a pointer to the ASN1 encoded message and **asn1DataLenOut** points to the length of the ASN1 encoded buffer.

Include: gse_mgmt.h

Function Prototype:

```
ST_UCHAR * getGlbErrorRspEncode (GSE_GLB_ERR_RSP   *ctrl,
                                 ST_UCHAR          *asn1DataBuf,
                                 ST_INT            asn1DataBufLen,
                                 ST_INT            *asn1DataLenOut,
                                 ETYPE_INFO        *etype_info,
                                 ST_UINT8          *dstMac,
                                 ST_UINT8          *srcMac);
```

Parameters:

`ctrl`	This parameter points to a **GSE_GLB_ERR_RSP** data structure.
`asn1DataBuf`	This parameter points to the buffer to be used for the ASN1 message encoding.
`asn1DataBufLen`	This parameter contains the size of the ASN1 buffer in bytes.
`asn1DataLenOut`	This parameter points to the length of the ASN1 encoded message buffer when the function returns.
`etype_info`	This parameter points to an **ETYPE_INFO** structure.
`dstMac`	This parameter points to a destination MAC address.
`srcMac`	This parameter points to a source MAC address.

Return Value: The function returns a (**ST_UCHAR ***) pointer to the ASN1 encoded message buffer.

getGoRefReqEncode

Usage: This function encodes the GSE Management Go Reference request, including the 14 byte Ethertype header. The parameters in the **(GSE_REF_REQ *)** and **(ETYPE_INFO *)** structures must be filled in before this function is called. The (**ST_UCHAR ***) argument passed to this function points to the encode buffer and **asn1DataBufLen** parameter contains the length of the buffer. The function returns a pointer to the ASN1 encoded message and **asn1DataLenOut** points to the length of the ASN1 encoded buffer.

Include: **gse_mgmt.h**

Function Prototype:

```
ST_UCHAR *getGoRefReqEncode (GSE_REF_REQ   *ctrl,
                             ST_UCHAR      *asn1DataBuf,
                             ST_INT        asn1DataBufLen,
                             ST_INT        *asn1DataLenOut,
                             ETYPE_INFO    *etype_info,
                             ST_UINT8      *dstMac,
                             ST_UINT8      *srcMac);
```

Parameters:

`ctrl` This parameter points to a **GSE_REF_REQ** structure. The structure contains a pointer to an array of reference offsets.

`asn1DataBuf` This parameter points to the buffer to be used for the ASN1 message encoding.

`asn1DataBufLen` This parameter contains the size of the ASN1 buffer in bytes.

`asn1DataLenOut` This parameter points to the length of the ASN1 encoded message buffer when the function returns.

`etype_info` This parameter points to an **ETYPE_INFO** structure.

`dstMac` This parameter points to a destination MAC address.

`srcMac` This parameter points to a source MAC address.

Return Value: The function returns a (**ST_UCHAR ***) pointer to the ASN1 encoded message buffer.

getGoRefRspEncode

Usage: This function encodes the GSE Management Go Reference response, including the 14 byte Ethertype header. The parameters in the (**GSE_REF_RSP ***) and (**ETYPE_INFO ***) structures must be filled in before this function is called. The (**ST_UCHAR ***) argument passed to this function points to the encode buffer and **asn1DataBufLen** parameter contains the length of the buffer. The function returns a pointer to the ASN1 encoded message and **asn1DataLenOut** points to the length of the ASN1 encoded buffer.

Include: **gse_mgmt.h**

Function Prototype:

```
ST_UCHAR *getGoRefRspEncode (GSE_REF_RSP   *ctrl,
                             ST_UCHAR      *asn1DataBuf,
                             ST_INT        asn1DataBufLen,
                             ST_INT        *asn1DataLenOut,
                             ETYPE_INFO    *etype_info,
                             ST_UINT8      *dstMac,
                             ST_UINT8      *srcMac);
```

Parameters:

`ctrl` This parameter points to a **GSE_REF_RSP** structure.

`asn1DataBuf` This parameter points to the buffer to be used for the ASN1 message encoding.

`asn1DataBufLen` This parameter contains the size of the ASN1 buffer in bytes.

`asn1DataLenOut` This parameter points to the length of the ASN1 encoded message buffer when the function returns.

`etype_info` This parameter points to an **ETYPE_INFO** structure.

`dstMac` This parameter points to a destination MAC address.

`srcMac` This parameter points to a source MAC address.

Return Value: The function returns a (**ST_UCHAR ***) pointer to the ASN1 encoded message buffer

getGOOSEEleNumReqEncode

Usage: This function encodes the GSE Management GOOSE Element Number request, including the 14 byte Ethertype header. The parameters in the (**GSE_OFFSET_REQ ***) and (**ETYPE_INFO ***) structures must be filled in before this function is called. The (**ST_UCHAR ***) argument passed to this function points to the encode buffer and **asn1DataBufLen** parameter contains the length of the buffer. The function returns a pointer to the ASN1 encoded message and **asn1DataLenOut** points to the length of the ASN1 encoded buffer.

Include: **gse_mgmt.h**

Function Prototype:

```
ST_UCHAR *getGOOSEEleNumReqEncode (GSE_OFFSET_REQ *ctrl,
                                   ST_UCHAR       *asn1DataBuf,
                                   ST_INT         asn1DataBufLen,
                                   ST_INT         *asn1DataLenOut,
                                   ETYPE_INFO     *etype_info,
                                   ST_UINT8       *dstMac,
                                   ST_UINT8       *srcMac);
```

Parameters:

`ctrl` This parameter points to an **GSE_OFFSET_REQ** structure. The structure contains a pointer to an array of visible reference strings. The **numVStrings** variable must be set to the number of visible reference strings in the array.

`asn1DataBuf` This parameter points to the buffer to be used for the ASN1 message encoding.

`asn1DataBufLen` This parameter contains the size of the ASN1 buffer in bytes.

`asn1DataLenOut` This parameter points to the length of the ASN1 encoded message buffer when the function returns.

`etype_info` This parameter points to an **ETYPE_INFO** structure.

`dstMac` This parameter points to a destination MAC address.

`srcMac` This parameter points to a source MAC address.

Return Value: The function returns a (**ST_UCHAR ***) pointer to the ASN1 encoded message buffer.

getGOOSEEleNumRspEncode

Usage: This function encodes the GSE Management GOOSE Element Number request, including the 14 byte Ethertype header. The parameters in the (**`GSE_OFFSET_RSP *`**) and (**`ETYPE_INFO *`**) structures must be filled in before this function is called. The (**`ST_UCHAR *`**) argument passed to this function points to the encode buffer and **`asn1DataBufLen`** parameter contains the length of the buffer. The function returns a pointer to the ASN1 encoded message and **`asn1DataLenOut`** points to the length of the ASN1 encoded buffer.

Include: gse_mgmt.h

Function Prototype:

```
ST_UCHAR *getGOOSEEleNumRspEncode (GSE_OFFSET_RSP *ctrl,
                                   ST_UCHAR       *asn1DataBuf,
                                   ST_INT         asn1DataBufLen,
                                   ST_INT         *asn1DataLenOut,
                                   ETYPE_INFO     *etype_info,
                                   ST_UINT8       *dstMac,
                                   ST_UINT8       *srcMac);
```

Parameters:

`ctrl` This parameter points to an **`GSE_OFFSET_RSP`** structure.

`asn1DataBuf` This parameter points to the buffer to be used for the ASN1 message encoding.

`asn1DataBufLen` This parameter contains the size of the ASN1 buffer in bytes.

`asn1DataLenOut` This parameter points to the length of the ASN1 encoded message buffer when the function returns.

`etype_info` This parameter points to an **`ETYPE_INFO`** structure.

`dstMac` This parameter points to a destination MAC address.

`srcMac` This parameter points to a source MAC address.

Return Value: The function returns a (**`ST_UCHAR *`**) pointer to the ASN1 encoded message buffer.

getGsRefReqEncode

Usage: This function encodes the GSE Management Gs Reference request, including the 14 byte Ethertype header. The parameters in the **(GSE_REF_REQ *)** and **(ETYPE_INFO *)** structures must be filled in before this function is called. The (**ST_UCHAR ***) argument passed to this function points to the encode buffer and **asn1DataBufLen** parameter contains the length of the buffer. The function returns a pointer to the ASN1 encoded message and **asn1DataLenOut** points to the length of the ASN1 encoded buffer.

Include: gse_mgmt.h

Function Prototype:

```
ST_UCHAR *getGsRefReqEncode (GSE_REF_REQ   *ctrl,
                             ST_UCHAR      *asn1DataBuf,
                             ST_INT        asn1DataBufLen,
                             ST_INT        *asn1DataLenOut,
                             ETYPE_INFO    *etype_info,
                             ST_UINT8      *dstMac,
                             ST_UINT8      *srcMac);
```

Parameters:

`ctrl` This parameter points to a **GSE_REF_REQ** structure. The structure contains a pointer to an array of reference offsets. The **numIntegers** variable must be set to the number of offsets in the array.

`asn1DataBuf` This parameter points to the buffer to be used for the ASN1 message encoding.

`asn1DataBufLen` This parameter contains the size of the ASN1 buffer in bytes.

`asn1DataLenOut` This parameter points to the length of the ASN1 encoded message buffer when the function returns.

`etype_info` This parameter points to an **ETYPE_INFO** structure.

`dstMac` This parameter points to a destination MAC address.

`srcMac` This parameter points to a source MAC address.

Return Value: The function returns a (**ST_UCHAR ***) pointer to the ASN1 encoded message buffer

getGsRefRspEncode

Usage: This function encodes the GSE Management Gs Reference response, including the 14 byte Ethertype header. The parameters in the **(GSE_REF_RSP *)** and (**ETYPE_INFO ***) structures must be filled in before this function is called. The (**ST_UCHAR ***) argument passed to this function points to the encode buffer and **asn1DataBufLen** parameter contains the length of the buffer. The function returns a pointer to the ASN1 encoded message and **asn1DataLenOut** points to the length of the ASN1 encoded buffer.

Include: **gse_mgmt.h**

Function Prototype:

```
ST_UCHAR *getGsRefRspEncode (GSE_REF_RSP   *ctrl,
                             ST_UCHAR      *asn1DataBuf,
                             ST_INT        asn1DataBufLen,
                             ST_INT        *asn1DataLenOut,
                             ETYPE_INFO    *etype_info,
                             ST_UINT8      *dstMac,
                             ST_UINT8      *srcMac);
```

Parameters:

`ctrl` This parameter points to a **GSE_REF_RSP** structure.

`asn1DataBuf` This parameter points to the buffer to be used for the ASN1 message encoding.

`asn1DataBufLen` This parameter contains the size of the ASN1 buffer in bytes.

`asn1DataLenOut` This parameter points to the length of the ASN1 encoded message buffer when the function returns.

`etype_info` This parameter points to an **ETYPE_INFO** structure.

`dstMac` This parameter points to a destination MAC address.

`srcMac` This parameter points to a source MAC address.

Return Value: The function returns a (**ST_UCHAR ***) pointer to the ASN1 encoded message buffer.

getGSSEDataOffsetReqEncode

Usage: This function encodes the GSE Management GSSE Data Offset request, including the 14 byte Ethertype header. The parameters in the (**GSE_OFFSET_REQ ***) and (**ETYPE_INFO ***) structures must be filled in before this function is called. The (**ST_UCHAR ***) argument passed to this function points to the encode buffer and **asn1DataBufLen** parameter contains the length of the buffer. The function returns a pointer to the ASN1 encoded message and **asn1DataLenOut** points to the length of the ASN1 encoded buffer.

Include: **gse_mgmt.h**

Function Prototype:

```
ST_UCHAR *getGSSEDataOffsetReqEncode (GSE_OFFSET_REQ     *ctrl,
                                      ST_UCHAR           *asn1DataBuf,
                                      ST_INT             asn1DataBufLen,
                                      ST_INT             *asn1DataLenOut,
                                      ETYPE_INFO         *etype_info,
                                      ST_UINT8           *dstMac,
                                      ST_UINT8           *srcMac);
```

Parameters:

`ctrl` This parameter points to a **GSE_OFFSET_REQ** structure. The structure contains a pointer to an array of visible reference strings. The **numVStrings** variable must be set to the number of visible reference strings in the array.

`asn1DataBuf` This parameter points to the buffer to be used for the ASN1 message encoding.

`asn1DataBufLen` This parameter contains the size of the ASN1 buffer in bytes.

`asn1DataLenOut` This parameter points to the length of the ASN1 encoded message buffer when the function returns.

`etype_info` This parameter points to an **ETYPE_INFO** structure.

`dstMac` This parameter points to a destination MAC address.

`srcMac` This parameter points to a source MAC address.

Return Value: The function returns a (**ST_UCHAR ***) pointer to the ASN1 encoded message buffer.

getGSSEDataOffsetRspEncode

Usage: This function encodes the GSE Management GSSE Data Offset response, including the 14 byte Ethertype header. The parameters in the (**GSE_OFFSET_RSP ***) and (**ETYPE_INFO ***) structures must be filled in before this function is called. The (**ST_UCHAR ***) argument passed to this function points to the encode buffer and **asn1DataBufLen** parameter contains the length of the buffer. The function returns a pointer to the ASN1 encoded message and **asn1DataLenOut** points to the length of the ASN1 encoded buffer.

Include: **gse_mgmt.h**

Function Prototype:

```
ST_UCHAR *getGSSEDataOffsetRspEncode (GSE_OFFSET_RSP     *ctrl,
                                      ST_UCHAR           *asn1DataBuf,
                                      ST_INT             asn1DataBufLen,
                                      ST_INT             *asn1DataLenOut,
                                      ETYPE_INFO         *etype_info,
                                      ST_UINT8           *dstMac,
                                      ST_UINT8           *srcMac);
```

Parameters:

`ctrl`	This parameter points to a **GSE_OFFSET_RSP** structure.
`asn1DataBuf`	This parameter points to the buffer to be used for the ASN1 message encoding.
`asn1DataBufLen`	This parameter contains the size of the ASN1 buffer in bytes.
`asn1DataLenOut`	This parameter points to the length of the ASN1 encoded message buffer when the function returns.
`etype_info`	This parameter points to an **ETYPE_INFO** structure.
`dstMac`	This parameter points to a destination MAC address.
`srcMac`	This parameter points to a source MAC address.

Return Value: The function returns a (**ST_UCHAR ***) pointer to the ASN1 encoded message buffer.

GSE Management Message Decode Functions

gse_mgmt_msg_decode

Usage: This function decodes GSE Management messages, including the Ethernet header. This function allocates a **`GSE_MGMT_MSG`** structure, fills it in, and returns a pointer to it. The function also fills in the **`ETPE_INFO`** structure referenced by the **`etypeInfo`** argument. The **`SN_UNITDATA`** structure must not be freed until after the **`GSE_MGMT_MSG`** structure is freed because **`GSE_MGMT_MSG`** contains pointers to data in the **`SN_UNITDATA`** structure.

Include: **gse_mgmt.h**

Function Prototype:

```
GSE_MGMT_MSG *gse_mgmt_msg_decode (SN_UNITDATA       *sn_req,
                                   ETYPE_INFO        *etypeInfo);
```

Parameters:

`sn_req` This parameter points to a **`SN_UNITDATA`** structure.

`etype_info` This parameter points to an **`ETYPE_INFO`** structure.

Return Value: The function returns a (**`GSE_MGMT_MSG *`**) pointer message data.

gse_mgmt_msg_free

Usage: This function frees all the resources allocated for the **`GSE_MGMT_MSG`** structure.

Include: **gse_mgmt.h**

Function Prototype: `ST_VOID gse_mgmt_msg_free (GSE_MGMT_MSG *gseMgmt);`

Parameters:

`gseMgmt` This parameter points to the **`GSE_MGMT_MSG`** structure which gets filled depending on the **`msgType`**.

Return Value: This function does not return a value.

Chapter 12

MMS Object Foundry

MMS Object Foundry is a MMS-*Lite* tool for creating MMS server objects, including Types, Variables, Named Variable Lists, and Domains. MMS Object Foundry must be used for all MMS-*Lite* applications that make use of MVL. Its use greatly simplifies the process of creating links between MMS objects such as variables and local program variables or processes. In addition, MMS Object Foundry has UCA device model specific features that make implementing such devices a straightforward task.

MMS Object Foundry is generally run on the command line or in a makefile. Complete source code is provided as well as a Windows executable (useful if you can't compile or run Foundry on your target platform).

MMS Object Foundry Workflow

As shown below, the primary function of MMS Object Foundry is to take a MVL Object Definition File (text file) as input and create a C source code module and associated header file as output. These output files are then compiled and linked to the MMS-*Lite* application, where they provide code to initialize all of the defined MMS objects automatically. The additional input file **align.cfg** is used to tell MMS Object Foundry the alignment requirements of the target compiler for data structure member alignment.

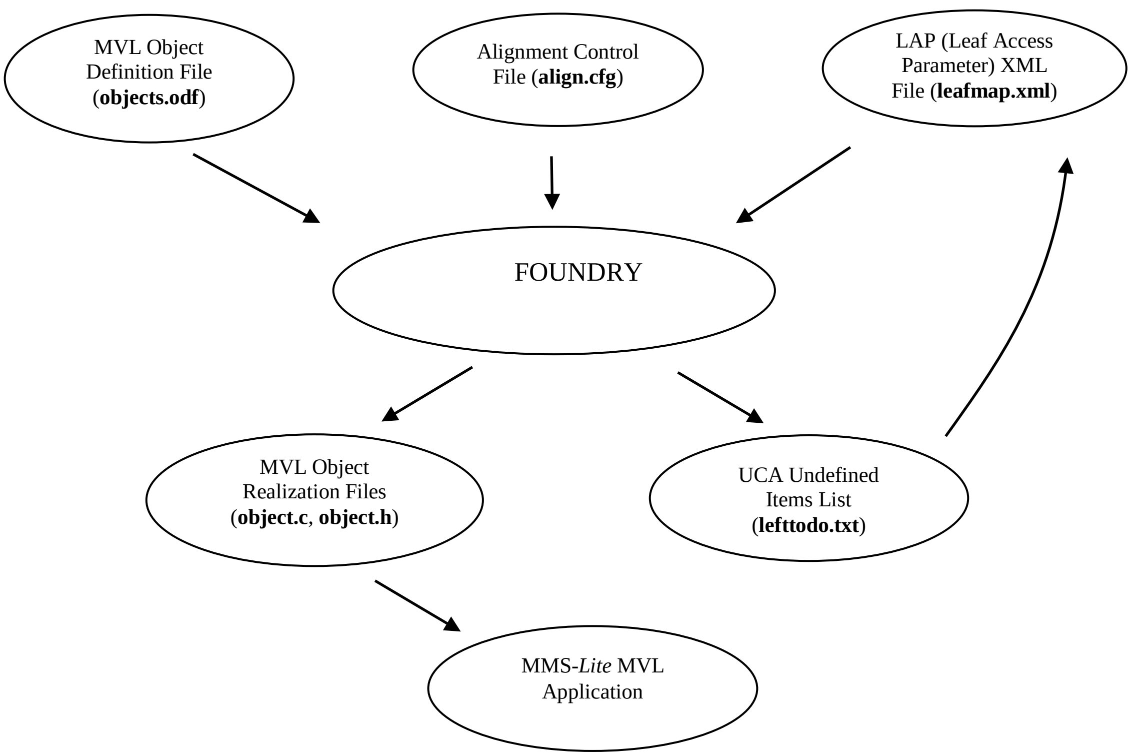


Figure 12: MMS Object Foundry Workflow Diagram

In the simple case, this is done with the following steps.

1. Review the alignment control file for correctness.
2. Create an Object Definition File
3. Run MMS Object Foundry with the ODF and alignment control file as input.
4. Compile the resulting C file and link to your application.

Note: *No user modification to the output C file is needed or desirable; the only source that is to be edited is the Object Definition File and the Alignment Control File.*

Command Line Parameters

MMS Object Foundry uses the following command line syntax:

`foundry [options] [-calignFile] [-tlapXmlFile] objectFile [outputFile]`

where:

`-c{alignFile}` specifies the structure alignment input file

`-t{lapXmlFile}` specifies the LAP (Leaf Access Parameter) XML input file

`objectFile` specifies the Object Definition input file

`outputFile` specifies the name of the output file

and optionFlags are one or more of the following:

`[-o]`: Overwrite target

`[-n]`: Extract UCA Variable Names

`[-v]`: Create UCA Variable Names & Associations

`[-p]`: Print line numbers being processed

`[-d]`: Debug mode

LAP XML Input File

This file, specified with the "-t"command line option, contains "**Leaf Access Parameter**" information to map primitive data elements to "leaf" functions and "references" for IEC 61850 or UCA variables. The file name must contain the extension "**.xml**". If the file name does NOT contain the extension "**.xml**", it is assumed to be a "Template File" (described later). The "Template File" should **NOT** be used because it is much more complicated. It remains an option only for backward compatibility.

Below is a very simple example of a "LAP XML input file":

```
<Leafmap>
	<Leaf Name="DI$Name" RdIndFun="rdString" WrIndFun="noWrite" Ref="42"/>
	<Leaf Name="DI$Class" RdIndFun="rdString" WrIndFun="noWrite" Ref="43"/>
</Leafmap>
```

- The **Name** attribute contains the name of the leaf.
- The **RdIndFun** attribute contains the name of the "Read leaf function".
- The **WrIndFun** attribute contains the name of the "Write leaf function".
- The **Ref** attribute contains any text that may be used as the "reference" value (the **`ref`** element of the **`RUNTIME_TYPE`** structure) in the output "C" file. The "reference" is the parameter that is passed in the "primRef" element of the **`MVLU_RD_VA_CTRL`** structure (passed to "read" leaf functions) or the **`MVLU_WR_VA_CTRL`** structure (passed to "write" leaf functions). For example, if the XML file contains the following **Ref**:
  Ref="&user_global_var"
  the following line is generated in the appropriate **`RUNTIME_TYPE`** structure in the output "C" file:
  ```
  &user_global_var                  /*   ref                    */
  ```

Note: The same XML file may be passed to the function **`mvlu_load_xml_leaf_file`** to load the parameters at runtime.

IMPORTANT:

1. Foundry also generates a "**LAP XML output file**" named **lap_out.xml**. It follows exactly the same format as the "LAP XML input file". However, it contains "dummy" entries for any leafs that are not mapped in the input file. It may easily be edited to replace the "dummy" entries with correct entries, then used to replace the "LAP XML input file".
2. If the "LAP XML Input File" (not the "Template File") is used as input to Foudry, the **lefttodo.txt** output file generated by Foundry contains an easy to read summary of missing Leaf Access Parameters (instead of starter functions).

Output File

Note that the **outputFile** parameter is used (minus extension) to create the filenames to be written as output files, with the **.c** and **.h** extensions. If outputFile is omitted, the output files names will be derived from the objectFile name.

Alignment Control File

This file is used to help MMS-*Lite* map complex data types onto local C data types. It specifies the data alignment requirements of the various primitive and complex data elements. See *Alignment Control File* on page 269 for more information on creating and maintaining this file.

The Object Definition File

The primary input to MMS Object Foundry is the Object Definition File. This is a text file with notation for creating MMS objects and controlling their attributes easily and automatically.

Some general features of the Object Definition File are:

- Anything following the # character is treated as a comment and ignored.
- Blank lines are ignored.
- All object information is contained in quotes.
- Object Definition Strings can span multiple lines.
- Object Definition Files can “include” other Object Definition Files.

AA-Specific Variables in the Foundry ODF Input File

Objects with the **`AA_SCOPE:`** **prefix** are no longer allowed in the Foundry ODF input file. These objects are rarely needed. If they are needed, it is recommended that they be created dynamically using code similar to the following:

```
{
/* Add AA_SPEC variable named "rptCtrl" on each calling connection.           */
/* To do same thing for called conns, change "calling" to "called".           */
ST_INT16          calling_data [MAX_CALLING]; /*data to use for calling conns */
ST_INT            type_id, j;
OBJECT_NAME       object_name;
MVL_VAR_ASSOC     *var_assoc;

/* This simple example assumes number of conns within limits.                 */
assert (mvl_cfg_info->num_calling <= MAX_CALLING);

/* Construct AA-Specific object name.                                         */
object_name.object_tag = AA_SPEC;
object_name.obj_name.vmd_spec = "rptCtrl";
type_id = mvl_typename_to_typeid ("I16");

/* Create AA-Specific variable on every connection.                           */
for (j = 0; j< mvl_cfg_info->num_calling; j++)
  var_assoc = mvl_vmd_var_add (&object_name,
                  &mvl_calling_conn_ctrl[j], /* MVL_NET_INFO *                */
                  type_id,
                  &calling_data[j],   /* different data for each var          */
                  NULL,               /* MVL_VAR_PROC *                       */
                  SD_TRUE);           /* ALWAYS copy name to var_assoc        */
}
```

Including Object Definition Files

ODF files can “include” other ODF files. This allows reuse of Object Definitions as building blocks. This is done with the following syntax:

include **xxxxx**

where **xxxxx** is the file to be included. Note that the keyword “include” is not in quotes and must be the first word on a line, followed by one space and then the file to be included.

Object Definition Syntax

In general, an object definition string is of the following form:

"{Object Type}{Object Flags)","Object Specific String1", "String2", ...

Where the Object Type is a single character used to identity the type of object being defined, the Object Flags is one or more characters used to specify some processing attribute for the object, and the Object Specific Strings are used to specify the attributes of the object.

Object	Object Type Code	Object Option Flags
MMS Object Foundry Execution Control	C	F, C, U, P
User Include File	I	
MMS Data Type	T	K, U, T, V, X
MMS Domain	D	
MMS Variable	V	D, P, U
MMS Named Variable List	L	
UCA Name Generation	N	

MMS Object Foundry Execution Control

These objects do not result in MMS object creation, but rather provide control over the creation of subsequent objects. The form of this object definition is as follows:

":C{flags}", "ControlArgument"

Parameter	Description
Control Argument	The possible values and effects of this parameter depend on the flags used. See the following chart for valid control arguments.

Flag Character	Attribute
P	This parameter is used to identify an include path for MMS Object Foundry Object Definition Files. Multiple paths may be specified. MMS Object Foundry will try to open the include file in the working directory and then in each of the specified path directories. In this case, the ControlArgument string is the path to be searched.
C	This parameter is used to select the alignment control file to be used. In this case, the ControlArgument string is the filename for the alignment control file.
F	This flag is used to override the default attributes for the Named Variable and Data Type object types. The valid ControlArgument string values are: :V{DP} :T{UTBV} The attributes that are present for the object type will then be applied to subsequent objects of that type. Attributes that are not present will revert to default values. See *MMS Data Types* on page 266 and *MMS Variable Objects* on page 267 for attribute value descriptions.
U	This parameter is used to control UCA/IEC 61850 specific processing by MMS Object Foundry. The valid values for ControlArgument are: MVL_UCA - enables MVL UCA/IEC 61850 processing MVLU_USE_REF - enables use of references See *MMS Object Foundry UCA Specific Features* on page 270 for more information on the use of these parameters and other UCA support issues.

User Include File

This object type is used to specify files that are to be included in the output C file. This is necessary when creating variables with data or processing initialization strings. The form of this object definition is as follows:

":I", "fileName"

Parameter	Description
fileName	This string will be placed in an #include statement output C file.

An example of this is to include the user header file **srvrobj.h** in the object definition.

":I", "srvrobj.h"

This will result in the following line being placed in the output C file:

#include "srvrobj.h"   /* User Specified */

MMS Data Type

This section is used to create MMS-*Lite* data types. The form of this object definition is as follows:

":T{flags}", "TypeId", "TDL", "Comment"

Parameter	Description
TypeId	This string will be used to create the define to be used to reference the type in the application.
TDL	This is the SISCO type definition language string, which defines the type. See Type Description Language on page 351.
Comment	This string is a text comment used only in the output C file.

Flag Character	Attribute
K	Keep this type unconditionally.
U	Unique type.
T	Transient type; discard after processing. Note that transient types are to be used only in constructing more complex types.
V	Discard this type unless referenced by a configured variable.
X	UCA/IEC 61850 type. Perform additional initialization for UCA/IEC 61850 (i.e. set leaf functions and references) even if there are no UCA/IEC 61850 variables using this type. **Important if UCA/IEC61850 variables created at runtime**.

For example, to create a MMS data type for a simple structure like the following:

```
typedef struct struct1
        {
        ST_INT16     s;
        ST_INT32     l;
        } STRUCT1;
```

Use the following configuration element:

```
":T", "STRUCT1_TYPE","{(s)Short,(l)Long}", "Basic simple structure"
```

MMS Domain

This section is used to create MMS-*Lite* domains. The single parameter is the domain name, which must be a legal MMS domain name. The form of this object definition is as follows:

":D", "domName"

To create a domain named mvlLiteDomain, use the following command:

":D", "mvlLiteDomain"

Parameter	Description
DomainName	Name of the MMS domain to create.

MMS Named Variables

This section is used to create MMS-*Lite* MVL Variable Associations, which are the MVL control element instantiated MMS Named Variables. The form of this object definition is as follows:

":V{flags}", "VarName", "TypeId", {"Data"}, {"ProcFuns"}

Parameter	Description
VarName	Name of MMS variable, which must conform to MMS naming conventions: 1-32 characters, valid characters being [a-zA-Z0-9$_], and must not start with a digit. The scope selector may optionally prefix the VarName. For instance, “domName:VarName” will result in a variable named “VarName” belonging to the scope of the domain named “domName”. Application Association scope is selected by using the prefix “AA_SCOPE:”. When no scope selector prefix is used, the scope is VMD.
TypeId	TypeID for MMS data type. Must have been previously defined.
Data	This optional string is used to initialize the **`va->data`** element in a MVL Variable Association. To use this option, the D flag must be present. Note that elements referenced by the Data string must typically be resolved by using an Include directive.
ProcFuns	This optional string is used to initialize the **`va->proc`** element in a MVL Variable Association. To use this option, the P flag must be present. Note that elements referenced by the ProcFuns string must typically be resolved by using an Include directive.

Flag Character	Attribute
D	When present, the 3rd string is used to initialize the **`va->data`** element.
P	When present, the 4th string (or 3rd if no D flag) is used to initialize the **`va->procFuns`** element.
U	UCA variable. When present, the 3rd string is used to initialize the **`va->user_info`** element.

MMS Named Variables Examples

Example 1

Use the following command to create a VMD scope variable named **myStructVar** of type **STRUCT1** that maps to a local variable **STRUCT1 myStructVar**. In addition, use pre/post processing selected by **MVL_VAR_PROC varProcFuns**.

```
":VDP", "myStructVar", "STRUCT1_TYPE", "&myStructVar", "&varProcFuns"
```

Example 2

Use the following command to create a VMD scope variable named **myStructVar** of type **STRUCT1** that maps to a local variable **STRUCT1 myStructVar**.

```
":VD", "myStructVar", "STRUCT1_TYPE", "&myStructVar"
```

Example 3

Use example 2 but create a domain scope belonging to the domain **mvlLiteDomain**.

```
":VD", "mvlLiteDomain:myStructVar", "STRUCT1_TYPE", "&myStructVar"
```

Example 4

Define an Application Association scope variable named **reportControl** that maps onto an element of a local array of 16 bit integers. Note the use of the **[i]** array index in the data string. This works to associate the elements of the variable array with the MVL called connection control array **`mvl_called_conn_ctrl`**.

```
":VD", "AA_SCOPE:reportControl", "INTEGER16_TYPE", "&reportControl[i]"
```

Example 5

Create a domain specific UCA variable called “MU” belonging to the domain “ln0”.

```
":VU", "ln0:_UCA_MU", "MU", "1"
```

MMS Named Variable List

This section is used to create MMS-*Lite* Named Variable Lists. A Named Variable List is essentially a list of previously defined Named Variables. The form of this object definition is as follows:

```
":L", "VarListName", "VarName", {"VarName"} ... , ":S"
```

Parameter	Description
VarListName	Name of MMS Named Variable List, must conform to MMS naming conventions: 1-32 characters, valid characters being [a-zA-Z0-9$_], and must not start with a digit. The scope selector may optionally prefix the VarListName. For instance, **domName:VarListName** will result in a Named Variable List named “VarListName” belonging to the scope of the domain named `domName`. Application Association scope is selected by using the prefix “AA_SCOPE”. When no scope selector prefix is used, the scope is VMD.
VarName	This is a sequence of strings selecting Named Variables to be included in the NamedVariableList. These VarNames must have all scope information included and must be defined previously. Note that the scopes of all items are independent. For instance, a VMD scope Named Variable List can reference variables from VMD, domain, or AA scopes. **UCA Note:** When the MVL_UCA mode is enabled, these variables do not need to be defined as they may be derived.
:S	This string functions as an “end of variables” marker.

MMS Named Variable List Examples

Example 1

Use the following command to create a VMD scope Named Variable List named **nvl1** that contains the Named Variables **arr1** and **Temperature**.

```
":L", "nvl1", "arr1", "Temperature", ":S"
```

Example 2

Use the following command to create a Domain scope NamedVariableList named **nvl1** that contains the Named Variables **domArr1** and **domTemperature**. All elements belong to the domain **mvlLiteDom**.

```
":L", "mvlLiteDom:nvl1",  "domArr1",  "mvlLiteDom:domTemperature",  ":S"
```

UCA Model Name Generation

MMS Object Foundry can generate UCA model form variable names from a selected structure type. This naming convention uses the $ symbol as a structure nesting delimiter and provides alternate views of the structure at all levels. Note that MMS Object Foundry will only do name generation separately from its normal mode of operation; it will not generate standard object realization code at the same time. A command line switch is used to toggle MMS Object Foundry modes. The form of this object definition is as follows:

```
":N", "BaseName", "TypeId"
```

The first parameter is the name base to be used. The second parameter is the type to use in extracting the names and will generally be a high level UCA object type.

Note: *These objects are used only when the* ***–v*** *or* ***-n*** *command line parameter is used.*

Parameter	Description
BaseName	This is the base name to be used in generating the variable names.
TypeId	TypeID for MMS data type. Must have been previously defined.

As an example, derive UCA device model names from the data structure type **STRUCT1_TYPE** using **struct1** as the base variable name. **STRUCT1_TYPE** has been defined as:

```
":T", "STRUCT1_TYPE","{(s)Short,(l)Long}", "Basic simple structure"
":N", "struct1", "STRUCT1_TYPE"
```

The output would appear as follows:

```
struct1
struct1$s
struct1$l
```

Alignment Control File

The contents of the alignment control file are used to tell MMS Object Foundry how data is stored in memory by the C compiler. The idea is that addresses of the data types described in the table cannot have bits set that are set in the table values.

For instance, if the value is 0x0000, the corresponding data type can be on any memory boundary. If it is 0x0001, it must be on even work boundary.

SISCO supplies standard data alignment files for DOS, WIN32, and QNX environments. Others may be created by reading the compiler alignment rules, or by examining the source file **mms_tdef.c** for the desired environment's table. Alternatively, the SISCO utility program **findalgn** may be compiled and executed in the target environment and will output an appropriate alignment control file.

The contents of the alignment control file are as follows:

```
ST_INT m_def_data_algn_tbl[NUM_ALGN_TYPES] =
  {
  0x0000,    /* ARRSTRT_ALGN     00  */
  0x0000,    /* ARREND_ALGN      01  */
  0x0003,    /* STRSTRT_ALGN     02  */
  0x0000,    /* STREND_ALGN      03  */
  0x0000,    /* INT8_ALGN        04  */
  0x0001,    /* INT16_ALGN       05  */
  0x0003,    /* INT32_ALGN       06  */
  0x0007,    /* INT64_ALGN       07  */
  0x0003,    /* FLOAT_ALGN       08  */
  0x0007,    /* DOUBLE_ALGN      09  */
  0x0000,    /* OCT_ALGN         10  */
  0x0000,    /* BOOL_ALGN        11  */
  0x0000,    /* BCD1_ALGN        12  */
  0x0001,    /* BCD2_ALGN        13  */
  0x0003,    /* BCD4_ALGN        14  */
  0x0000,    /* BIT_ALGN         15  */
  0x0000     /* VIS_ALGN         16  */
  };
#define M_STRSTART_MODE          M_STRSTART_MODE_LARGEST
#define M_STREND_MODE            M_STREND_MODE_LARGEST
```

MMS Object Foundry UCA Specific Features

MVL_UCA Overview

The MMS-*Lite* “UCA Extensions” (MVLU) is a run time installable subsystem for MVL that makes handling the complex UCA device models significantly easier and more efficient. By making use of this package, the developer can rely on MVL to generate and support all variable names and permutations, handle MMS Alternate Access transparently, and provide an easy to use mechanism to associate the UCA MMS variables to the real application data.

The general MVLU processing model is that there is one or more high level “base types” present in the device model. A base type is the highest level object accessible and is made up of a set of “sub-types”, which present subset views of the base type; this is similar in nature to the MMS alternate access mechanisms. The base MMS UCA variables are defined using the base types. MVLU then derives the sub-variables from the base type and allows the user application to deal only with the primitive data elements.

When UCA processing is enabled, the MMS-*Lite* Runtime Type is enhanced to support specialized processing and MMS Object Foundry generates code to initialize these new elements. MMS Object Foundry identifies UCA Variables and NamedVariableLists via a naming convention. For each UCA data type, MMS Object Foundry provides Read and Write Indication functions for each primitive elements of the type, as well as a user controlled Reference handle for the primitive element.

Note that one-to-one local application variables for the UCA variables need not exist; **`MVL_UCA`** provides all required mapping and buffer management to correctly support the UCA model for the device.

In order to use MVLU to provide UCA object support, the user application must provide functions to provide access to the primitive data that collectively makes up the device object. MVLU generates starter code for all required user functions. The two types of functions used are:

Read Indication:	Used to handle MMS Read indications
Write Indication:	Used to handle MMS Write indications

The starter code for these functions is written to **lefttodo.txt** and is to be edited to become an input Template File.

MMS Object Foundry can also generate reference elements to be associated with the primitive elements of a type. This reference allows the application to use an indication function to service multiple elements of the type, thereby reducing coding effort and code size. The reference is of type **`ST_RTREF`**, which by default is defined as **`ST_VOID *`**. This can be changed as necessary for the application indication functions. This typedef is in the MMS-*Lite* header file **mms_vvar.h**.

WARNING: *If the typedef is changed, all the MMS-Lite source modules must be recompiled so the new definition is used consistently.*

MMS Object Foundry Workflow for UCA Devices

For UCA devices, in order to realize the application's MMS objects, the main objective of MMS Object Foundry is to take your Object Definition File (a text file) and a UCA Function/Define Template File, and produce a C output file that is linked to your application.

To accomplish this, the following process is used:

1. Review the Alignment Control File (ACF) for correctness.
2. Create an Object Definition File (ODF), which will reference the UCA model definitions.
3. Run MMS Object Foundry with the ODF and ACF as input.
4. Take the resulting **lefttodo.txt** file and use as the start of the Template Input file.
5. Implement the Read/Write indication functions found in the Template Input File.
6. Run MMS Object Foundry with the ODF, Template, and alignment control file as input.
7. Compile the resulting C file and link to your application.

Note that no user modification to the output C file is needed or desirable. The only source that is to be edited is the Object Definition File, the UCA Function Template file, and the Alignment Control File.

UCA Model Object Definition Files

SISCO provides a set of Object Definition Files for UCA objects with MMS-*Lite*. These ODFs contain the fully expanded UCA data type definitions for the following UCA models:

Switch (Sw)
Switch Controller (SwC),
Automatic Switch Controller (ASwC),
Breaker (Bkr)
Breaker Controller (BkrC)
Time Delay Starting or Closing Relay
Checking of Interlocking Relay
Voltage per Hertz Relay
Directional Power Relay
Under Current or Under Power Relay
Reverse Phase or Phase Balance Current Relay
Incomplete Sequence Relay
Machine, Transformer Thermal Relay
Instantaneous Overcurrent Relay

Voltage or Current Balance Relay
Time Delay Starting or Stopping Relay
Alarm Relay
Phase Angle Measuring Relay
Frequency Relay
Carrier or Pilot-wire Relay
Lockout Relay
Tripping or Trip Free Relay
Closing Relay/Contactor
XYZ Auxiliary Relays
Under Voltage Relay
Over Voltage Relay
Time Overcurrent Relay
Distance Relay
Sync Relay
High Impedance Ground Detector Relay
Directional Overcurrent Relay
Reclosing Relay
Differential Relay
Generic Object Oriented Substation Event
Capcitor Bank
Measuring Unit

Enabling MMS Object Foundry UCA Processing

To allow MMS Object Foundry to generate UCA specific code, the following control option must be present in the Object Definition File.

```
":CU", "MVL_UCA"
```

Most UCA applications will want to use reference handles for the primitive data elements and should also include the following control option:

```
":CU", "MVLU_USE_REF"
```

In addition, the following control object should normally be included, allowing MMS Object Foundry to discard all intermediate types used in creating the UCA data types.

```
":CF", ":TV"        # Delete types not used by variables
```

These settings will result in the most effective implementation and will allow MMS Object Foundry to discard all types that are not used directly by configured variables.

UCA Named Variable Handling

UCA Variables are configured with the prefix **_UCA_**. The variable name (minus prefix) is used as the base name for all derived UCA variables.

The following are examples of how to create a UCA Instantaneous Overcurrent Relay variable and all its derived variables. They show one in the VMD scope and one in domain scope.

```
":V","_UCA_IOC","BRO"
":V","ucaDomain:_UCA_IOC","BRO"
```

NamedVariableList Handling

UCA Named Variable Lists are also configured with the prefix **_UCA_**. The name (minus prefix) is the exposed MMS name. For UCA NVLs, the variables in the list need not be defined as configured variables as they are assumed to contain manufactured variables such as the derived UCA variables.

Miscellaneous Foundry Features

- Generates Leaf Function-Name to Function-Address Lookup Tables

If **`MVLU_LEAF_FUN_LOOKUP_ENABLE`** is defined (preferably in **glbopt.h**), Foundry generates "2-dimensional" leaf function tables for the read and write indication "leaf" functions. These tables contain function-name to function-address lookup information, which is required by the dynamic type creation functions **`mvlu_set_leaf_param_name`** and **`mvlu_load_xml_leaf_file`**, because they must search for the leaf functions by name.

Appendix A

Subset Creation

Since MMS-*Lite* is supplied in library form, it is easy to create applications that only use a subset of the supplied services. This allows programming without the code overhead of the unused functions. MMS-EASE library modules are divided by requester/responder classes and functionality.

To ensure that the application code size is kept to a minimum, please use the following steps. These steps will eliminate unused functions and create a MMS-EASE subset.

1. Make sure that your application code references only the functions required for your application.
2. Edit the file **mmsop_en.h**. A segment of this file is shown below. Enable only the MMS functionality required, by changing the definitions to enable or disable support for a particular MMS service. Responses and requests can be enabled or disabled independently. For example, if you want to disable a particular service such as the Status service, change the definition of the predefined constant, **`MMS_STATUS_EN`** to be equal to:
   a. **`REQ_RESP_DIS`** if you are NOT going to support this service at all, or
   b. **`REQ_EN`** if you are only going to support this service as a requestor, or
   c. **`RESP_EN`** if you are only going to support this service as a responder, or
   d. **`REQ_RESP_EN`** if you are going to support this service both as a requestor and a responder.

```
/*********************************************************************/
/* define the operation enable switches                              */
/*********************************************************************/
#define REQ_RESP_DIS         0x00   /* no support for req or resp  */
#define REQ_EN               0x01   /* support for request         */
#define RESP_EN              0x02   /* support for response        */
#define REQ_RESP_EN          0x03   /* support for resp and req    */

/*********************************************************************/
/* define the opcode enable switches                                 */
/*********************************************************************/
#define MMS_INIT_EN          REQ_RESP_EN
#define MMS_CONCLUDE_EN      REQ_RESP_EN
#define MMS_CANCEL_EN        REQ_RESP_EN

#define MMS_STATUS_EN        REQ_RESP_DIS
#define MMS_USTATUS_EN       REQ_RESP_DIS
#define MMS_GETNAMES_EN      REQ_RESP_DIS
#define MMS_IDENT_EN         REQ_RESP_EN
```

3. Compile the **mmsop_en.c** file. This compilation changes the default values of some of the preferred initiate parameters, and some internal MMS-EASE variables.
4. **mmsop_en.c** file MUST be compiled with the **MAP30_ACSE** symbol defined.

Note: *Failure to compile with the* ***`MAP30_ACSE`*** *symbol defined will result in an error reported by the linker.*

---

5. When linking your programs with the MMS-EASE libraries, the **mmsop_en** object must be linked with the libraries and your application's object code.

   This process prevents all unnecessary MMS-EASE code from being included in your application.

Appendix B

Error Codes

Many different error codes may be returned by various functions in MMS-*Lite*. The error codes that are shared with the SISCO MMS-EASE product are documented in the *MMS-EASE Reference Manual*. Error codes that are unique to MMS-*Lite* are documented here.

All functions using a return code may return the following:

`#define SD_SUCCESS`	`0`	Error

ACSE Error Codes

Any of the functions that he ACSE-service-user may call (e.g., the **a**_* functions) will return one of the following error codes:

The following error codes are returned from the ACSE layer:

`E_ACSE_ENC_ERR`	`0x3001`	ACSE Encode error Error in ACSE encoding.
`E_ACSE_SEND_ERR`	`0x3002`	ACSE Send Error Error sending an ACSE PDU.
`E_ACSE_INVALID_CONN_ID`	`0x3003`	Invalid connection ID Connection ID is not valid.
`E_ACSE_INVALID_STATE`	`0x3004`	Invalid State ACSE is not in a valid state.
`E_ACSE_INVALID_PARAM`	`0x3005`	Invalid Parameter Parameter sent is invalid.
`E_ACSE_BUFFER_OVERFLOW`	`0x3006`	Buffer Overflow Error ACSE buffer overflow.
`E_ACSE_MEMORY_ALLOC`	`0x3007`	Error Allocating Memory Memory Allocation Failed.

ACSE Exception Codes

`EX_ACSE_DECODE`	`0x3081`	ACSE Decode Error Can’t decode incoming PDU.
`EX_ACSE_INVALID_STATE`	`0x3082`	Invalid State ACSE is not in the correct state for the received PDU.

TP4 Error Codes

`TP4E_SHMALLOC`	`0x1201`	OBSOLETE: no longer used.
`TP4E_BADCONN`	`0x1202`	Bad Connection ID TP4 connection ID is not valid or connection is in invalid state.
`TP4E_QUEUE_FULL`	`0x1203`	SPDU queue full Session layer SPDU queue is full.
`TP4E_CONN_STATE`	`0x1204`	Illegal Connection state Unable to connect – illegal state.

The following error codes (**`TP4E_INVAL_*`**) indicate that the corresponding parameters in the **`TP_CFG`** structure are not legal.

`TP4E_INVAL_TPDU_LEN`	`0x1205`	
`TP4E_INVAL_REM_CDT`	`0x1206`	
`TP4E_INVAL_LOC_CDT`	`0x1207`	
`TP4E_INVAL_SPDU_OUTST`	`0x1208`	
`TP4E_INVAL_NUM_CONNS`	`0x1209`	
`TP4E_INVAL_SPDU_LEN`	`0x120A`	
`TP4E_INVAL_WINDOW_TIME`	`0x120B`	
`TP4E_INVAL_INACT_TIME`	`0x120C`	
`TP4E_INVAL_RETRANS_TIME`	`0x120D`	
`TP4E_INVAL_MAX_TRANS`	`0x120E`	
`TP4E_MALLOC`	`0x120F`	OBSOLETE: no longer used.

CLNP Error Codes

The following error codes may be returned from the CLNP API functions:

`LLC_ERR_SRC_ADDR`	`0x3481`	LLC header Source field invalid.
`LLC_ERR_DEST_ADDR`	`0x3482`	LLC header Dest field invalid.
`LLC_ERR_CONTROL`	`0x3483`	LLC header Control field invalid.

Note: These are not currently used.

CLNP General Errors

`CLNP_ERR_CFG_FILE`	`0x3400`	OBSOLETE: no longer used.
`CLNP_ERR_NOT_INIT`	`0x3401`	CLNP has not been initialized Protocol not started.
`CLNP_ERR_MEM_ALLOC`	`0x3402`	Error in allocating memory Cannot allocate memory.
`CLNP_ERR_NULL_PTR`	`0x3403`	NULL pointer error Null pointer passed to a **`clnp`** function.

CLNP Errors in Configuration Structure `clnp_param`

`CLNP_ERR_NSAP_LEN`	`0x3404`	NSAP length error NSAP length is 0 or more than the allowed value. This is an unrecoverable error during CLNP initialization.
`CLNP_ERR_LIFETIME`	`0x3405`	Invalid PDU lifetime Recoverable error during CLNP initialization. Lifetime value will be set to default.
`CLNP_ERR_LIFETIME_DEC`	`0x3406`	Invalid PDU lifetime decrement Recoverable error during CLNP initialization. Lifetime decrement value will be set to default.
`CLNP_ERR_ESH_CFG_TIMER`	`0x3407`	Invalid ESH Configuration Timer Recoverable error during CLNP initialization. End System Holder timer will be set to default.
`CLNP_ERR_ESH_DELAY`	`0x3408`	Invalid Delay Time for First ESH Recoverable error during CLNP initialization. Delay will be set to default.
`CLNP_ERR_MAC_ADDR`	`0x3409`	Local MAC address not configured Must have a local MAC address – this is required for ADLC sub-network. Unrecoverable error during CLNP initialization.
`CLNP_ERR_UDATA_LEN`	`0x3410`	CLNP-user data length too large User data exceeds maximum length.

CLNP PDU Parsing (Decoding) Errors

`CLNP_ERR_PDU_MAC_ADDR`	`0x3420`	Error decoding MAC address The MAC address in a received PDU is not valid.
`CLNP_ERR_PDU_ID`	`0x3421`	Invalid PDU ID Not a supported PDU. Currently ISO 8473 and ISO 9452 standards are supported.

CLNP_ERR_PDU_VER	0x3422	Invalid PDU version Not a supported PDU version. Currently Version 1 of ISO 8473 and ISO 9452 are supported.
CLNP_ERR_PDU_TYPE	0x3423	Invalid PDU type Not a supported PDU type. Currently DT, ER, ESH, and ISH PDUs are supported.
CLNP_ERR_PDU_LEN	0x3424	Invalid PDU length Received PDU length does not match the length indicated by sub-network.
CLNP_ERR_PDU_EXPIRED	0x3425	PDU expired DT (Data Type) or ER (Error) PDUs lifetime has expired.
CLNP_ERR_PDU_NSAP_ADDR	0x3426	Error NSAP addressing to PDU PDU is improperly addressed to a NSAP that is not assigned locally.
CLNP_ERR_PDU_SEGMENTING	0x3427	Error segmenting PDUs Segmented PDUs are not supported – PDUs must arrive in one packet.
CLNP_ERR_PDU_CHECKSUM	0x3428	Error PDU Checksum PDU checksum verification failed.
CLNP_ERR_PDU_LAST_SEG	0x3429	Segmented PDU Error Last segment bit not set – indicating an unsupported segmented PDU.
CLNP_ERR_PDU_ER_PDU	0x342A	Error ER PDU Code not compiled for ER (Error) PDU processing.

Subnetwork API Error Codes

The following error codes may be returned from the Subnetwork API functions:

SNET_ERR_INIT	0x3501	Error Initializing Sub-network Interface Sub-network interface not available.
SNET_ERR_WRITE	0x3502	Sub-network Write Function Failed Cannot write to sub-network
SNET_ERR_READ	0x3503	Sub-network Read Function Failed Cannot read from sub-network or no data to read.

SNET_ERR_MAC_INVALID	0x3504	Invalid MAC address Unable to obtain requested End System (ES) or Intermediate System (IS) MAC address.
SNET_ERR_FRAME_LEN	0x3505	Frame Length Error Received more data then reserved in buffer.
SNET_ERR_UDATA_LEN	0x3506	User Data Length Error Invalid length of data to send (too large)

The following are Subnetwork errors specific to the Ethernet driver interface:

SNET_ERR_DRV_OPEN	0x3520	Open Driver Command Failed NOTE: each portation of the driver interface is different, so the particular cause varies.
SNET_ERR_DRV_LOC_MAC	0x3521	Driver Error for Local MAC Address Failure to obtain local MAC address from the Ethernet board.
SNET_ERR_DRV_ADD_ES_ADDR	0x3522	ES Address Driver Error Failure to activate All End System Address or any other Multicast address.
SNET_ERR_DRV_BIND_LSAP	0x3523	OBSOLETE: no longer used
SNET_ERR_DRV_POST_BUFS	0x3524	OBSOLETE: no longer used. Driver **OSILLC$** (Win 3.x driver) cannot post buffers.

MVL Error Codes

The following are error codes specific to MVL

MVL_ERR_USR_TIMEOUT	0x6A01	Indicates that the user timed out waiting for a MMS response (i.e., the user function called via the function pointer **u_mvl_check_timeout** returned an error).
MVL_ERR_REQ_CONTROL	0x6A02	Indicates an error in the request control structure.
MVL_ERR_UNKNOWN_PDU_TYPE	0x6A03	Indicates an unknown PDU type. NOTE: not currently used.
MVL_ERR_RUNTIME_TYPE_ID	0x6A04	Runtime Type ID passed to a function is invalid.
MVL_ERR_ASN1_TO_RUNTIME	0x6A05	Indicates an error in the ASN.1 to Runtime processing. NOTE: not currently used
MVL_ERR_NOT_SYM_ADDR	0x6A06	Described variable contains unsupported address tag (only symbolic addresses currently supported).
MVL_ERR_ARRAY_ELEMENT_CNT	0x6A07	Described variable array element count exceeds maximum allowed.
MVL_ERR_LOCAL_ADDRESS	0x6A08	Described variable local address is invalid.

MVL_ERR_BUFFER_SIZE	0x6A09	Indicates a buffer size error. NOTE: not currently used.
MVL_ERR_DOM_CONTROL	0x6A0A	Indicates an error in the MVL Domain control. NOTE: not currently used.
MVL_ERR_AA_CONTROL	0x6A0B	NOTE: Not currently used.
MVL_ERR_AA_SPECIFIC	0x6A0C	NOTE: Not currently used.
MVL_ERR_NVL_NOT_FOUND	0x6A0D	NamedVariableList not found
MVL_ERR_ALT_ACCESS	0x6A0E	Indicates an error in AlternateAccess. NOTE: not currently used.
MVL_ERR_VA_NOT_FOUND	0x6A0F	Indicates the requested variable is not found. NOTE: not currently used.
MVL_ERR_VA_SPEC	0x6A10	Indicates an error in the variable specification.
MVL_ERR_NO_REQ_CTRL	0x6A11	Error getting MVL Request Control.
MVL_ERR_NO_CONN_CTRL	0x6A12	Error getting MVL Connection Control (i.e., All in use).
MVL_ERR_ASSOC_REQ	0x6A13	ACSE Associate Request failed.
MVL_ERR_COMM_SERVE_ACTIVE	0x6A14	Already in **mvl_comm_serve** function (i.e., recursion problem).
MVL_ERR_REQ_PEND_COUNT	0x6A15	Number of MMS Requests outstanding on a particular connection exceeds the negotiated maximum.
MVL_ERR_CNF_REJ_ERR	0x6A16	MMS Reject sent or received. Either the decoding of an MMS response failed so an MMS Reject was sent, or an MMS Reject was received for an earlier MMS request.
MVL_ERR_CNF_ERR_OK	0x6A17	MMS Error response was received for an earlier MMS request. NOTE: the "OK" in the define is misleading. Usually it is not considered OK to get an error response.
MVL_ERR_CNF_DISCONNECTED	0x6A18	Connection has been disconnected.
MVL_ERR_BAD_TYPE	0x6A19	OBSOLETE: no longer used.
MVL_ERR_RESOURCE_NOT_AVAIL	0x6A1A	OBSOLETE: no longer used.

Appendix C

Logging Tools

MMS-EASE contains a logging system, referred to as SLOG (**S**ISCO **Log**ging) system. This system provides a flexible and useful approach to system logging, and is easily expanded to meet the logging requirements of most end user applications.

General Logging

Below is a list of features available in the general SLOG system:

- Logging data is accepted in **printf** type format.
- Hex buffers are logged.
- Continuation is supported (i.e., multi-line messages).
- Information is time stamped. The time stamp may be expressed as Date and Time (e.g., 2008-07-21 17:02:16.140) or elapsed time in microseconds (Windows Only).
- SLOG allows the capability of using multiple logging control elements with one log file per logging control element.
- It provides the capability to include Source file and Line Number information for debugging.
- In-memory logging is available for profiling timing information

File Logging

The following features are provided for logging to a file.

- SLOG logs to circular file.
- It allows dynamic enabling and disabling of file logging using the supplied functions.
- Controllable options:
    - File Name
    - File Size
    - Wipe Bar
    - File Wrap
    - Message Header
    - Append/Overwrite on open
    - Hard Flush
    - Disable buffering using “setbuf”

Memory Logging

The following features are provided for logging to memory.

- SLOG logs to a list of memory resident buffers for collection of log information in real time.
- Buffers are accessible to the application and can be written to file under program control (e.g., when a particular error occurs or when a critical operation completes).

Log Control Data Structure

This structure is used to set logging control flags including file and memory logging control. Additionally, it contains bit-masked variables that can be used by the application to determine whether an item is to be logged.

```
typedef struct log_ctrl
  {
  ST_UINT32         logCtrl;
  FILE_LOG_CTRL     fc;
  MEM_LOG_CTRL      mc;
/* Application specific information     */
  ST_UINT32         logMask1;
  ST_UINT32         logMask2;
  ST_UINT32         logMask3;
  ST_UINT32         logMask4;
  ST_UINT32         logMask5;
  ST_UINT32         logMask6;
  } LOG_CTRL;
```

`logCtrl`	A mask of bits that determine the type or types of logging desired. These bits can be ORed together to form any combination. Acceptable values are:	
	`LOG_MEM_EN (0x0001L)`	Enables Memory Logging
	`LOG_FILE_EN (0x0002L)`	Enables File Logging
	`LOG_TIME_EN (0x0008L)`	Time stamping is enabled.
	`LOG_IPC_EN`	Enables IPC logging.
`fc`	This structure of type **`FILE_LOG_CTRL`** contains the control information for file logging. This is used if the logCtrl bit **`LOG_FILE_EN`** is set. See the next sections for more information.	
`mc`	This structure of type **`MEM_LOG_CTRL`** contains the control information for memory logging. This is used if the logCtrl bit **`LOG_MEM_EN`** is set. See the next sections for more information.	
`logMask1...6`	These are available for use by the application to determine whether an item is to be logged. Using these masks, you will have 192 bits available for setting various log levels. The application would normally reference these logmasks in a C MACRO. The following example shows the simplest approach for SLOG integration into an existing system.	

Using the SLOG Logmasks

This section describes how to use the **logMask1...6** capabilities of SLOG.

```
/**********************************************************************/
/* For debug version, use a static pointer to avoid duplication of    */
/* __FILE__ strings.                   */
static ST_CHAR *thisFileName = __FILE__;
```

In the following example **SLOG1_1** is used as a way to send application specific error messages with one data item to the log file. The application code might look like:

```
PR_Log_Err( "Hard error detected %d", errno );
```

and the macro **PR_Log_Err** might be defined as follows:

```
#define PR_LOG_ERR         0x00000001L
#define PR_ERR_LT        0
#define PR_Log_Err1(a,b) SLOG1_1(sLogCtrl,PR_LOG_ERR,PR_ERR_LT,a,b)
```

The macro for **SLOG1_1** is found in the header file **slog.h** and is defined as follows::

```
#define SLOG1_1(lc,mask,id,a,b) {\
  if (lc->logMask1 & mask)\
  slog (sLogCtrl,id, thisFileName,__LINE__,a,b);\
  }
```

SLOG macros found in slog.h follow the naming convention: **SLOG x_y**, where **x** indicates which of the 6 logmasks to AND with the log mask, **y** denotes the number of data elements to use with the format specifier (a). For example, because the SLOG macro listed below examines log mask 2 and passes three data items to be written to the log format specifier, it is called SLOG2_3.

```
define SLOG2_3(lc,mask,id,a,b,c,d) {\
    if (lc->logMask2 & mask)\
    slog (sLogCtrl,id, thisFileName,__LINE__,a,b,c,d);\
    }
```

Using log masks is not the only way for the application to call SLOG. The application may use a different MACRO convention. As a comparison, MMS-EASE uses global variables to determine when it should call SLOG functions. It does not use **logMask1...6** as is shown in the example below.

```
#define MLOG_DEC2(a,b,c) {\
    if (mms_debug_sel & MMS_LOG_DEC)\
    slog (sLogCtrl,MMS_LOG_DEC_TYPE,\
    thisFileName,__LINE__,a,b,c);\
    }
```

File Control Data Structure

This structure is used to set logging control information for file logging.

```
typedef struct file_log_ctrl
  {
  ST_ULONG   maxSize;
  ST_CHAR    *fileName;
  ST_UINT    ctrl;
  ST_UINT    state;        /* DO NOT USE */
  FILE       *fp;          /* DO NOT USE */
  } FILE_LOG_CTRL;
```

maxSize	This indicates the maximum size of the log file when file wrap is enabled (default is 1MB).
fileName	This is a pointer to the log file name. Default name is **mms.log**.

`ctrl` These are file logging control flags. The following are control bits used to enable and disable the file logging options. These bits can be ORed together to form any combination. Acceptable values are:

FIL_CTRL_WIPE_EN (0x0001)	Enables the use a **wipe bar** to show where the current data is in a wrapped file.
FIL_CTRL_WRAP_EN (0x0002)	Enables wrapping of the file. Note that file wrapping is temporarily disabled during a hex dump.
FIL_CTRL_MSG_HDR_EN (0x0004)	Enables a message header to be displayed when the file is written.
FIL_CTRL_NO_APPEND (0x0008)	When first opening the log file, the existing contents are destroyed.
FIL_CTRL_HARD_FLUSH (0x0010)	Close and reopen the log file after each write. This should be used to better ensure not losing any log data if there is a crash.
FIL_CTRL_SETBUF_EN (0x0020)	Enables the use of the **setbuf(fh,NULL)** command to turn off buffering. For some compilers, this will slow application processing down but should be used to better ensure not losing log data if there is a crash.

`state` /* For Internal SISCO Use — Do Not Use */

`fp` /* For Internal SISCO Use — Do Not Use */

Memory Control Data Structure

This structure is used to set logging control flags for memory logging.

```
typedef struct mem_log_ctrl
  {
  ST_INT            maxItems;
  ST_CHAR           *dumpFileName;
  ST_UINT           ctrl;
  ST_UINT           state;              /* DO NOT USE*/
  LOGMEM_ITEM       *item;              /* DO NOT USE*/
  ST_INT            nextPut;            /* DO NOT USE*/
  } MEM_LOG_CTRL;
```

`maxItems` This indicates the maximum numbers of items to allocate at powerup.

`dumpFileName` This is a pointer to the file name of the memory dump.

`ctrl` These are memory logging control flags. The following are control bits used to enable and disable the memory logging options. These bits can be ORed together to form any combination. Acceptable values are:

MEM_CTRL_MSG_HDR_EN (0x0001)	Enables a message header to be displayed when the file is written.
MEM_CTRL_AUTODUMP_EN (0x0002)	Enables autodump of memory buffers.
MEM_CTRL_HEX_LOG (0x0004)	Enables memory logging in hexadecimal.

`state` /* For Internal SISCO Use — Do Not Use */

`item` /* For Internal SISCO Use — Do Not Use */

`nextPut` /* For Internal SISCO Use — Do Not Use */

IPC LOGGING

SISCO revised its application logging to allow for collecting log messages over a TCP connection. If a developer implements logging using the **logcfg.xml** file, then the IPC logging can be enabled from there without any other programming. Otherwise, the following section describes how to use IPC logging in an application.

IPC Logging in an Application

An application can enable IPC logging by setting the following flag in the SISCO global log control structure:

```
sLogCtrl->logCtrl |= LOG_IPC_EN;
```

The user should always call **`slog_start`** at startup, after logging configuration completes but before any log messages are generated. This function initializes the logging system including IPC logging.

The default listening port designated by SISCO for an application is **`IPC_LOG_BASE_PORT (55147)`** defined in the **slog.h**.

Note that MMS-*Lite* libraries have only the error log mask turned ON. If an application needs to log various levels of MMS communication/processing it needs to turn the proper masks ON.
The application can change the default IPC logging parameters by modifying fields in the **`IPC_LOG_CTRL`** structure (referenced by **`sLogCtrl->ipc`**):

`port`	Base port number where application will listen for socket connections from Client applications such as Hyper Terminal or Telnet. Default is **`IPC_LOG_BASE_PORT`** (55147).
`portCnt`	Number of listening ports starting with base port, that are available to multiple instances of the application. Default is 1.
`portUsed`	This is the listen port actually used by given instance of an application. Set in the **`slogIpcInit`** function.
`maxConns`	Maximum number of socket connections that can be accepted for IPC logging. The default is **`IPC_LOG_MAX_CONNECTIONS (10)`**.
`maxQueCnt`	Maximum number of log messages that can be queued on any one connection. The default is **`IPC_LOG_MAX_QUEUE_CNT (100)`**.
`appId`	This is pointer to a NULL terminated string identifying the application. The buffer holding this information must be persistent while the program is running. There is no size limit on the buffer. The application identification string is sent to a Client in the first message after socket connection has been established. The default is the NULL pointer.

SLOG (SISCO Logging)

Global Variables and Constants

The following variables are used with SISCO Logging:

```
extern ST_INT sl_max_msg_size = MAX_LOG_SIZE;
```

This variable contains the maximum message size of a SLOG message. The default value is set to the constant, **`MAX_LOG_SIZE`**. The default is set in the include file, **slog.h**.

```
extern ST_CHAR slogTimeText[TIME_BUF_LEN];
```

This variable is used to create time strings for logging. The maximum size of the buffer **`TIME_BUF_LEN`** is defined as a default to be 30.

```
#define SLOG_MEM_BUF_SIZE
```

This constant represents the maximum line length of a memory resident message. Messages longer than this constant supplied to the **slogMem** function are truncated at this limit. The default is 125 characters.

Initializing SLOG

To use SLOG, a **LOG_CTRL** data structure must be created and initialized, and the MMS-EASE global variable **sLogCtrl** set to point to the structure. Be sure to zero out all internal fields in the structure: **fc.state** and **fc.fp** for file logging and **mc.state**, **mc.item**, and **mc.nextPut** for memory logging. If the application does not set **sLogCtrl**, it points to a global default structure **slogCtrlDefault** containing the following values:

```
logCtrl = LOG_TIME_EN;
fc.maxSize = 1000000;
fc.fileName = "mms.log";
fc.ctrl = FIL_CTRL_WIPE_EN | FIL_CTRL_WRAP_EN | FIL_CTRL_MSG_HDR_EN;
```

SLOG Functions

The following functions are used perform application level logging.

slog

Usage: This function is the general purpose logging function. It takes care of both memory and file logging as required.

Function Prototype:

```
ST_VOID slog (LOG_CTRL     *lc,
              ST_INT       logType,
              ST_CHAR      *sourceFile,
              ST_INT       lineNum,
              ST_CHAR      *format, ...);
```

Parameters:

`lc`	This is a pointer to the log control structure of type **LOG_CTRL**.
`logType`	This is the log type identifier used to indicate the log message class. The purpose of the **logType** is to place some arbitrary number next to the message in the log file. When dealing with large log files, choosing the number carefully makes it easy to find the message using the search feature of a text editor.
`sourceFile`	This is a pointer to the name of the source file containing the call to slog. It is used when logging debug information indicating which C file received the log message. It may be passed a **NULL** argument if this information is unwanted.
`lineNum`	This indicates the source file line number if a source file argument is passed in as a non-**NULL** value. The typical way to determine the line number of a C program is to use the built-in pre-processor command **__LINE__**.
`format`	This is a pointer to the optional **printf** type message to log.

Return Value: `ST_VOID`

slogHex

Usage: This function is the Hexadecimal data logging function. It takes care of both memory and file logging as required.

Function Prototype:

```
ST_VOID slogHex (LOG_CTRL  *lc,
                 ST_INT    logType,
                 ST_CHAR   *fileName,
                 ST_INT    lineNum,
                 ST_INT    numBytes,
                 ST_VOID   *hexData);
```

Parameters:

`lc`	This is a pointer to the log control structure of type **`LOG_CTRL`**.
`logType`	This is the log type identifier used to indicate the log message class. The purpose of the **`logType`** is to place some arbitrary number next to the message in the log file. When dealing with large log files, choosing the number carefully makes it easy to find the message using the search feature of a text editor.
`sourceFile`	This is a pointer to the name of the source file containing the call to slog. It is used when logging debug information indicating which C file received the log message. It may be passed a null argument if this information is unwanted.
`lineNum`	This indicates the source file line number if a source file argument is passed in as a non-null value. The typical way to determine the line number of a C program is to use the built-in preprocessor command **`__LINE__`**.
`numBytes`	This indicates the number of bytes to log.
`hexData`	This is a pointer to a data buffer that is logged in hexadecimal format.

Return Value: `ST_VOID`

slogCloneFile

Usage: This function is used to copy the contents of a log file to a new file name. The source log file is supplied in the **`LOG_CTRL`** information. The new file name is supplied in the second argument. When the source log file is open and being used by the SLOG susbsystem, it is closed, copied, and reopened to its prior location before the function returns.

Function Prototype:

```
ST_VOID slogCloneFile (LOG_CTRL *lc, ST_CHAR *newfile);
```

Parameters:

`lc`	This is a pointer to the log control structure of type **`LOG_CTRL`**. The **`lc->fc.fileName`** is the name of the source file name.
`newfile`	This is a pointer to a string containing the new file name.

Return Value: `ST_VOID`

slogCloseFile

Usage: This function closes the file being used for logging. The next item logged will cause the file log to be re-initialized.

Function Prototype: `ST_VOID slogCloseFile (LOG_CTRL *lc);`

Parameters:

`lc` This is a pointer to the log control structure of type **`LOG_CTRL`**.

Return Value: `ST_VOID`

slogGetMemCount

Usage: This function returns the number of used memory resident message buffers when memory slogging is in use.

Function Prototype: `ST_INT slogGetMemCount (LOG_CTRL *lc);`

Parameters:

`lc` This is a pointer to the log control structure of type **`LOG_CTRL`**.

Return Value: `ST_INT` Returns the number of memory buffers containing slog messages.

slog_dyn_log_fun

Usage: This function pointer can be set to point to a function in the application which is called each time information is sent to **`slog`** or **`slogHex`**. This mechanism allows the application to process log data in a manner not available in the SLOG system

---

Function Pointer Global Variable:

```
extern ST_VOID (*slog_dyn_log_fun) (LOG_CTRL   *lc,
                                    ST_INT     logType,
                                    ST_CHAR    *sourceFile,
                                    ST_INT     lineNum,
                                    ST_INT     bufLen,
                                    ST_CHAR    *buf);
```

Parameters:

`lc`	This is a pointer to the log control structure of type **`LOG_CTRL`**.
`logType`	This is the log type identifier used to indicate the log message class. The purpose of the **`logType`** is to place some arbitrary number next to the message. When dealing with large quantities of information, choosing the number carefully makes it easy to see the message.
`sourceFile`	This is a pointer to the name of the source file containing the call to slog. It allows the application to know which C file called **slog** or **slogHex**. It may be received as a null argument if this information is intentionally not given or unknown.
`lineNum`	This indicates the source file line number if a source file argument is passed in as a non-null value. The typical way to determine the line number of a C program is to use the built-in preprocessor command **`__LINE__`**.
`bufLen`	This is the length of the string being sent to the log file.
`buf`	This is a pointer to the information buffer.

Return Value: `ST_VOID`

Note: The sample source module, **mmsamisc.c**, has an example of how to use “dynamic” logging. Refer to the functions **`do_debugset`** and **`screenLogFun`** for an example that displays the log information to the screen or to a file using the **`mms_debug_log`** stream.

slog_service_fun

Usage: This function pointer may be set to point to a function in the application that is called periodically during slow SLOG operations such as cloning a file. The intention of this function is to allow a real-time application processing time while SLOG has been transferred control of the processor. File logging is temporarily disabled when this function is called.

Function Pointer Global Variable: `extern ST_VOID (*slog_service_fun) (ST_VOID);`

Parameters: NONE

Return Value: `ST_VOID`

slog_max_msg_size_set

Usage: This function changes the maximum size allowed for each log message.

Function Prototype:

```
ST_RET slog_max_msg_size_set (LOG_CTRL  *lc,
                              ST_INT    max_msg_size);
```

Parameters:

`lc` This is a pointer to the **`LOG_CTRL`** structure used to control logging.

`max_msg_size` Indicates the maximum size allowed for each log message.

Return Value: `ST_RET` `SD_SUCCESS` or Error.

slog_max_msg_size_get

Usage: This macro is used to get the maximum message size. This macro replaces a function, but is much faster.

Macro:

```
#define slog_max_msg_size_get(log_ctrl)(log_ctrl->max_msg_size)
```

Parameters:

`log_ctrl` This is a pointer to the **`LOG_CTRL`** structure used to control logging.

Return Value: `ST_INT` Maximum size allowed for a log message.

sLogDumpMem

Usage: When this function is called, the entire contents of the memory buffer will be written to this file. It is only useful when Memory logging (i.e., storing log messages in memory) is enabled.

Function Prototype: `ST_VOID slogDumpMem (LOG_CTRL *lc);`

Parameters:

`lc` This is a pointer to the log control structure of type **`LOG_CTRL`**.

Return Value: None

logCfgAddMaskGroup

Usage: This function defined in **logcfgx.c** adds **`LOGCFG_VALUE_GROUP`** variables to the parsing engine for use during the XML logging configuration file parsing. This function is prototyped in **slog.h**.

Function Prototype: `ST_VOID logCfgAddMaskGroup (LOGCFG_VALUE_GROUP *logMaskGroup);`

Parameters:

`logMaskGroup` This is a pointer to the **`LOGCFG_VALUE_GROUP`** variable.

Return Value: None

logcfgx_ex

Usage: This function defined in **logcfgx.c** parses the specified logging configuration XML file (usually **logcfg.xml)** to set up application logging parameters and masks. This function is prototyped in **slog.h**. SISCO libraries contain **`LOGCFG_VALUE_GROUP`** variables that specify logging masks for each component. All possible variables are listed in the **slog.h**. The sample in the *Enhanced Logging Features* section shows several calls to **`logCfgAddMaskGroup`**, passing the most important **`LOGCFG_VALUE_GROUP`** variables for MMS users. A user could add additional logging parameters to the provided sample, **logcfg.xml**. Additionally other program parameters could also be configured through this file when needed. The **`LOGCFGX_VALUE_MAP`** and **`LOGCFG_VALUE_GROUP`** need to be created in user application as shown in the *Enhanced Logging Features* section.

Function Prototype:

```
ST_RET logcfgx_ex (LOG_CTRL       *lc,
                   ST_CHAR        *logFileName,
                   ST_CHAR        *fileNamePrefix,
                   ST_BOOLEAN     masksOnly,
                   ST_BOOLEAN     saveTagVals);
```

Parameters:

`lc`	This is a pointer to the log control structure of type **`LOG_CTRL`**. Typically, it would be the global pointer **`sLogCtrl`**.
`LogFileName`	This is the logging configuration XML file name. This file must have structure as shown in the provided sample **logcfg.xml**.
`fileNamePrefix`	This is an optional prefix to be added to any file name found in the logging configuration XML file. It may be used to specify base directory for the file.
`masksOnly`	This option, if set to **`SD_TRUE`**, will parse only the masks from the XML logging configuration file.
`saveTagVals`	This option, if set to **`SD_TRUE`**, will save values for all tags in the XML logging configuration file. This feature is used internally by SISCO.

Return Value: `ST_RET` `SD_SUCCESS` If the function is successful; otherwise `SD_FAILURE`

The **`dataType`** in a **`LOGCFGX_VALUE_MAP`** structure can be one of following defines:

```
_LOGCFG_DATATYPE_UINT_MASK
_LOGCFG_DATATYPE_UINT32_MASK
_LOGCFG_DATATYPE_RUINT32_MASK
_LOGCFG_DATATYPE_BOOLEAN
_LOGCFG_DATATYPE_INT
_LOGCFG_DATATYPE_LONG
_LOGCFG_DATATYPE_INT16
_LOGCFG_DATATYPE_INT32
_LOGCFG_DATATYPE_UINT
_LOGCFG_DATATYPE_ULONG
_LOGCFG_DATATYPE_UINT16
_LOGCFG_DATATYPE_UINT32
_LOGCFG_DATATYPE_STRING
_LOGCFG_DATATYPE_STRINGBUF
_LOGCFG_DATATYPE_DOUBLE
_LOGCFG_DATATYPE_FILENAME
_LOGCFG_DATATYPE_CALLBACK
```

Enhanced Logging Features

SISCO provides library functions and new macros aiding application developers in implementing application logging. The following sample can be used for setting application logging using a XML logging configuration file. The **logcfgx.c** must be linked to the application.

In an application header file:

```
 /* logging masks */
#define MYLOG_ERR          0x00000001
#define MYLOG_FLOW   0x00000002
#define MYLOG_DATA   0x00000004
extern ST_UINT my_debug_sel;
extern SD_CONST ST_CHAR *SD_CONST _mylog_err_logstr;
extern SD_CONST ST_CHAR *SD_CONST _mylog_flow_logstr;

/*  error log macros /
#define MY_LOG_ERR0(a)    SLOG_0 (my_debug_sel & MYLOG_ERR,_mylog_err_logstr, a)
#define MY_LOG_ERR1(a, b) SLOG_1 (my_debug_sel & MYLOG_ERR,_mylog_err_logstr, a, b)

/* Create new macros MY_LOG_ERR2, etc.,                  */
/* for each additional argument passed to the log macro. */
/*  error log continuation macros (do not include log message header) */
#define MY_LOG_ERRC0(a)    SLOGC_0 (my_debug_sel & MYLOG_ERR,_mylog_err_logstr, a)
#define MY_LOG_ERRC1(a, b) SLOGC_1 (my_debug_sel & MYLOG_ERR,_mylog_err_logstr, a, b)

/* program flow log macros */
#define MY_LOG_FLOW0(a)   SLOG_0 (my_debug_sel & MYLOG_FLOW,_mylog_flow_logstr, a)

/* hex logging */
#define MY_LOG_DATA(num, ptr)   SLOGH (my_debug_sel & MYLOG_DATA, num , ptr)
```

In an application's C or C++ file:

```
 #include “glbtypes.h”       /* SISCO’s file */
#include “sysincs.h” /* SISCO’s file */
#include “glbsem.h”  /* SISCO’s file – needed for S_MT_SUPPORT define */
#include “slog.h”           /* SISCO’s file */
#include “myapp.h”

SD_CONST static ST_CHAR *SD_CONST thisFileName = __FILE__;
ST_UINT my_debug_sel = MYLOG_ERR;
/* log errors, other masks maybe set during program execution  */
SD_CONST ST_CHAR *SD_CONST _mylog_err_logstr =  “MYLOG_ERR”;
SD_CONST ST_CHAR *SD_CONST _mylog_flow_logstr = “MYLOG_FLOW”;

LOGCFGX_VALUE_MAP myLogMaskMaps[] =
  {
    {"MYLOG_ERR",     MYLOG_ERR,  &my_debug_sel, _LOGCFG_DATATYPE_UINT_MASK, "Error"},
    {"MYLOG_FLOW", MYLOG_FLOW, &my_debug_sel, _LOGCFG_DATATYPE_UINT_MASK, "Flow"},
    {"MYLOG_DATA", MYLOG_DATA, &my_debug_sel, _LOGCFG_DATATYPE_UINT_MASK, "Data"}
  };

LOGCFG_VALUE_GROUP myLogMaskMapCtrl =
    {
    {NULL,NULL},
    "User",
    sizeof(myLogMaskMaps)/sizeof(LOGCFGX_VALUE_MAP),
    myLogMaskMaps
    };
/*
The code below, used to configure log masks from the logcfg.xml file, needs to be at the
beginning of main before any logging (MMS or application) is done.
    logCfgAddMaskGroup (&myLogMaskMapCtrl);
  #if defined(S_SEC_ENABLED)
    logCfgAddMaskGroup (&secLogMaskMapCtrl);
  #endif
    logCfgAddMaskGroup (&mmsLogMaskMapCtrl);
    logCfgAddMaskGroup (&acseLogMaskMapCtrl);
    logCfgAddMaskGroup (&tp4LogMaskMapCtrl);
    logCfgAddMaskGroup (&asn1LogMaskMapCtrl);
    logCfgAddMaskGroup (&sxLogMaskMapCtrl);
```

```
  #if defined(S_MT_SUPPORT)
    logCfgAddMaskGroup (&gsLogMaskMapCtrl);
  #endif
    logCfgAddMaskGroup (&sockLogMaskMapCtrl);
    logCfgAddMaskGroup (&memLogMaskMapCtrl);
    logCfgAddMaskGroup (&memDebugMapCtrl);

ret =  logcfgx_ex (sLogCtrl, "logcfg.xml", NULL, SD_FALSE, SD_FALSE);
if (ret != SD_SUCCESS)
  printf ("Parsing Log Configuration file failed '%s'...\n", "logcfg.xml");

  /* sample of application logging */
  if  (type == expected_type)
    {
    MY_LOG_FLOW1 ("Received message type= %d", type);
    MY_LOG_DATA (num_bytes, data_ptr);
    }
  else
    MY_LOG_ERR1 ("Unexpected message received type= %d", type);
```

SISCO logging functions can be accessed directly but the SLOG macros are a more convenient and simpler way of writing logging code.

MMS-*Lite* Log Levels

The amount of logging produced by MMS-*Lite* is controlled by setting global MMS-EASE variables. These variables hold log control bits for enabling and disabling the various levels of logging as shown below.

mms_debug_sel

`extern ST_ULONG mms_debug_sel;`

CONSTANT	BIT ASSIGNMENTS	ENABLE LOGGING OF...
MMS_LOG_DEC	0x00000001L	MMS decoding process
MMS_LOG_ENC	0x00000002L	MMS encoding process
MMS_LOG_ERR	0x00010000L	Abnormal errors
MMS_LOG_NERR	0x00020000L	Normal errors
MMS_LOG_RT	0x00010000L	All RunTime Type transactions
MMS_LOG_RTAA	0x00020000L	All RunTime Type AlternateAccess transactions
MMS_LOG_AA	0x00040000L	All Alternate Access transactions

The following defines are user-reserved. These are not used by MMS-*Lite*

MMS_LOG_USR_IND	0x00000100L	User Indications
MMS_LOG_USR_CONF	0x00000200L	User Confirmations

By default, **`mms_debug_sel`** is set to **`MMS_LOG_ERR`**.

asn1_debug_sel

`extern ST_UINT asn1_debug_sel;`

CONSTANT	BIT ASSIGNMENTS	ENABLE LOGGING OF...
ASN1_LOG_DEC	0x0001	ASN.1 decode process
ASN1_LOG_ENC	0x0002	ASN.1 encode process
ASN1_LOG_ERR	0x0004	Abnormal ASN.1 errors
ASN1_LOG_NERR	0x0008	Normal ASN.1 errors

By default, **`asn1_debug_sel`** is set to **`ASN1_LOG_ERR`**.

list_debug_sel

```
extern ST_BOOLEAN list_debug_sel;
```

Setting this variable to **`SD_TRUE`** causes all internal MMS-EASE list operations to be logged. By default, **`list_debug_sel`** is not set.

chk_debug_en

```
extern ST_UINT chk_debug_en;
```

CONSTANT	BIT ASSIGNMENTS	ENABLE LOGGING OF...
MEM_LOG_ERR	0x0001	Abnormal memory errors
MEM_LOG_MALLOC	0x0002	**chk_malloc** calls
MEM_LOG_CALLOC	0x0004	**chk_calloc** calls
MEM_LOG_REALLOC	0x0008	**chk_realloc** calls
MEM_LOG_FREE	0x0010	**chk_free** calls

By default, **`chk_debug_en`** is set to **`MEM_LOG_ERR`**.

mvl_debug_sel

The global variable **`mvl_debug_sel`** may be used to control the logging of the MVL layer.

```
extern ST_UINT mvl_debug_sel;
```

The following values may be used to set the global variable **`mvl_debug_sel`** to enable different types of logging in the MVL layer.

CONSTANT	BIT ASSIGNMENTS	ENABLE LOGGING OF...
MVLLOG_ERR	0x00000001	MVL Critical Errors
MVLLOG_NERR	0x00000002	MVL Normal Errors
MVLLOG_ACSE	0x00000040	MVL ACSE Encoding/Decoding
MVLLOG_ACSEDATA	0x00000080	MVL ACSE Encoding/Decoding HEX data
MVLULOG_FLOW	0x00000200	MVL program Flow (mostly for special UCA and IEC 61850 code)

acse_debug_sel

The global variable **`acse_debug_sel`** may be used to control the logging of the ACSE, Presentation (COPP), and Session (COSP) layers of the OSI stack (the Presentation and Session settings are included here simply to avoid extra unnecessary global variables).

```
extern ST_UINT acse_debug_sel;
```

The following values may be used to set the global variable **`acse_debug_sel`** to enable different types of logging in the ACSE, Presentation (COPP), and Session (COSP) layers.

CONSTANT	BIT ASSIGNMENTS	ENABLE LOGGING OF...
ACSE_LOG_ERR	0x00000001	ACSE Errors
ACSE_LOG_ENC	0x00000002	ACSE Encoding
ACSE_LOG_DEC	0x00000004	ACSE Decoding
ACSE_LOG_DIB	0x00000008	ACSE DIB (i.e., network addressing)

COPP_LOG_ERR	0x00000100L	COPP Errors
COPP_LOG_DEC	0x00001000L	COPP Decoding
COPP_LOG_DEC_HEX	0x00002000L	COPP Decoding Hex
COPP_LOG_ENC	0x00004000L	COPP Encoding
COPP_LOG_ENC_HEX	0x00008000L	COPP Encoding Hex
COSP_LOG_ERR	0x00010000L	COSP Errors
COSP_LOG_DEC	0x00100000L	COSP Decoding
COSP_LOG_DEC_HEX	0x00200000L	COSP Decoding Hex
COSP_LOG_ENC	0x00400000L	COSP Encoding
COSP_LOG_ENC_HEX	0x00800000L	COSP Encoding Hex

tp4_debug_sel

The global variable **`tp4_debug_sel`** may be used to control the logging of the TP4 layer.

```
extern ST_UINT tp4_debug_sel;
```

The following values may be used to set the global variable **`tp4_debug_sel`** to enable different types of logging in the TP4 layer:

CONSTANT	BIT ASSIGNMENTS	ENABLE LOGGING OF...
TP4_LOG_ERR	0x00000001	Transport Errors
TP4_LOG_FLOWUP	0x00000002	Transport Decode (incoming TPDUs)
TP4_LOG_FLOWDOWN	0x00000004	Transport Encode (outgoing TPDUs)

The default setting is to log errors only as follows:

```
tp4_debug_sel = TP4_LOG_ERR;
```

clnp_debug_sel

To control CLNP API logging, a global variable, **`clnp_debug_sel`**, is provided. It is used to select the amount and nature of logging produced by the CLNP API.

```
extern ST_UINT clnp_debug_sel;
```

It may be set to one of the following values:

CONSTANT	BIT ASSIGNMENTS	ENABLE LOGGING OF...
CLNP_LOG_ERR	0x00000001L	CLNP Critical Errors
CLNP_LOG_NERR	0x00000002L	CLNP Normal Errors
CLNP_LOG_REQ	0x00000010L	CLNP Requests
CLNP_LOG_IND	0x00000020L	CLNP Indications
CLNP_LOG_ENC_DEC	0x00000100L	CLNP Encode/Decode
CLNP_LOG_LLC_ENC_DEC	0x00000200L	LLC Encode/Decode
CLSNS_LOG_REQ	0x00001000L	CLSNS (Subnetwork) Requests
CLSNS_LOG_IND	0x00002000L	CLSNS (Subnetwork) Indications

smp_debug_sel

The global variable **`smp_debug_sel`** may be used to control the logging of the SMP layer (i.e. UCA Station Management Protocol layer used for time synchronization). NOTE: Very few applications use the SMP code or logging.

```
extern ST_UINT smp_debug_sel;
```

The following values may be used to set the global variable **`smp_debug_sel`** to enable different types of logging in the SMP layer.

CONSTANT	BIT ASSIGNMENTS	ENABLE LOGGING OF...
`SMP_LOG_ERR`	`0x00000001L`	SMP Errors
`SMP_LOG_REQ`	`0x00000010L`	SMP Requests
`SMP_LOG_IND`	`0x00000020L`	SMP Indications
`SMP_LOG_HEX`	`0x00000080L`	Hex encoding of SMP Packets

Configuring Log Masks with the XML file

The log masks defined above may be set by reading values from an XML file by calling the function described earlier **`logcfgx_ex`**. Each bit mask is controlled by an XML tag. The XML tag name usually exactly matches the bit mask define name.

Setting a mask to "ON" enables the logging. Setting it to "OFF" disables it. Log masks found in the **logcfg.xml** file supplied with samples are described below:

XML Tags For Configuring Logging	
LogConfigurationMasks section: Diagnostic information for "logcfg.xml" parse problems	
`LOGCFG_ERR`	Critical errors
`LOGCFG_NERR`	Recoverable errors
`LOGCFG_FLOW`	Program flow
UserLogMasks section: User Logging	
`USER_LOG_CLIENT`	User client logging. Any log macro like **`USER_LOG_CLIENT*`** in **mmslog.h** may be added to user code and it will be controlled by this mask.
`USER_LOG_SERVER`	User server logging. Any log macro like **`USER_LOG_SERVER*`** in **mmslog.h** may be added to user code and it will be controlled by this mask
SecurityConfiguationMasks section: Diagnostic information for security issues in the Security Interface (SEC) or the SSL Engine (SSLE) on Windows called shared library on UNIX or LINUX (SecurityLogMasks). These log masks are utilized in MMS-Lite Secure.	
`SEC_LOG_NERR`	Recoverable errors
`SEC_LOG_FLOW`	Program flow
`SEC_LOG_DATA`	SSL data: Encrypted received data will be logged as hex, followed by decrypted data in hexidecimal
`SEC_LOG_DEBUG`	Information useful for debugging
`SSLE_LOG_NERR`	Recoverable errors
`SSLE_LOG_FLOW`	Program flow
`SSLE_LOG_DATA`	Logs data before/after encryption/decryptytion
`SSLE_LOG_DEBUG`	Debugging information
SemaphoreLogMasks section: Diagnostic information for semaphore or thread problems	
`GS_LOG_NERR`	Recoverable errors
`GS_LOG_FLOW`	Program flow

Asn1LogMasks section: Diagnostic information related to ASN.1	
ASN1_LOG_ERR	Critical ASN.1 errors
ASN1_LOG_NERR	Recoverable ASN.1 errors (or bad grammar)
ASN1_LOG_DEC	ASN.1 decode
ASN1_LOG_ENC	ASN.1 encode
MmsLogMasks section: Diagnostic information related to MMS messaging	
MMS_LOG_ERR	Critical MMS errors
MMS_LOG_NERR	Recoverable MMS errors (bad grammar)
MMS_LOG_DEC	MMS decode
MMS_LOG_ENC	MMS encode
MMS_LOG_RT	Log creation of runtime types
MMS_LOG_RTAA	Log creation of runtime types using Alternate Access
MMS_LOG_AA	Logs creation of Alternate Access
MvlLogMasks section: Useful for examining connection issues and MVL layer operation	
MVLLOG_NERR	Recoverable errors
MVLLOG_ACSE	MVL interface to ACSE
MVLLOG_ACSEDATA	Displays ACSE messages in hexadecimal
MVLULOG_FLOW	Program flow
MVLULOG_DEBUG	Logs creation of Alternate Access
AcseLogMasks section: Useful in diagnosing ACSE layer problems	
ACSE_LOG_DEC	ACSE layer encoding
ACSE_LOG_ENC	ACSE layer decoding
COPP_LOG_DEC	COPP (Presentation) layer decoding
COPP_LOG_DEC_HEX	COPP(Presentation) layer decoding in HEX
COPP_LOG_ENC	COPP (Presentation) layer encoding
COPP_LOG_ENC_HEX	COPP (Presentation) layer encoding in HEX
COSP_LOG_DEC	COSP (Session) layer decoding
COSP_LOG_DEC_HEX	COSP (Session) layer decoding in HEX
COSP_LOG_ENC	COSP (Session) layer encoding
COSP_LOG_ENC_HEX	COSP (Session) layer encoding in HEX
Tp4LogMasks section: Useful for examining TP4 services and functions with either connection-oriented or connectionless network service	
TP4_LOG_FLOWUP	Incoming TP4 packets
TP4_LOG_FLOWDOWN	Outgoing TP4 packets
ClnpLogMasks section: Useful for examining the CLNP network layer of the OSI protocol stack or for connectionless datagram services over OSI networks	
CLNP_LOG_NERR	Recoverable errors
CLNP_LOG_REQ	CLNP requests
CLNP_LOG_IND	CLNP indications
CLSNS_LOG_REQ	Sub-network requests
CLSNS_LOG_IND	Sub-network indications
SxLogMasks section: Useful when diagnosing XML parsing problems	
SX_LOG_NERR	Recoverable errors
SX_LOG_DEC	Decoding of XML
SX_LOG_ENC	Encoding of XML
SX_LOG_FLOW	Program flow
SX_LOG_DEBUG	Information useful for debugging

SocketLogMasks section: Useful when diagnosing "gensock2" or socket problems	
SOCK_LOG_NERR	Recoverable errors
SOCK_LOG_FLOW	Program flow
SOCK_LOG_TX	Socket transmit
SOCK_LOG_RX	Socket receive
SmpLogMasks section: Diagnostic information related to UCA Station Management Protocol	
SMP_LOG_REQ	UCA Station Management Protocol Requests
SMP_LOG_IND	UCA station Management Protocol indications
MemLogMasks section: Dynamic Memory Tracking (good for detecting leaks and multiple frees)	
MEM_LOG_ERR	Memory misuse, buffer overwrites, multiple frees, etc.
MEM_LOG_CALLOC	File and line of where buffers are calloced
MEM_LOG_MALLOC	File and line of where buffers are malloced
MEM_LOG_REALLOC	File and line of where buffers are realloced
MEM_LOG_FREE	File and line of where buffers are freed

Appendix D

Memory Management Tools

There are two types of Memory Management for MMS-*Lite*, Standard and Pooled. By default, Standard Memory Management is used.

Standard Memory Management

MMS-*Lite* provides a set of memory management tools that include logging and integrity checking. To do so, replacement macros for the standard C runtime library functions **`malloc`**, **`calloc`**, **`realloc`**, and **`free`** are provided. These replacement macros are **`chk_malloc`**, **`chk_calloc`**, **`chk_realloc`**, and **`chk_free`**, respectively. These macros accept the same arguments as their counterparts from the standard C runtime library and are used internally by MMS-*Lite*. The macros are exposed so that MMS-EASE applications can take advantage of their features. The MMS-*Lite* memory management tools have the following features:

1. Every time **`chk_free`** is called to free a pointer that was not returned by **`chk_calloc`**, **`chk_malloc`**, or **`chk_realloc`**, an error message is logged. This can be helpful to determine the following problems:
   a. The application was freeing an invalid pointer.
   b. The application was freeing the same pointer more than once.
   c. The application was freeing a null pointer.
2. If the application uses a lot of memory and eventually is running out, the functions **`chk_calloc`**, **`chk_malloc`**, and **`chk_realloc`** will detect this condition, log all the pointers currently under the view of the tools, and report this error using a function pointer. This can be helpful in finding the following problems:
   a. The application is running out of memory because it is allocating the memory but not giving it back.
   b. The application is overwriting a portion of dynamic memory and corrupting the C runtime library memory management list.
3. Calling the function **`dyn_mem_ptr_status`** will log a current list of allocated pointers. This can be helpful in finding the following problems:
   a. If the list continues to grow, the application is probably allocating memory but not giving it back.
   b. If **`dyn_mem_ptr_status`** crashes in the middle of displaying information, the memory list has been corrupted before that point. In this situation, it is helpful to insert temporary calls in the program to **`chk_mem_list`**. The calls to the memory list validation tool may help you zero in on the program logic which is causing the problem.

Compiling and Linking with Standard Memory Management

All memory allocation in MMS-*Lite* is done using macros (defined in **mem_chk.h**). The macros are defined such that different functions are called depending on how the source code is compiled. To use the Standard Memory Management, all source code must be compiled with **`DEBUG_SISCO`** defined (**`SMEM_ENABLE`** *NOT* defined), and then the following macros are used:

```
#define M_MALLOC(ctx,x)          x_chk_malloc  (x,  thisFileName,__LINE__)
#define M_CALLOC(ctx,x,y)        x_chk_calloc  (x,y,thisFileName,__LINE__)
#define M_REALLOC(ctx,x,y)       x_chk_realloc (x,y,thisFileName,__LINE__)
#define M_STRDUP(ctx,x)          x_chk_strdup  (x,  thisFileName,__LINE__)
#define M_FREE(ctx,x)            x_chk_free    (x,  thisFileName,__LINE__)

#define chk_malloc(x)            x_chk_malloc  (x,  thisFileName,__LINE__)
#define chk_calloc(x,y)          x_chk_calloc  (x,y,thisFileName,__LINE__)
#define chk_realloc(x,y)         x_chk_realloc (x,y,thisFileName,__LINE__)
#define chk_strdup(x)            x_chk_strdup  (x,  thisFileName,__LINE__)
#define chk_free(x)              x_chk_free    (x,  thisFileName,__LINE__)
```

Notice that the **M_MALLOC** and **chk_malloc** macros produce the same result. The **ctx** argument to **M_MALLOC** is not used. Similarly, the **M_CALLOC** and **chk_calloc** macros produce the same result, and so on.

Every module using these memory management macros must also define a static variable, **thisFilename**, and include **mem_chk.h**, as follows:

```
#ifdef DEBUG_SISCO
static char *thisFileName = __FILE__;
#endif

#include "mem_chk.h"
```

Memory Allocation Global Variables

The following variables are used with the SISCO Memory Allocation Tools:

`extern ST_BOOLEAN m_check_list_enable;`

This variable is used to enable list validation and overwrite checking on every alloc and free call. When the application experiences random crashes, enabling this feature is highly recommended. The default is **SD_FALSE**.

`extern ST_BOOLEAN m_find_node_enable;`

This variable is used to enable searching the memory list for the element before accessing the memory during **chk_realloc** and **chk_free** calls. The value of **SD_TRUE** enables searching the memory list. The value of **SD_FALSE** disables the search and may speed up the application. The default is **SD_FALSE**.

`extern ST_BOOLEAN m_no_realloc_smaller;`

This variable will cause **chk_realloc** not to realloc when the new size is smaller than the old size. Not reallocating a buffer to a smaller size is desirable on systems whose memory management algorithms lead to excessive fragmentation. The default is **SD_FALSE**.

`extern ST_CHAR *m_pad_string;`

This is a pointer to string of octets, which are placed as a header and footer around the actual contents of the buffer. When **m_check_list_enable** is set to **SD_TRUE** the value in this string must be present as the header and footer each time the buffer is validated or the memory error function pointer ***mem_chk_err** will be invoked. The default value of the string is **0xDEADBEEF**.

`extern ST_INT m_num_pad_bytes;`

This variable indicates the number of bytes in the **m_pad_string**. The default is 4 bytes.

`extern ST_BOOLEAN m_fill_en;`

This variable is used to enable a feature which will fill up a freed buffer with values that may cause the program to crash should references to locations within the buffer still be active after the buffer has been freed. When set to **SD_TRUE** the value of the **m_fill_byte** is written to each byte in a buffer freed by calling **chk_free**. The default is **SD_FALSE**.

`extern ST_UCHAR m_fill_byte;`

This variable contains the value that is written to buffers freed when **m_fill_en** is set to **SD_TRUE**. The default is `0xCC`.

`extern ST_BOOLEAN m_mem_debug;`

This variable must be set to **SD_TRUE** to enable any of the memory tool validation features. Setting this value to **SD_FALSE** causes all memory validation code to be circumvented and calls to **chk_calloc**, **chk_malloc**, **chk_realloc**, and **chk_free** essentially map on to the C runtime library with little or no overhead. The default is **SD_TRUE**.

Dynamic Memory Allocation

Dynamic Memory Allocation Functions

dyn_mem_ptr_status

Usage: This function will log the current list of allocated pointers to a file using the **SLOG** subsystem. The information contains the size of each buffer, the file and line where the buffer was allocated, statistics on how many pointers are allocated, and how much total dynamic memory is in use.

Function Prototype: `ST_VOID dyn_mem_ptr_status (ST_VOID);`

Parameters: None

Return Value: `ST_VOID`

dyn_mem_ptr_statistics

Usage: This function will log statistics associated with the dynamic memory heap to a file using the **SLOG** subsystem. The four pieces of information shown are:

1. The total number of pointers allocated
2. The total amount of memory allocated
3. The maximum number of pointers ever allocated by the program
4. The maximum amount of memory ever allocated by the program

Unless the program is not releasing the dynamic memory it allocates using the memory management tools, the maximum values will be greater than the total values.

Function Prototype: `ST_VOID dyn_mem_ptr_statistics (ST_BOOLEAN log_to_screen);`

Parameters:

`log_to_screen`	**SD_TRUE**	Dynamic memory statistics are shown to the screen.
	SD_FALSE	Dynamic memory statistics will be logged to the file attached to the **SLOG** subsystem.

Return Value: `ST_VOID`

check_mem_list

Usage: This function will check the integrity of the memory heap associated with the **chk_** family of functions. Pointers in the heap are validated and traversed to verify that the list is intact. The memory buffer headers and footers are checked to catch memory overwrite problems. Although this function can be called from anywhere in the application to catch an overwrite, setting the global variable **m_check_list_enable** to **SD_TRUE** will cause this function to be called by the **chk_** functions each time they are used. Any error detected by this function is reported by calling the **mem_chk_err** function pointer. To be of any use, the **mem_chk_err** function pointer should be set to point to a function in the application that displays the error or logs it to a file.

Function Prototype: `ST_VOID check_mem_list (ST_VOID);`

Parameters: None

Return Value: `ST_VOID`

chk_alloc_ptr

Usage: This function will verify that the pointer passed to this function is on the memory management list and when **m_check_list_enable** is set to **SD_TRUE**, header footer checking is performed on the buffer. If the pointer or buffer was in error, the **mem_chk_err** function pointer will be invoked.

Function Prototype: `ST_RET chk_alloc_ptr (ST_VOID *ptr);`

Parameters:

`ptr` This is a pointer to a dynamically allocated memory buffer.

Return Value: `ST_RET`

ST_RET	SD_SUCCESS	This means the buffer was OK.
	SD_FAILURE	This means the pointer or buffer was corrupted.

x_chk_malloc

Usage: This function replaces the standard C malloc function and returns a pointer to a buffer of dynamic memory whose size in bytes is determined by the **size** argument. The contents of the returned buffer are undetermined. Dynamic memory returned from this function is subject to the validation provided by the global variables and other tools described in this section.

Function Prototype:

```
ST_VOID *x_chk_malloc (ST_UINT   size,
                       ST_CHAR   *file,
                       ST_INT    line);
```

Parameters:

size	This indicates the size in bytes of the buffer to be allocated.
file	Name of source file where this function is called.
line	Line number in source file where this function is called.

Return Value:

ST_VOID *	<> null	This is a pointer to the allocated buffer.
	= null	The memory allocation has failed.

x_chk_calloc

Usage: This function replaces the standard C calloc function and returns a pointer to a buffer of dynamic memory whose size in bytes is determined as a product of the **num** and **size** argument. The contents of the returned buffer are all 0x00. Dynamic memory returned from this function is subject to the validation provided by the global variables and other tools described in this section.

Function Prototype:

```
ST_VOID *x_chk_calloc (ST_UINT   num,
                       ST_UINT   size,
                       ST_CHAR   *file,
                       ST_INT    line);
```

Parameters:

num	This indicates the number of continuous areas of memory to allocate.
size	This indicates the size in bytes of each memory are to allocate.
file	Name of source file where this function is called.
line	Line number in source file where this function is called.

Return Value:

ST_VOID *	<> null	This is a pointer to the allocated buffer.
	= null	The memory allocation failed.

x_chk_realloc

Usage: This function replaces the standard C realloc function and returns a pointer to a buffer of dynamic memory whose size in bytes is determined by the size argument. The contents of the returned buffer contain the contents of the old buffer. Dynamic memory returned from this function is subject to the validation provided by the global variables and other tools described in this section.

Function Prototype:

```
ST_VOID *x_chk_realloc (ST_VOID   *old,
                        ST_UINT   size,
                        ST_CHAR   *file,
                        ST_INT    line);
```

Parameters:

`old`	This pointer indicates the old buffer.
`size`	This indicates the new size of the buffer.
`file`	Name of source file where this function is called.
`line`	Line number in source file where this function is called.

Return Value:

`ST_VOID *`	`<> null`	This is a pointer to the resized buffer.
	`= null`	The memory reallocation failed.

x_chk_free

Usage: This function deallocates a memory buffer allocated with **`x_chk_calloc`**, **`x_chk_malloc`**, or **`x_chk_realloc`**. Integrity checking is present to detect if pointers are being freed more than once, or if bogus pointers are being freed.

Function Prototype:

```
ST_VOID x_chk_free (ST_VOID      *ptr,
                    ST_CHAR      *file,
                    ST_INT       line);
```

Parameters:

`ptr`	This is a pointer to the memory buffer that is to be deallocated.
`file`	Name of source file where this function is called.
`line`	Line number in source file where this function is called.

Return Value: `ST_VOID`

mem_chk_err

Usage: This function pointer may be set to point to an exception function in the application. The memory management tools will invoke this function pointer when a memory buffer related problem is detected.

Function Pointer Global Variable: `extern ST_VOID (*mem_chk_err) (ST_VOID);`

Parameters: None

Return Value: `ST_VOID`

Pooled Memory Management Using SMEM

The SMEM Memory Manager allows the user to create pools of memory buffers. An application may then obtain memory buffers from the pools instead of using the system memory allocation functions (**`malloc`**, etc.). By avoiding use of the system memory allocation functions, **memory fragmentation** can be eliminated. SMEM also allows the user to monitor or track the usage of the pools defined. The information produced can help the user adjust the input parameters and thus configure different areas of memory to produce more desirable results.

The pools are generally created at startup. When an application calls SMEM to obtain a memory buffer, SMEM finds an available buffer in its pools, and returns a pointer to the buffer

Parameters specific to SMEM Memory Management may be configured by data entered in the **smemcfg.xml** file. This file is parsed by calling the function **`smemcfgx`** (in **smemcfgx.c**) and the results are placed in various global data structures for later use.

Compiling and Linking with Pooled Memory Management

All memory allocation in MMS-*Lite* is done using macros (defined in **mem_chk.h**). The macros are defined such that different functions are called depending on how the source code is compiled. To use the Pooled Memory Management, all source code must be compiled with **`DEBUG_SISCO`** *and* **`SMEM_ENABLE`** defined, and then the following macros are used:

```
#define M_MALLOC(ctx,x)    x_m_malloc  (ctx,x,  thisFileName,__LINE__)
#define M_CALLOC(ctx,x,y)  x_m_calloc  (ctx,x,y,thisFileName,__LINE__)
#define M_REALLOC(ctx,x,y) x_m_realloc (ctx,x,y,thisFileName,__LINE__)
#define M_STRDUP(ctx,x)    x_m_strdup  (ctx,x,  thisFileName,__LINE__)
#define M_FREE(ctx,x)      x_m_free    (ctx,x,  thisFileName,__LINE__)
#define chk_malloc(x)      x_m_malloc  (MSMEM_GEN,x,  thisFileName,__LINE__)
#define chk_calloc(x,y)    x_m_calloc  (MSMEM_GEN,x,y,thisFileName,__LINE__)
#define chk_realloc(x,y)   x_m_realloc (MSMEM_GEN,x,y,thisFileName,__LINE__)
#define chk_strdup(x)      x_m_strdup  (MSMEM_GEN,x,  thisFileName,__LINE__)
#define chk_free(x)        x_m_free    (MSMEM_GEN,x,  thisFileName,__LINE__)
```

Notice that the **`M_MALLOC`** and **`chk_malloc`** macros produce the same result, except that the **`chk_malloc`** macro assumes the **`ctx`** argument is always **`MSMEM_GEN`** (i.e., the General context is always used). Similarly, the **`M_CALLOC`** and **`chk_calloc`** macros produce the same result, and so on.

Every module using these memory management macros must also define a static variable, **thisFilename**, and include **mem_chk.h**, as follows:

```
#ifdef DEBUG_SISCO
static char *thisFileName = __FILE__;
#endif

#include "mem_chk.h"
```

SMEM Contexts

One or more contexts may be configured in the **smemcfg.xml** file. Each context defined will contain a list of available memory pools and optional range tracking information.

A context contains a list of memory pools stored from smallest to largest. Multiple pools of the same size are allowed. Each pool is defined by a buffer size, the number of buffers, and optional parameters that specify if auto cloning can be implemented and if so, the maximum number of clones allowed

A context may also contain range limits for monitoring or tracking the usage of the defined pools. Up to a specified number of range limits may be entered. Each set of limits contains a high limit and a low limit. The specified ranges may overlap.

SMEM Pools

Each SMEM context may contain many SMEM pools. The following parameters may be specified to create a pool: the name of the pool, the size of each buffer, the number of buffers, whether cloning is allowed, and if so, the maximum number of clones that may be created. All parameters are read from the **smemcfg.xml** file and stored in a pool control block.

If either the buffer size OR the number of buffers is omitted from the configuration of a pool, then the user function **u_smem_get_pool_params** is called to get the necessary information.

Selecting auto cloning for a pool of memory allows more memory pools of that size to be created if none are available. Non-availability occurs because all existing pools of the specified size are being used or no pool(s) of the specified size exist.

If “auto clone” is not configured in the configuration, then it will default to ‘No’.

If “max clones” is not configured in the configuration, then it will default to an infinite number of clones.

“System” Memory Allocated when Creating Pools

SMEM creates a memory pool by calling **malloc** to obtain a large block of memory from the operating system. All the SMEM buffers are contained within this large block (i.e., **BlockSize = NumberOfBuffers * BufferSize**). Small amounts of additional memory are allocated for the Pool Control structure and other overhead.

Allocating Memory with SMEM

The SMEM context is passed to the SMEM allocation function.

A search is made for the first pool in the selected context large enough to hold the requested buffer size. If none exist, the message “***SMEM has no buffers large enough for size …***” is logged and an attempt to create one is made. If that fails then the error message “***Error: no SMEM control elements for pool size …***” is logged.

If a pool larger then or equal to the requested size exists then a check is made for availability within that pool. If all the buffers in the pool are used up the message “***SMEM needs more buffers of size …***” is logged and a check is made for another pool of that same size. If the buffers in the second pool are all used up then the message “***User did not supply enough buffers of size …***” is logged and no memory is allocated.

Freeing Memory with SMEM

The SMEM context is passed to the SMEM free function.

A context's pool list is searched for the specified buffer to be freed. If the buffer is not found in the list, the message "***SMEM free could not find SMEM pool control for the ptr …***", and the buffer is NOT freed.

Range Monitoring

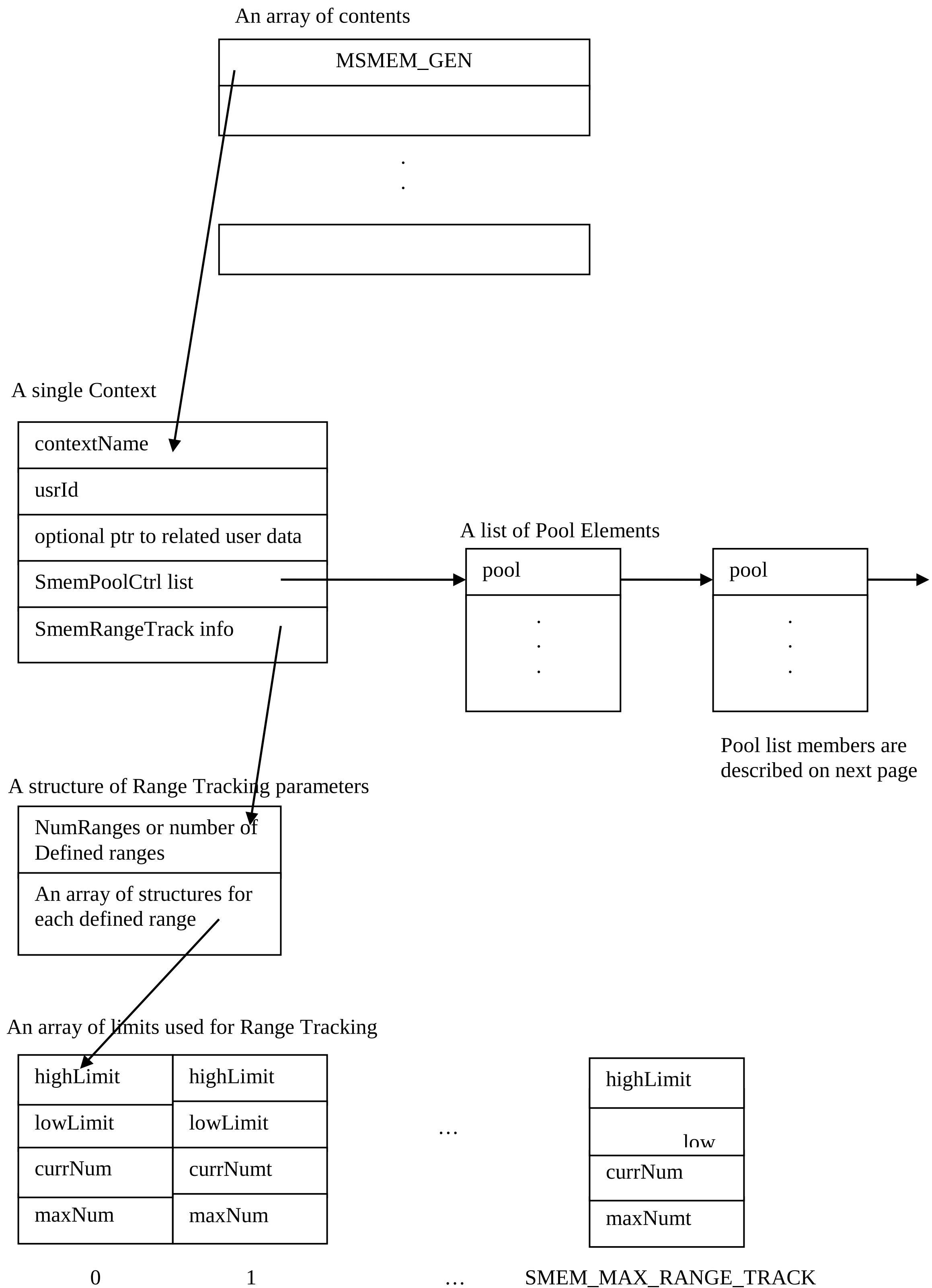
Up to **`SMEM_MAX_RANGE_TRACK`** (see define in **smem.h**) ranges of memory may be monitored to determine the amount of usage of each configured memory area. The ranges are defined by a high limit (**HighLimit**) and a low limit (**LowLimit**) entered in the configuration file for each specified range. These limits and the number of ranges to monitor are saved.

After configuration, during execution of the program, totals will be kept for the maximum number of memory buffers used in each range (**maxNum**) and the current number used (**currNum**). These totals are set to zero at startup.

When a buffer is allocated in a SMEM context, its size is compared with each range configured. If it is inside a configured range then the count for that range is incremented. If the current count is larger than the maximum number used in this range so far, then the maximum is set to the current count.

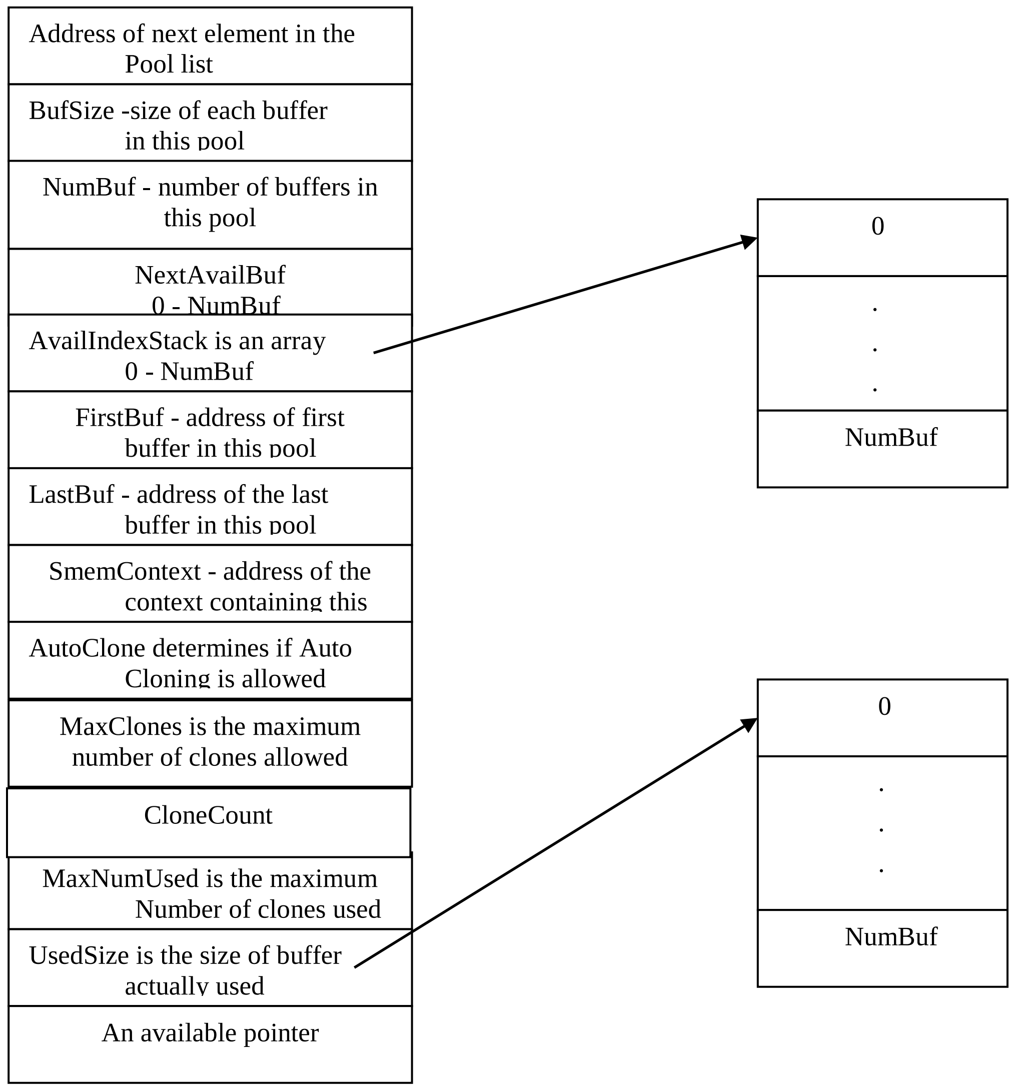
When a buffer is freed in a SMEM context, its size is compared with each range configured. If it is inside a configured range, then the count for that range is decremented.

The diagram of data structures is shown on the next page:



An array of contents
MSMEM_GEN
A single Context
contextName
usrId
optional ptr to related user data
SmemPoolCtrl list
SmemRangeTrack info
A list of Pool Elements
pool
pool
Pool list members are described on next page
A structure of Range Tracking parameters
NumRanges or number of Defined ranges
An array of structures for each defined range
An array of limits used for Range Tracking
highLimit
lowLimit
currNum
maxNum
highLimit
lowLimit
currNumt
maxNum
…
highLimit
low
currNum
maxNumt
0
1
…
SMEM_MAX_RANGE_TRACK

An element in the list of available pools



AvailIndexStack array

SMEM Data Type Definitions

The OPTIONAL "Range Tracking" feature uses the following structures.

```
typedef struct _smem_range_track
  {
  ST_UINT           lowLimit;
  ST_UINT           highLimit;
  ST_LONG           currNum;
  ST_LONG           maxNum;
  } SMEM_RANGE_TRACK;

typedef struct _smem_rt_ctrl
  {
  ST_INT            numRanges;
  SMEM_RANGE_TRACK  rt[SMEM_MAX_RANGE_TRACK];
  } SMEM_RT_CTRL;
```

The following structure is used to configure and control a specific SMEM Pool within a SMEM Context.

```
typedef struct _smem_pool_ctrl
  {
  struct _smem_pool_ctrl   *next;
  ST_CHAR                  *poolName;          /* configuration parameter */
  ST_UINT                  bufSize;            /* configuration parameter */
  ST_UINT8                 numBuf;             /* configuration parameter */
  ST_UINT8                 nextAvailBuf;       /* internal use            */
  ST_UINT8                 *availIndexStack;   /* internal use            */
  ST_CHAR                  *firstBuf;          /* internal use            */
  ST_CHAR                  *lastBuf;           /* internal use            */
  struct _smem_context     *smemContext;       /* context using this pool */

  ST_BOOLEAN               autoClone;          /* configuration parameter */
  ST_INT                   maxClones;          /* configuration parameter */
  ST_INT                   cloneCount;         /* internal use            */


#ifdef DEBUG_SISCO
  ST_UINT8                 maxNumUsed;         /* internal use            */
  ST_UINT16                *usedSize;          /* internal use            */
#endif

  ST_VOID                  *usr;               /* SMEM user can use this .*/
  } SMEM_POOL_CTRL;
```

The following structure is the top-level structure containing all, important information about a SMEM Context.

```
typedef struct _smem_context
  {
  ST_CHAR           *contextName;       /* set automatically by smemcfgx to*/
                                        /* appropriate name in table below */
  ST_INT            usrId;              /* configuration parameter         */
  ST_VOID           *usr;               /* SMEM user can use this ...      */

  SMEM_POOL_CTRL    *smemPoolCtrlList;  /* list of pools in this context   */

  /* Optional range tracking control structure                             */
  SMEM_RT_CTRL      *smemRangeTrack;
} SMEM_CONTEXT;
```

SMEM Control Global Variables

SMEM is controlled by this global array of context control structures. Array elements 0 - 25 are used by the MMS-*Lite* libraries. Array elements 26 -29 may be used by user code.

```
#define M_SMEM_MAX_CONTEXT 30
extern SMEM_CONTEXT m_smem_ctxt[M_SMEM_MAX_CONTEXT];
```

CONTEXT NAME	**m_smem_ctxt ARRAY INDEX**
MSMEM_GEN	0
MSMEM_DEC_OS_INFO	1
MSMEM_ENC_OS_INFO	2
MSMEM_WR_DATA_DEC_BUF	3
MSMEM_ASN1_DATA_ENC	4
MSMEM_PDU_ENC	5
MSMEM_COM_EVENT	6
MSMEM_RXPDU	7
MSMEM_NETINFO	8
MSMEM_DYN_RT	9
MSMEM_AA_ENCODE	10
MSMEM_REQ_CTRL	11
MSMEM_IND_CTRL	12
MSMEM_MVLU_VA	13
MSMEM_MVLU_VA_CTRL	14
MSMEM_MVLU_VA_DATA	15
MSMEM_MVLU_GNL	16
MSMEM_MVLU_AA	17
MSMEM_ACSE_CONN	18
MSMEM_ACSE_DATA	19
MSMEM_COSP_CN	20
MSMEM_N_UNITDATA	21
MSMEM_SOCK_INFO	22
MSMEM_SPDU_TX	23
MSMEM_STARTUP	24
MSMEM_TPKT	25

SMEM Functions

init_mem_chk

Usage: This function must be called before any other allocation functions to initialize the memory manager.

Function Prototype: `ST_VOID init_mem_chk (ST_VOID);`

Parameters: NONE

Return Value: `ST_VOID`

smemcfgx

Usage: This function reads an XML file and uses the information to configure one or more SMEM contexts and optionally create one or more pools within each context. All data is stored in the **`m_smem_ctxt`** array of **`SMEM_CONTEXT`** structures and associated **`SMEM_POOL_CTRL`** structures. Contexts may be referenced by "Context Name" (see the table of Context Names above), or by "Context Index" (the index into the **`m_smem_ctxt`** array).

Function Prototype: `ST_RET smemcfgx (ST_CHAR *xml_filename);`

Parameters:

`xml_filename` Name of standard XML file containing the SMEM configuration information.

Return Value:

`ST_RET`	`= SD_SUCCESS`	Configuration done.
	`!= SD_SUCCESS`	Configuration failed.

u_smem_get_pool_params

Usage: This user function is called from **`smemcfgx`** if a pool is configured but either the "number of buffers" OR the "buffer size" is 0 (or not configured). This allows the user to determine at runtime the appropriate "buffer size" or "number of buffers" (possibly based on other configuration parameters. For example, the "number of buffers" may be based on the number of connections, or the "buffer size" may be based on the maximum MMS message size or the maximum TPDU size. Pointers to the current values of each parameter are passed to the function, so it is possible for the function to use the current values to compute new values and then to write the new values at the pointer location.

Function Prototype:

```
ST_VOID  u_smem_get_pool_params (SMEM_CONTEXT     *smemContext,
                                 ST_UINT8         *numBuf,
                                 ST_UINT          *bufSize,
                                 ST_BOOLEAN       *autoClone,
                                 ST_INT           *maxClones,
                                 ST_CHAR          **poolName);
```

Parameters:

`smemContext`	Pointer to a SMEM context containing this pool. This will always be a pointer to an element of the **`m_smem_ctxt`** global array of contexts.
`numBuf`	Pointer to the "number of buffers" in the pool.
`bufSize`	Pointer to the "buffer size".
`autoClone`	Pointer to flag to indicate if this pool should be automatically cloned when it runs out of buffers.
`maxClones`	Pointer to maximum number of clones to create if automatic cloning is enabled.
`poolName`	Pointer to pointer to optional pool name string.

Return Value: `ST_VOID`

u_smem_need_buffers

Usage: This user function is called when a SMEM context has no more available buffers of a particular buffer size. The user must create an appropriate pool by calling **`smem_add_pool`** and return a pointer to the new pool control structure.

Function Prototype:

```
SMEM_POOL_CTRL *u_smem_need_buffers (SMEM_CONTEXT   *smemContext,
                                     ST_UINT8       numBuf,
                                     ST_UINT        bufSize);
```

Parameters:

`smemContext` Pointer to a SMEM context containing this pool. This will always be a pointer to an element of the **`m_smem_ctxt`** global array of contexts.

`numBuf` Number of buffers in an existing pool for this buffer size or 0 if no pools exist for this buffer size.

`bufSize` Size of buffers needed. This buffer size (or a larger value) should be passed to **`smem_add_pool`**.

***WARNING**:* DO NOT pass **`numBuf`** = 0 or **`bufSize`** = 0 to **`smem_add_pool`** (these are not legal values).

Return Value: (`SMEM_POOL_CTRL *`) Pointer to new pool created or **NULL** if the pool could not be created.

smem_add_pool

Usage: This function adds a new pool to a SMEM context.

Function Prototype:

```
SMEM_POOL_CTRL *smem_add_pool (SMEM_CONTEXT   *smemContext,
                               ST_UINT8       numBuf,
                               ST_UINT        bufSize,
                               ST_BOOLEAN     autoClone,
                               ST_INT         maxClones,
                               ST_CHAR        *poolName);
```

Parameters:

`smemContext` Pointer to a SMEM context containing this pool. This MUST be a pointer to an element of the **`m_smem_ctxt`** global array of contexts.

`numBuf` Number of buffers in the pool.

`bufSize` Buffer size.

`autoClone` Flag to indicate if this pool should be automatically cloned when it runs out of buffers.

`maxClones` Maximum number of clones to create if automatic cloning is enabled.

`poolName` Optional pool name string.

Return Value: (`SMEM_POOL_CTRL *`) Pointer to new pool created or **NULL** if pool could not be created.

smem_log_state

Usage: This function writes the current state of the SMEM context to the log file, including all pools and buffers currently in use. This information may help determine if the pools configured in this context are appropriate.

Function Prototype: `ST_VOID smem_log_state (SMEM_CONTEXT *smemContext);`

Parameters:

`smemContext`	Pointer to a SMEM context containing this pool. This MUST be a pointer to an element of the **`m_smem_ctxt`** global array of contexts.

Return Value: `ST_VOID`

m_add_pool

Usage: This function adds a new pool to a SMEM context. This function is exactly the same as **`smem_add_pool`** except it adds overhead to each buffer for additional tracking information such as the file and line number where the buffer was allocated.

Function Prototype:

```
SMEM_POOL_CTRL *m_add_pool (SMEM_CONTEXT      *smemContext,
                            ST_UINT8          numBuf,
                            ST_UINT           bufSize,
                            ST_BOOLEAN        autoClone,
                            ST_INT            maxClones,
                            ST_CHAR           *poolName);
```

Parameters:

`smemContext`	Pointer to a SMEM context containing this pool. This MUST be a pointer to an element of the **`m_smem_ctxt`** global array of contexts.
`numBuf`	Number of buffers in the pool.
`bufSize`	Buffer size. Overhead will be added to this size.
`autoClone`	Flag to indicate if this pool should be automatically cloned when it runs out of buffers.
`maxClones`	Maximum number of clones to create if automatic cloning is enabled.
`poolName`	Optional pool name string.

Return Value: `(SMEM_POOL_CTRL *)` Pointer to new pool created or **NULL** if pool could not be created.

x_m_malloc

Usage: This function replaces the standard C malloc function and returns a pointer to a buffer of dynamic memory whose size in bytes is determined by the **`size`** argument. The contents of the returned buffer are undetermined. Dynamic memory returned from this function is subject to the validation provided by the global variables and other tools described in this section.

Function Prototype:

```
ST_VOID *x_m_malloc (SMEM_CONTEXT       *ctx,
                     ST_UINT            size,
                     ST_CHAR            *file,
                     ST_INT             line);
```

Parameters:

`ctx`	Context from which to allocate buffer.
`size`	This indicates the size in bytes of the buffer to be allocated.
`file`	Name of source file where this function is called.
`line`	Line number in source file where this function is called.

Return Value:	`ST_VOID *`	`<> null`	This is a pointer to the allocated buffer.
		`= null`	The memory allocation has failed.

x_m_calloc

Usage: This function replaces the standard C calloc function and returns a pointer to a buffer of dynamic memory whose size in bytes is determined as a product of the **`num`** and **`size`** argument. The contents of the returned buffer are all `0x00`. Dynamic memory returned from this function is subject to the validation provided by the global variables and other tools described in this section.

Function Prototype:

```
ST_VOID *x_m_calloc (SMEM_CONTEXT       *ctx,
                     ST_UINT            num,
                     ST_UINT            size,
                     ST_CHAR            *file,
                     ST_INT             line);
```

Parameters:

`ctx`	Context from which to allocate buffer.
`num`	This indicates the number of continuous areas of memory to allocate.
`size`	This indicates the size in bytes of each memory are to allocate.
`file`	Name of source file where this function is called.
`line`	Line number in source file where this function is called.

Return Value:	`ST_VOID *`	`<> null`	This is a pointer to the allocated buffer.
		`= null`	The memory allocation failed.

x_m_realloc

Usage: This function replaces the standard C realloc function and returns a pointer to a buffer of dynamic memory whose size in bytes is determined by the size argument. The contents of the returned buffer contain the contents of the old buffer. Dynamic memory returned from this function is subject to the validation provided by the global variables and other tools described in this section.

Function Prototype:

```
ST_VOID *x_m_realloc (SMEM_CONTEXT      *ctx,
                      ST_VOID           *old,
                      ST_UINT           size,
                      ST_CHAR           *file,
                      ST_INT            line);
```

Parameters:

`ctx` Context from which to reallocate buffer.

`old` This pointer indicates the old buffer.

`size` This indicates the new size of the buffer.

`file` Name of source file where this function is called.

`line` Line number in source file where this function is called.

Return Value:			
	`ST_VOID *`	`<> null`	This is a pointer to the resized buffer.
		`= null`	The memory reallocation failed.

x_m_free

Usage: This function deallocates a memory buffer allocated with **`x_m_calloc`**, **`x_m_malloc`**, or **`x_m_realloc`**. Integrity checking is present to detect if pointers are being freed more than once, or if bogus pointers are being freed.

Function Prototype:

```
ST_VOID x_m_free (SMEM_CONTEXT    *ctx,
                  ST_VOID         *ptr,
                  ST_CHAR         *file,
                  ST_INT          line);
```

Parameters:

`ctx` Context from which to deallocate buffer.

`ptr` This is a pointer to the memory buffer that is to be deallocated.

`file` Name of source file where this function is called.

`line` Line number in source file where this function is called.

Return Value: `ST_VOID`

Changes Required to Use SMEM

The libraries and sample applications provided with MMS-*Lite* use the SISCO **MEM_CHK** Memory Manager by default. The source code and build process must be modified as follows to use the SISCO SMEM Memory Manager instead.

Source Code Changes

1. At startup, **init_mem_chk** must be called ***BEFORE*** any memory allocation function (including **smemcfgx**) is called. If it is not called, the application will exit due to an assertion.
2. Also at startup, **smemcfgx** should be called (after **init_mem_chk**) to configure memory contexts and pools. If this function is not called, there will be no memory pools configured at startup. In this case, when a memory allocation function is called, the user function **u_smem_need_buffers** (see below) will be called to allow the user to create a pool as needed.
3. The user functions **u_smem_get_pool_params** and **u_smem_need_buffers** must be written.
4. Before exiting the application, **smem_log_state** should be called for each SMEM context, to write to the log file detailed information about the current and the maximum memory used in each context.

Build Process Changes

1. Build the Foundry executable ***BEFORE*** making any changes. This program is not written to use SMEM.
2. If using Microsoft Windows and Microsoft Visual C++, change the "Project Dependencies" so that the application you wish to build does ***NOT*** depend on the Foundry. This will prevent it from being rebuilt when you select "Rebuild All" to rebuild the application.
3. Define **SMEM_ENABLE** in the makefile (or VCPROJ file) for each library and application to be built.
4. Change the linker command in the makefile (or VCPROJ file) for the application, to link to **smem.lib** (**smemd.lib** for DEBUG) instead of **mem.lib** (**memd.lib** for DEBUG).
5. Rebuild the application and all associated libraries.

Recommended SMEM Configuration Procedure

The following procedure is recommended for obtaining the optimum SMEM configuration.

1. Make sure that the application is compiled with **DEBUG_SISCO** defined and that, just before exiting, it calls **smem_log_state** for each context.
2. Create an empty **smemcfg.xml** file so that no SMEM contexts or pools are configured.
3. Run the application, preferably under extreme conditions (e.g. maximum number of connections, transferring large amounts of data, etc.). With no SMEM configuration, the application will call the user function **u_smem_need_buffers** when it needs a new SMEM pool. This will usually NOT create optimum pools.
4. Exit the application and examine the log file. It should contain details about each SMEM pool created, including the maximum number of buffers used in each pool, and the number of bytes actually used in each buffer. For example, if there is a pool containing unused buffers that are 8000 bytes, and an allocation function requests 200 bytes, SMEM will use one of the 8000 byte buffers, wasting 7800 bytes.
5. Edit the **smemcfg.xml** file to configure pools that contain ONLY the number of buffers and the buffer sizes that are actually needed.
6. Run the application again. If the configuration is optimum, all buffers in all pools will be used at some time, and the user function **u_smem_need_buffers** will NEVER be called. Use a debugger or a printf to determine if **u_smem_need_buffers** is ever called.
7. If necessary, edit the configuration and run the application again until the optimum pools are created.
8. Run the application under all reasonable conditions to be sure that the configured pools are adequate.

Appendix E

Linked List Tools

MMS-*Lite* provides a set of data structures and functions that allow access to a circular doubly linked list. You can use these functions in your application.

Link List Data Structure

In order to use the MMS-EASE list functions, you must create a data structure that contains the following data structure as its first element. This allows using one set of list manipulation primitives with any structure containing it.

```
typedef struct dbl_lnk
  {
  struct dbl_lnk    *next;
  struct dbl_lnk    *prev;
  } DBL_LNK;
```

`next` This points to the next element in the linked list.

`prev` This points to the previous element in the linked list.

Generic Link List Handling Functions

list_get_first

Usage: This function is used to unlink the first element from a list and return its address.

Function Prototype: `ST_VOID *list_get_first (DBL_LNK **first_el);`

Parameters:

`first_el` This is a pointer of type **`DBL_LNK`** to the address of the head of a list pointer.

Return Value: A pointer to the unlinked element.

list_get_next

Usage: This function is used to traverse a circular doubly linked list from the beginning to the end using the next **`DBL_LNK`** structure member.

Function Prototype:

```
ST_VOID *list_get_next (DBL_LNK   *list_head,
                        DBL_LNK   *next_el);
```

Parameters:

`list_head` This is a pointer of type **`DBL_LNK`** to the address of the head of a list.

`next_el` This is a pointer of type **`DBL_LNK`** to the current element in the list.

Return Value: This is the pointer to the next node element in the list. When the next element in the list is the head of the list pointer, then the function returns a null value.

list_unlink

Usage: This function is used to unlink an element from a circular doubly linked list.

Function Prototype:

```
ST_RET list_unlink (DBL_LNK      **list_head,
                    DBL_LNK      *unlink_el);
```

Parameters:

`list_head`	This is a pointer of type **`DBL_LNK`** to the address of the head of a list.
`unlink_el`	This is a pointer of type **`DBL_LNK`** to the element to be unlinked from the list.

Return Value:			
	`ST_RET`	`SD_FAILURE`	The element is not present in the list, or bad parameter.
		`SD_SUCCESS`	The element was found in the list and unlinked.

list_add_first

Usage: This function is used to add an element as the first element to a circular doubly linked list.

Function Prototype:

```
ST_RET list_add_first (DBL_LNK    **list_head,
                       DBL_LNK    *first_el);
```

Parameters:

`list_head`	This is a pointer to a pointer to the first element of the list of type **`DBL_LNK`**.
`first_el`	This is a pointer of type **`DBL_LNK`** to element to be added to the list.

Return Value:			
	`ST_RET`	`SD_FAILURE`	The element was not added to the front of the list. The old state of the list is preserved.
		`SD_SUCCESS`	The element was added to the beginning of the list. The pointer to the head of the list (**`list_head`**) has been modified.

list_add_last

Usage: This function is used to add an element as the last element to a circular doubly linked list.

Function Prototype:

```
ST_RET list_add_last (DBL_LNK     **list_head,
                      DBL_LNK     *last_el);
```

Parameters:

`list_head`	This is a pointer of type **`DBL_LNK`** to the address of the head of a list pointer.
`last_el`	This is a pointer of type **`DBL_LNK`** to element to be added to the list.

Return Value: `ST_RET`

`SD_FAILURE`	The element was not added to the back of the list. The old state of the list is preserved.
`SD_SUCCESS`	The element was added to the end of the list. The pointer to the head of the list (**`list_head`**) has been modified if this was an empty list.

list_add_first

Usage: This function is used to add an element as the first element to a circular doubly linked list.

Function Prototype:

```
ST_RET list_add_first (DBL_LNK   **list_head,
                       DBL_LNK   *first_el);
```

Parameters:

`list_head`	This is a pointer of type **`DBL_LNK`** to the address of the head of a list pointer.
`first_el`	This is a pointer of type **`DBL_LNK`** to element to be added to the list.

Return Value: `ST_RET`

`SD_FAILURE`	The element was not added to the front of the list. The old state of the list is preserved.
`SD_SUCCESS`	The element was added to the beginning of the list. The pointer to the head of the list (**`list_head`**) has been modified.

list_move_to_first

Usage: This function is used to unlink an element from where ever it is present in the list and add it as the first element of a second linked list.

Function Prototype:

```
ST_RET list_move_to_first (DBL_LNK      **list_head,
                           DBL_LNK      **next_head,
                           DBL_LNK      *first_el);
```

Parameters:

`list_head`	This is a pointer of type **`DBL_LNK`** to the address of the head of a list pointer.
`next_head`	This is a pointer of type **`DBL_LNK`** to the address of the head of a next list pointer.
`first_el`	This is a pointer of type **`DBL_LNK`** to element to be moved from the first list and added to the list.

Return Value: `ST_RET`

`SD_FAILURE`	The element was not moved from the first list to the second list. The unlink step has failed, so the old state of the first list is preserved.
`SD_SUCCESS`	The element was unlinked from the first list and added to beginning of the second list.

list_find_node

Usage: This function is used to verify that a node is linked in as a member of a linked list.

Function Prototype:

```
ST_RET list_find_node (DBL_LNK    *list_head,
                        DBL_LNK   *first_el);
```

Parameters:

`list_head`	This is a pointer of type **`DBL_LNK`** to the address of the head of a list pointer.
`first_el`	This is a pointer of type **`DBL_LNK`** to element to be verified.

Return Value: `ST_RET`

`SD_FAILURE`	The node was not found in the list.
`SD_SUCCESS`	The node was present in the list.

list_add_node_after

Usage: This function is used to add a node to the list.

Function Prototype:

```
ST_RET list_add_node_after (DBL_LNK     *cur_node,
                            DBL_LNK     *new_node);
```

Parameters:

`cur_node`	This is a pointer of type **`DBL_LNK`** that represents the location in the list after which to add the **`new_node`**.
`new_node`	This is a pointer of type **`DBL_LNK`** to the node that is added to the list.

Return Value:			
	`ST_RET`	`SD_FAILURE`	The **`new_node`** was not added to the list.
		`SD_SUCCESS`	The **`new_node`** was added to the list.

list_get_sizeof

Usage: This function is used to get the size of a circular doubly linked list.

Function Prototype:

```
ST_INT list_get_sizeof (DBL_LNK *list_head_pointer);
```

Parameters:

`list_head_pointer`	This is a pointer of type **`DBL_LNK`** to the head of a list.

Return Value:			
	`ST_INT`	`= 0`	The list is empty.
		`<>0`	Returns the number of elements in the linked list.

Appendix F

GLBSEM Subsystem for Multi-Threaded Support

This section addresses the issues related to writing a thread-safe MMS-*Lite* application.

To support thread-safe applications in a portable manner, MMS-EASE provides a set of APIs and macros. These functions and macros are used to create, request, and release semaphore objects available in your operating system environment as well as to lock and unlock global MMS-EASE resources.

Please note that multitasking/multithreading and pipes are ONLY required for the old stack (ositcpe or ositpxe libraries).

The functions and macros described below are defined in **glbsem.h**. If you use these macros, you need to define the symbol **S_MT_SUPPORT** when you compile your program.

The API makes use of the data type **`ST_EVENT_SEM`** used to represent a handle to an event semaphore. This data type is platform-specific.

IMPORTANT: *These functions and macros are only available on operating systems that support muli-threading. They may need to be "ported" to your system.*

SISCO's Global Mutex (Mutual Exclusion) Semaphore Macros

S_LOCK_COMMON_RESOURCES

Usage: Gives the current thread exclusive access to MMS global objects.

Function Prototype: `S_LOCK_COMMON_RESOURCES ();`

Parameters: None

Return Value: None

S_UNLOCK_COMMON_RESOURCES

Usage: Releases exclusive access to MMS global objects.

Function Prototype: `S_UNLOCK_COMMON_RESOURCES ();`

Parameters: None

Return Value: None

Mutex Semaphore Functions

gs_mutex_create

Usage: This function creates a mutex semaphore.

Function Prototype: `ST_RET gs_mutex_create (ST_MUTEX_SEM *ms);`

Parameters:

`ms` This is a pointer to **`ST_MUTEX_SEM`** where information about the created mutex semaphore is stored.

Return Value: `SD_RET` `SD_SUCCESS` or `SD_FAILURE`

gs_mutex_get

Usage: This function obtains ownership of a mutex semaphore.

Function Prototype: `ST_VOID gs_mutex_get (ST_MUTEX_SEM *ms);`

Parameters:

`ms` This is a pointer to the mutex semaphore.

Return Value: `ST_VOID`

gs_mutex_free

Usage: This function releases ownership of a mutex semaphore.

Function Prototype: `ST_VOID gs_mutex_free (ST_MUTEX_SEM *ms);`

Parameters:

`ms` This is a pointer to the mutex semaphore.

Return Value: `ST_VOID`

gs_mutex_destroy

Usage: This function destroys the mutex semaphore.

Function Prototype: `ST_VOID gs_mutex_destroy (ST_MUTEX_SEM *ms);`

Parameters:

`ms` This is a pointer to the mutex semaphore.

Return Value: `SD_RET` `SD_SUCCESS` or `SD_FAILURE`

Event Semaphore Functions

gs_get_event_sem

Usage: This function creates and initializes a manual-reset or auto-reset event semaphore.

Function Prototype: `ST_EVENT_SEM gs_get_event_sem (ST_BOOLEAN manualReset);`

Parameters:

`manualReset` This is a boolean flag that is set to **`SD_TRUE`** or **`SD_FALSE`**.

Return Value: `ST_EVENT_SEM` This is a handle to an event semaphore.

gs_signal_event_sem

Usage: This function is used to signal an event semaphore.

Function Prototype: `ST_VOID gs_signal_event_sem (ST_EVENT_SEM es);`

Parameters:

`es` This is the handle to an event semaphore returned from **`gs_get_event_sem`**.

Return Value: `ST_VOID`

Notes: **Manual-reset event semaphore:**
When you use **`gs_signal_event_sem`**, all waiting threads are released, and the event remains in signaled state until you explicitly reset it using **`gs_reset_event_sem`**.

Auto-reset event semaphore:
When you use **`gs_signal_event_sem`**, only the first waiting thread is released, and the event is reset to non-signaled state before the function returns. However, if no thread is waiting, the state remains signaled unless reset explicitly using **`gs_reset_event_sem`**.

gs_pulse_event_sem

Usage: This function is used to pulse an event semaphore.

Function Prototype: `ST_VOID gs_pulse_event_sem (ST_EVENT_SEM es);`

Parameters:

`es` This is the handle to an event semaphore returned from **`gs_get_event_sem`**.

Return Value: `ST_VOID`

Notes: **Manual-reset event semaphore:**
When you use **`gs_pulse_event_sem`**, all waiting threads are released, and the event's state is reset to non-signaled before the function returns.

Auto-reset event semaphore:
When you use **`gs_pulse_event_sem`**, only the first waiting thread is released, and the event is reset to non-signaled state before the function returns, even if there are no waiting threads.

gs_wait_event_sem

Usage: This function is used to check the state of an event semaphore. If the state of the semaphore is signaled, the function returns immediately. Otherwise, it blocks the caller until either the semaphore is signaled or a timeout occurs.

Function Prototype:

```
ST_RET gs_wait_event_sem (ST_EVENT_SEM     es,
                          ST_LONG          timeout);
```

Parameters:

`es`	This is the handle to an event semaphore.
`timeout`	This value specifies the timeout period in milliseconds. If the timeout is 0, the function returns immediately. If the timeout is -1, the function blocks until the semaphore is signaled. If the timeout is greater than 0, the function waits for the event semaphore for the duration of the timeout period

Return Value:

`SD_RET`	`SD_SUCCESS`	The semaphore is signaled.
	`SD_TIMEOUT`	The timeout period elapsed and the semaphore is non-signaled.
	`SD_FAILURE`	Any other error condition.

gs_wait_mult_event_sem

Usage: This function is implemented on Windows systems only. It is used to check the state of multiple event semaphores. If the state of a semaphore is signaled, the function returns immediately. Otherwise, it blocks the caller until either a semaphore is signaled or a timeout occurs.

Function Prototype:

```
ST_RET gs_wait_mult_event_sem (ST_INT          numEvents,
                               ST_EVENT_SEM    *esTable,
                               ST_BOOLEAN      *activity,
                               ST_LONG         timeout)
```

Parameters:

`numEvents`	This is the number of event semaphores to wait for.
`esTable`	This is a pointer to a table of event semaphore objects.
`activity`	This is a pointer to a table where this function will mark a proper index entry with **`SD_TRUE`** for the event semaphore that have been signaled.
`timeout`	This value specifies the timeout period in milliseconds. If the timeout is 0, the function returns immediately. If the timeout is -1, the function blocks until the semaphore is signaled. If the timeout is greater than 0, the function waits for the event semaphore for the duration of the timeout period

Return Value:

`SD_RET`	`SD_SUCCESS`	The semaphore is signaled.
	`SD_TIMEOUT`	The timeout period elapsed and the semaphore is non-signaled.
	`SD_FAILURE`	Any other error condition.

gs_reset_event_sem

Usage: This function is used to reset a manual-reset event semaphore. Call this function only if the function **`gs_wait_event_sem`** returns **`SD_SUCCESS`**. If **`gs_wait_mult_event_sem`** is used, this function should be called for every manual-reset semaphore with the **`activity`** table entry set to **`SD_TRUE`**.

Function Prototype: `ST_VOID gs_reset_event_sem (ST_EVENT_SEM es);`

Parameters:

`es` This is the handle to an event semaphore returned from **`gs_get_event_sem`**.

Return Value: `ST_VOID`

gs_free_event_sem

Usage: This function frees the event semaphore that was obtained using **`gs_get_event_sem`**.

Function Prototype: `ST_VOID gs_free_event_sem (ST_EVENT_SEM es);`

Parameters:

`es` This is the handle to an event semaphore that was returned from **`gs_get_event_sem`**.

Return Value: `ST_VOID`

Thread Functions

gs_start_thread

Usage: This function starts a new thread.

Function Prototype:

```
ST_RET gs_start_thread (ST_THREAD_RET (ST_THREAD_CALL_CONV *threadFunc)(ST_THREAD_ARG),
                                      ST_THREAD_ARG        threadArg,
                                      ST_THREAD_HANDLE     threadHandleOut,
                                      ST_THREAD_ID         *threadIdOut);
```

Parameters:

`threadFunc`	This is a pointer to thread function to run.
`threadArg`	This is a thread function argument list.
`threadHandleOut`	This is a pointer where to return the thread handle.
`threadIdOut`	This is a pointer where to return the thread ID.

Return Value: `SD_RET` `SD_SUCCESS` or `SD_FAILURE`

gs_wait_thread

Usage: This function waits until the thread with **`threadHandle`** terminates or timeout occurrs.

On UNIX systems, there is no option for timed wait. This function will wait until the thread is terminated.

Function Prototype:

```
ST_RET gs_wait_thread (ST_THREAD_HANDLE        threadHandle,
                       ST_THREAD_ID            threadId,
                       ST_LONG                 timeout);
```

Parameters:

`threadHandle`	This is the thread handle returned from **`gs_start_thread`**.
`threadId`	This is the thread ID returned from **`gs_start_thread`**.
`timeout`	This is the maximum time in milliseconds to wait for the thread to terminate.

Return Value: `SD_RET` `SD_SUCCESS` or `SD_FAILURE`

gs_close_thread

Usage: This function releases resources for the terminated thread.

Function Prototype: `ST_RET gs_close_thread (ST_THREAD_HANDLE threadHandle);`

Parameters:

`threadHandle` This is the thread handle returned from **`gs_start_thread`**.

Return Value: `SD_RET` `SD_SUCCESS` or `SD_FAILURE`

gs_start_thread

Usage: This function starts a new thread.

Function Prototype:

```
ST_RET gs_start_thread (ST_THREAD_RET (ST_THREAD_CALL_CONV  *threadFunc)(ST_THREAD_ARG),
                                       ST_THREAD_ARG        threadArg,
                                       ST_THREAD_HANDLE     threadHandleOut,
                                       ST_THREAD_ID         *threadIdOut);
```

Parameters:

`threadFunc`	This is a pointer to thread function to run.
`threadArg`	This is a thread function argument list.
`threadHandleOut`	This is a pointer where to return the thread handle.
`threadIdOut`	This is a pointer where to return the thread ID.

Return Value: `SD_RET` `SD_SUCCESS` or `SD_FAILURE`

Appendix G

Utility Functions

Miscellaneous Functions

The following functions do not fit into any particular category.

reverse_bytes

Usage: This function copies data from source to destination but reverses the order of the bytes (i.e., converts Big-Endian to Little-Endian or vice versa). Users must set the SampledValue data with the correct byte order. This function should be useful for doing that on some platforms.

Function Prototype:

```
ST_VOID reverse_bytes (ST_UINT8   *dst,
                       ST_UINT8   *src,
                       ST_INT     numbytes);
```

Parameters:

`dest`	Pointer to the destination buffer.
`src`	Pointer to the source buffer.
`numbytes`	Indicates the number of bytes to copy.

Return Value: `ST_VOID` Ignored

get_next_string

Usage: This function returns a pointer to the next string found in the input buffer (string may be surrounded by “double quotes”), up to the next delimiter in the input. It ignores leading spaces or commas in the input.

Note: This function works much like the standard function **`strtok`**, but it allows extracting “quoted strings”, and it is much better at discarding extra delimiter characters.

Function Prototype:

```
ST_CHAR *get_next_string (ST_CHAR      **ptrptr,
                          ST_CHAR      *delimiters);
```

Parameters:

`ptrptr`	Pointer to a pointer to the current position in the input buffer. The current position is changed by this function.
`delimiters`	Pointer to a set of delimiter characters (like **`strtok`** or **`strpbrk`**).

Return Value: `ST_CHAR *` Pointer to the next string in the input. NULL on an error or the end of the input string.

sxd_process_arb_data

Usage: This function provides a convenient way for users to process any MMS data once it has been decoded from ASN.1. The MMS data may represent a very complicated structure or array, but this function breaks it down to simple processing. The caller passes a set of pointers to processing functions. By passing different sets of function pointers, the behavior is very flexible.

Function Prototype:

```
ST_RET sxd_process_arb_data (ST_CHAR                  *datptr,
                             SD_CONST RUNTIME_TYPE    *rt_head,
                             ST_INT                   rt_num,
                             ST_VOID                  *usr,
                             SXD_ARB_DATA_CTRL        *ac,
                             ST_BOOLEAN               *elPres)
```

Parameters:

`datptr`	Pointer to "local" data (already decoded from ASN.1).
`rt_head`	Pointer to an array of **`RUNTIME_TYPE`** structures defining the type of this data.
`rt_num`	Number of elements in the **`rt_head`** array.
`usr`	User pointer to any convenient data to pass to all data processing functions.
`ac`	Pointer to a structure containing pointers to data processing functions.
`elPres`	Advanced option. Do not use. Simply set **`elPres`**=NULL.

Return Value: `ST_RET` `SD_SUCCESS` or `SD_FAILURE`

Comment: Examine the **`SXD_ARB_DATA_CTRL`** structure carefully. It contains pointers to functions to call when each primitive type of data is found. Structures are handled by calling one function when the start of a structure is found and another function when the end of a structure is found. For a good example of how to use this function, see **`m_log_data`** in **mlogavar.c**.

UTC Time Support Functions

The following structure is used by UTC Time support functions shown below.

```
/* Binary Time Of Day                                                      */

#define MMS_BTOD4   4
#define MMS_BTOD6   6

typedef struct btod_data
  {
  ST_INT            form;  /* MMS_BTOD6, MMS_BTOD4                         */
  ST_INT32          ms;    /* Number of milliseconds since midnight        */
  ST_INT32          day;   /* Number of days since Jan 1, 1984             */
  } MMS_BTOD;
```

The following structure is used to store the UCT Time MMS type.

```
typedef struct mms_utc_time_tag
  {
  ST_UINT32  secs;  /* Number of seconds since GMT midnight January 1, 1970  */
  ST_UINT32  usec;  /* Number of microseconds of a second                    */
  ST_UINT32  qflags;      /* Quality flags, 8 least-significant bits only   */
  } MMS_UTC_TIME;
```

asn1_convert_btod_to_utc

Usage: This function converts **MMS_BTOD** (time relative to 1/1/1984) to the **MMS_UTC_TIME** (time relative to 1/1/1970). The **qflags** field in the **MMS_UTC_TIME** needs to be set by the calling function. Only the **MMS_BTOD6** form of the **MMS_BTOD** struct can be converted to the **MMS_UTC_TIME**.

Function Prototype:

```
ST_RET asn1_convert_btod_to_utc (MMS_BTOD      *btod,
                                 MMS_UTC_TIME  *utc);
```

Parameters:

btod	This is a pointer to **MMS_BTOD** struct that should be converted to the **MMS_UTC_TIME**.
utc	This is a pointer to **MMS_UTC_TIME** structure where the result of the conversion will be placed.

Return Value: ST_RET SD_SUCCESS or SD_FAILURE

asn1_convert_utc_to_btod

Usage: This function converts **MMS_UTC_TIME** (time relative to 1/1/1970) to the **MMS_BTOD** (time relative to 1/1/1984). The form field in the **MMS_BTOD** is set to **MMS_BTOD6** by this function.

Function Prototype:

```
ST_RET asn1_convert_utc_to_btod (MMS_UTC_TIME  *utc,
                                 MMS_BTOD      *btod);
```

Parameters:

`utc` This is a pointer to **MMS_UTC_TIME** struct that should be converted to the **MMS_BTOD**.

`btod` This is a pointer to **MMS_BTOD** struct where the result of the conversion will be placed.

Return Value: `ST_RET` `SD_SUCCESS` or `SD_FAILURE`

Appendix H

Subnetwork API

The Subnetwork Layer's purpose is to provide a consistent interface to be used by the CLNP layer. Because the LLC layer is included in the CLNP Layer, the CLNP layer could interface directly to the MAC API (ADLC, Ethernet, etc.). However, this would require the CLNP Layer to be modified to interface to each MAC API (which vary significantly for different MAC layers and different operating systems). To avoid this, the Subnetwork layer is inserted. It provides a single Subnetwork API that is used by the CLNP layer. It performs the operations necessary to translate the Subnetwork API commands into the appropriate MAC API commands. Thus, porting to a new MAC layer requires only rewriting the Subnetwork API functions described below.

Subnetwork Data Structure

This structure below is used to write packets to the Subnetwork and to read packets from the Subnetwork.

```
typedef struct
  {
  ST_UCHAR    loc_mac [CLNP_MAX_LEN_MAC];
  ST_UCHAR    rem_mac [CLNP_MAX_LEN_MAC];
  ST_UINT16   lpdu_len;
  ST_UCHAR    *lpdu;
  }SN_UNITDATA;
```

`loc_mac`	This is the buffer for the local MAC address. Its length is **`CLNP_MAX_LEN_MAC`**.
`rem_mac`	This is the buffer for the remote MAC address. Its length is **`CLNP_MAX_LEN_MAC`**.
`lpdu_len`	The value of the IEEE 802.3 "Length/Type" field. The name **`lpdu_len`** is somewhat misleading. Sometimes it contains the length of the PDU, but if the value is greater than or equal to 0x600, is must be interpreted as the "Type" of the MAC frame.
`lpdu`	This is a pointer to the **`lpdu`** buffer to send.

Ethertype Data Structure

This structure contains Ethertype frame header information. It is used when encoding and decoding Ethertype frames (i.e., "Tagged MAC Frames", as defined in IEEE 802.3).

```
typedef struct {
  ST_UINT16   tci;
  ST_UINT16   etypeID;
  ST_UINT16   appID;
  } ETYPE_INFO;
```

`tci`	This is the VLAN Tag Control Info.
`etypeID`	This is the Ethertype ID. This is the value of the "Length/Type" field of the IEEE 802.3 Tagged MAC frame. This must always represent the "Type" (i.e., must be >= 0x600).
`appID`	This is the IEC 61850 APPID. This is stored in the first 2 bytes of the MAC Client Data of the IEEE 802.3 Tagged MAC frame. Appropriate values for APPID are defined by IEC 61850-8-1.

Subnetwork Functions

clnp_snet_init

Usage: This function will initialize the subnetwork layer.

Function Prototype: `ST_RET clnp_snet_init (CLNP_PARAM *clnp_param);`

Parameters:

`clnp_param` This is a pointer to a structure containing CLNP configuration parameters.

Return Value:	`ST_RET`	`SD_SUCCESS`	No Error
		`! = SD_SUCCESS`	Error

clnp_snet_term

Usage: This function will terminate the subnetwork layer.

Function Prototype: `ST_RET clnp_snet_term (ST_VOID);`

Parameters: NONE

Return Value:	`ST_RET`	`SD_SUCCESS`	No Error
		`!= SD_SUCCESS`	Error

clnp_snet_read

Usage: This function will receive a LPDU from a subnetwork.

Function Prototype: `ST_RET clnp_snet_read (SN_UNITDATA *sn_req);`

Parameters:

`sn_req` This is a pointer of structure type **`SN_UNITDATA`** to the Subnetwork Unit Data request to be received.

Return Value:	`ST_RET`	`= SD_SUCCESS`	No Error
		`!= SD_SUCCESS`	Error

clnp_snet_write

Usage: This function will send a LPDU to a subnetwork.

Function Prototype: `ST_RET clnp_snet_write (SN_UNITDATA *sn_req);`

Parameters:

`sn_req`	This is a pointer of structure type **`SN_UNITDATA`** to a Subnetwork Unit Data request to be sent.

Return Value:	`ST_RET`	`= SD_SUCCESS`	No Error
		`!= SD_SUCCESS`	Error

clnp_snet_free

Usage: This function frees up subnetwork resources associated with a received SN-UNITDATA PDU.

Function Prototype: `ST_VOID clnp_snet_free (SN_UNITDATA *sn_req);`

Parameters:

`sn_req`	This is a pointer to a structure containing information about the SN-UNITDATA PDU received.

Return Value: `ST_VOID` (None)

clnp_snet_get_local_mac

Usage: This function will copy to the buffer **`mac_buf`** the local MAC address for a given subnetwork.

Function Prototype: `ST_RET clnp_snet_get_local_mac (ST_UCHAR *mac_buf);`

Parameters:

`mac_buf`	This is a pointer to the buffer for MAC address. The buffer is at least **`CLNP_MAX_LEN_MAC`** bytes long.

Return Value:	`ST_RET`	`= SD_SUCCESS`	No Error
		`!= SD_SUCCESS`	Error

clnp_snet_set_multicast_filter

Usage: This function enables the reception of multicast packets by the Ethernet driver. Multicast packets include GOOSE messages and ES-IS protocol packets required by the OSI stack. The driver will accept incoming packets in which the destination MAC address matches one of these multicast MAC addresses. If the Ethernet driver is already set to promiscuous mode, this function does not need to be called.

Function Prototype:

```
ST_RET clnp_snet_set_multicast_filter (ST_UCHAR      *mac_list,
                                       ST_INT        num_macs);
```

Parameters:

`mac_list` This is a pointer to a set of multicast MAC addresses (6 bytes each) on which to accept incoming packets.

`num_macs` This is the number of MAC addresses contained in **`mac_list`**.

Return Value:

`ST_RET`	`= SD_SUCCESS`	No Error
	`!= SD_SUCCESS`	Error

Comments: This function may not be called until ***AFTER*** **`clnp_snet_init`** (or **`mvl_start_acse`**) is called.

clnp_snet_add_multicast_mac

Usage: This function is provided for backward compatibility only. It may overwrite the existing list of multicast addresses. It is recommended that you use **`clnp_snet_set_multicast_filter`** instead.

This function will add the multicast MAC address in **`mac_buf`** to the set of multicast addresses on which to accept incoming packets.

Function Prototype:

```
ST_RET clnp_snet_add_multicast_mac (ST_UCHAR *mac_buf);
```

Parameters:

`mac_buf` This is a pointer to the multicast MAC address on which to accept incoming packets. The buffer is at least **`CLNP_MAX_LEN_MAC`** bytes long.

Return Value:

`ST_RET`	`= SD_SUCCESS`	No Error
	`!= SD_SUCCESS`	Error

clnp_snet_rx_all_multicast_start

Usage: This function enables the reception of "ALL multicast" packets by the Ethernet driver so that ALL incoming multicast packets are accepted. Multicast packets include GOOSE messages and ES-IS protocol packets required by the OSI stack. The driver remains in this mode until **`clnp_snet_rx_all_multicast_stop`** is called.

Function Prototype: `ST_RET clnp_snet_rx_all_multicast_start (ST_VOID);`

Parameters: NONE

Return Value:			
	`ST_RET`	`= SD_SUCCESS`	Completed successfully.
		`!= SD_SUCCESS`	Error code.

Comments: This function may not be called until ***AFTER*** **`clnp_snet_init`** (or **`mvl_start_acse`**) is called.

clnp_snet_rx_all_multicast_stop

Usage: This function disables the reception of "ALL multicast" packets by the Ethernet driver. It will continue accepting multicast packets that were "subscribed" for using **`clnp_snet_set_multicast_filter`**.

Function Prototype: `ST_RET clnp_snet_rx_all_multicast_stop (ST_VOID);`

Parameters: NONE

Return Value:			
	`ST_RET`	`= SD_SUCCESS`	Completed successfully.
		`!= SD_SUCCESS`	Error code.

Comments: This function may not be called until ***AFTER*** **`clnp_snet_init`** (or **`mvl_start_acse`**) is called.

clnp_snet_get_max_udata_len

Usage: This function will return the maximum length of user data for a given subnetwork.

Function Prototype: `ST_UINT16 clnp_snet_get_max_udata_len (ST_VOID);`

Parameters: NONE

Return Value: `ST_UNIT16` This returns the maximum length of the user data.

clnp_snet_get_type

Usage: This function will return the subnetwork type.

Function Prototype: `ST_INT clnp_snet_get_type (ST_VOID);`

Parameters: NONE

Return Value: `ST_INT` `SUBNET_ETHE` (SISCO Ethernet Subnet)

Notes: If a new Subnetwork type is created, a new define should be added to **clnp_sne.h** to identify it. This is where the Subnetwork defines are stored.

Porting of the Subnetwork code to use a new MAC API (for a new operating system or new MAC layer), usually requires rewriting all of the Subnetwork API functions described above. SISCO provides examples of Subnetwork API functions to interface to a typical Ethernet NDIS MAC driver (in **clnp_eth.c**). This code must be modified if a different MAC API must be used.

clnp_snet_check_mac

Usage: This function examines the MAC address referenced by **mac_buf** and returns a value indicating if it is the local MAC address, the ALL-ES Multicast MAC address, etc.

Function Prototype:

```
ST_INT clnp_snet_check_mac (ST_UINT8 *mac_addr);
```

Parameters:

`mac_buf` Pointer to sequence of bytes representing MAC address.

Return Value: `ST_INT`

`CLNP_MAC_LOCAL`	(address of this computer)
`CLNP_MAC_ALL_ES`	(All-ES Multicast address)
`CLNP_MAC_GOOSE`	(Other Multicast address. Probably GOOSE.)
`CLNP_MAC_INVALID`	(Unrecognized address)

clnp_snet_frame_to_udt

Usage: This function extracts data from a raw frame and stores it in a **SN_UNITDATA** structure, needed by other subnetwork functions. This function should work on any platform, and should simplify the porting of the subnetwork interface to new platforms.

CRITICAL: The caller must initialize **sn_req->lpdu** to point to an allocated buffer before calling this function.

Note: To see how this function is used on Windows or LINUX, see **clnp_pcap.c** or **clnp_linux.c**.

Function Prototype:

```
ST_RET clnp_snet_frame_to_udt (ST_UINT8       *frame_buf,
                               ST_INT         frame_len,
                               SN_UNITDATA    *sn_req,
                               ST_INT         udata_max_len);
```

Parameters:

`frame_buf`	This is a pointer to the raw frame buffer.
`frame_len`	Indicates the length of the raw frame in bytes.
`sn_req`	Pointer to a structure used to store the result of the extraction.
`udata_max_len`	Indicates the maximum user data length. This length must match the size of the allocated buffer **sn_req->lpdu**, and should normally be set to **ETHE_MAX_LEN_UDATA** to allow for the largest possible Ethernet frame.

Return Value: `ST_RET` `SD_SUCCESS` or Error.

Functions for IEEE 802.3 Tagged MAC frames (Ethertype)

etype_hdr_decode

Usage: This function decodes the header of a IEEE 802.3 Tagged MAC frame (commonly called an Ethertype frame). It assumes the **`sn_req->lpdu_len`** contains the IEEE 802.3 Length/Type field and **`sn_req->lpdu`** points at the IEEE 802.3 MAC Client Data. It returns a pointer to the APDU (**A**pplication **P**rotocol **D**ata **U**nit) and sets the length of the APDU

Note: The use of this function is demonstrated in **iec_rx.c**.

Function Prototype:

```
ST_UCHAR *etype_hdr_decode(SN_UNITDATA     *sn_req,
                           ETYPE_INFO      *info,
                           ST_INT          *apduLen);
```

Parameters:

`sn_req`	Pointer to the subnetwork frame to be decoded.
`info`	Pointer to a structure to contain the decoded Ethertype header information
`apduLen`	Pointer to the length of the APDU (after the Ethertype header). The function sets the value of the integer pointed to by this argument

Return Value: `ST_UCHAR *` Pointer to the APDU (after Ethertype header)

etype_hdr_encode

Usage: This function encodes the header of a IEEE 802.3 Tagged MAC frame (commonly called an Ethertype frame). It returns a pointer to the beginning of the Ethertype header.

Note: The use of this function is demonstrated in **gsei_enc.c**.

Function Prototype:

```
ST_UCHAR *etype_hdr_encode(ST_UCHAR        *bufPtr,
                           ST_INT          bufLen,
                           ST_INT          *asn1Len
                           ETYPE_INFO      *etype_info);
```

Parameters:

`bufPtr`	Pointer to the APDU (somewhere within the encode buffer). **CAUTION:** The Ethertype header is encoded ***BEFORE*** this pointer. Based on **`bufLen`** and (**`*asn1Len`**), the function first makes sure there is room in the encode buffer to encode the header.
`bufLen`	Length of the encode buffer.
`asn1Len`	Pointer to the encoded length. The caller must set this to point to the length of the APDU. Before returning, the function adjusts the length to include the Ethertype header.
`etype_info`	This parameter points to an **`ETYPE_INFO`** structure containing the Ethertype header information to be encoded.

Return Value: `ST_UCHAR *` Pointer to the beginning of the Ethertype header.

Appendix I

MMS-EASE Type Description Language (TDL)

To create an ASN.1-encoded type specification, you would first create an ASCII string that represents that type using the MMS-EASE **T**ype **D**escription **L**anguage (TDL). TDL allows describing variable types in a much easier-to-understand manner than the ASN.1-encoded type specification.

TDL consists of two types of elements:

1. Predefined names used to describe simple types that will be combined to form a complex type.
2. Structure control marks used to specify the start and end of items such as structures, arrays, lengths.

Simple Type Names

The following is a description of the simple type names used by TDL and their corresponding C language representation in terms of the MMS-EASE global type definitions.

BCD

This type is encoded as a MMS signed integer where the value is dependent on the length **x** of the BCD type. **x** represents the number of 4 bit nibbles in the type. Each place specified by **x** may hold a value [0..9]. MMS-EASE only supports BCD types where **x** is [1..8]. The C language representation of BCD is a signed integer. The size of the integer used to hold the type varies according to **x**. A **`ST_INT8`** should be used when **x** is [1..2]. A **`ST_INT16`** should be used when **x** is [3..4]. The **`ST_INT32`** integer is used when **x** is [5..8]. The application is responsible for converting any native BCD data to its signed integer equivalent before sending the value. Similarly, the signed integer must be converted back to native BCD.

Example:	10 BCD	`0x0010`
	convert to	`0x000A` before sending

Bool

This type is encoded as a MMS Boolean variable. The value of variables of this type take on only two values: **`SD_TRUE`** (**`<> 0`**) or **`SD_FALSE`** (**`= 0`**). The SISCO macro for the C language representation of **Bool** is **`ST_BOOLEAN`**.

BstringXXX

This type is encoded as a MMS BitString of a fixed length of XXX bits. The SISCO macro for the C language representation of **BstringXXX** is a **`ST_UCHAR`** array where each individual byte of the array contains no more than 8 bits. The bit numbering within each byte starts with the most significant bits having a smaller bit number than the least significant bits of the byte. Therefore, if the bitstring length, specified by XXX, is not a multiple of 8, MMS-EASE only uses the necessary number of most significant bits of the last byte needed to complete the bit string. The least significant bits of the last byte will be ignored.

Btime4

This type is encoded as Binary TimeOfDay with no days. The SISCO macro for the C language representation of Btime4 is **`ST_INT32`**. This value represents the number of milliseconds since midnight of the current day.

Btime6 This type is encoded as BinaryTimeOfDay with days relative to January 1, 1984. The SISCO macro for the C language representation of Btime6 is a structure containing two consecutive **`ST_INT32`**. The value contained in the first **`ST_INT32`** represents the number of milliseconds since midnight of the current day. The value contained in the second **`ST_INT32`** represents the number of days relative to January 1 1984. This is because time (as described in the MMS spec) is relative to January 1, 1984. C Language implementations however, usually only have time functions relative to January 1, 1970.

Byte This type is encoded as a MMS signed integer one byte in length where the value must be between -128 and +127. The SISCO macro for the C language representation of **Byte** is **`ST_INT8`**. Do not use this type of variable to store ASCII; use one of the string types instead.

BVstringXXX This type is encoded as a MMS BitString of a variable length of not to exceed XXX bits. The bit numbering within each byte starts with the most significant bits having a smaller bit number than the least significant bits of the byte. Therefore, if the bitstring length, specified by XXX, is not a multiple of 8, MMS-EASE only uses the necessary number of most significant bits of the last byte needed to complete the bit string. The least significant bits of the last byte will be ignored. The SISCO structure for the C language representation of **BVstringXXX** is shown below:

```
struct  bvstring {
   ST_INT16  len;
   ST_UCHAR  data[YYY];
   };
```

The name and placement of the structure declaration is up to the application. **`len`** is the number of bits of data in the string not to exceed XXX. YYY is the number of bytes in the array equal to (XXX+7)/8.

Double This type is encoded as a double precision MMS floating point. The mantissa and exponent lengths are properly encoded to match the local format. The SISCO macro for the C language representation of **Double** is **`ST_DOUBLE`**.

Float This type is encoded as a single precision MMS floating point. The mantissa and exponent lengths are properly encoded to match the local format. The SISCO macro for the C language representation of **Float** is **`ST_FLOAT`**.

FstringXXX This type is encoded as a MMS visible string of a fixed length of XXX bytes. Variables of this type should be used to store fixed length VisibleStrings. Only the 7-bit ASCII characters minus the control characters (31 < char < 127) can be represented by a fixed length VisibleString. If you need to send non VisibleString data use the octet string type (OstringXXX) instead. The C language representation of **FstringXXX** is **`ST_CHAR [XXX+1]`**, where XXX is the number of characters in the string. The extra byte in the C language representation is used to store the null used by the C language. The null is not sent on the wire. The length of this type of variable as specified by the XXX is the actual length that will be sent on the wire. MMS-EASE sends all bytes specified by the length. This is so if the actual data does not occupy the entire string, the remainder of the string will have to be padded with spaces so that the entire length is XXX bytes. For example, Fstring16 specifies a fixed length VisibleString consisting of exactly 16 characters.

Gtime This type is encoded as MMS Generalized Time(Gtime). The C representation of Generalized Time is a **`time_t`** structure. This is an ANSI C typedef and is included in a header file supplied by the authors of the compiler. The value of the **`time_t`** variable in your application is treated as the number of seconds from midnight starting January 1, 1970. The value will only be encoded and decoded correctly if the time is greater than midnight starting January 1, 1984. This is because (time as described in the MMS spec) is relative to January 1, 1984. C Language implementations however, usually only have time functions relative to January 1, 1970.

Long This type is encoded as a MMS signed integer four bytes in length where the value must be between -2^{31} and $+2^{31}-1$. The SISCO macro for the C language representation of **Long** is **`ST_INT32`**.

Int64 This type is encoded as a MMS signed integer eight bytes in length where the value must be between -2^{63} and $+2^{63}-1$. The SISCO macro for the C language representation of **Int64** is **`ST_INT64`**.

OstringXXX This type is encoded as a MMS OctetString of a fixed length of XXX bytes. Variables of this type should be used to store binary data or character data that does not conform to the limitations specified for VisibleStrings. Each individual character of an OctetString can take on any value between 0 and 255. The SISCO macro for the C language representation of **OstringXXX** is **`ST_UCHAR [XXX]`**, where XXX is the number of bytes of data in the string. Note that there is no extra byte for the null because a null can be a valid member of an OctetString. The length of this type of variable as specified by the XXX is the actual length that will be sent on the wire. For example, Ostring256 specifies a data stream of exactly 256 bytes.

OVstringXXX This type is encoded as a MMS OctetString of a variable length not to exceed XXX bytes. Variables of this type should be used to store binary data or character data that does not conform to the limitations specified for VisibleStrings. Each individual character of an OctetString can take on any value between 0 and 255. The length of this type of variable as specified by the XXX is the maximum length that will be sent on the wire. For example, OVstring256 specifies a data stream of less than or equal to 256 bytes. The SISCO structure for the C language representation of **OVstringXXX** is:

```
struct  ovstring {
   ST_INT16  len;
   ST_UCHAR  data[XXX];
   };
```

The name and placement of the structure declaration is up to the application. **`len`** is the number of bytes of data in the string not to exceed XXX. Note that there is no extra byte for the null because a null can be a valid member of an OctetString.

Short This type is encoded as a MMS signed integer two bytes in length where the value must be between -32,768 and +32,767. The SISCO macro for the C language representation of **Short** is **`ST_INT16`**.

Ubyte This type is encoded as a MMS unsigned integer one byte in length where the value must be between 0 and 255. The SISCO macro for the C language representation of **Ubyte** is **`ST_UINT8`**. Do not use this type of variable to store ASCII; use one of the string types instead.

Uint64 This type is encoded as a MMS unsigned integer eight bytes in length where the value must be between 0 and $+2^{64}$ -1. The SISCO macro for the C language representation of **Uint64** is **`ST_UINT64`**.

Ulong This type is encoded as a MMS unsigned integer four bytes in length where the value must be between 0 and $+2^{32}$-1. The SISCO macro for the C language representation of **Ulong** is **`ST_UINT32`**.

Ushort This type is encoded as a MMS unsigned integer two bytes in length where the value must be between 0 and 65,535. The SISCO macro for the C language representation of **Ushort** is **`ST_UNT16`**.

Utctime This type is encoded as UtcTime with seconds relative to GMT midnight January 1, 1970. The SISCO macro for the C language representation of Utctime is a structure (**`MMS_UTC_TIME`**) containing 3 consecutive **`ST_UINT32`**. The value contained in the first **`ST_UINT32`** represents the number of seconds since January 1, 1970. The seconds **`ST_UINT32`** represents number of microseconds of a second. And the last **`ST_UINT32`** contains quality flags, only least significant byte is used.

UTF8VstringXX This type is encoded as Variable length Unicode UTF8string not to exceed XX Unicode "characters." (**Note**: Each Unicode character may take up to 4 bytes).

VstringXXX This type is encoded as a MMS visible string of a variable length not to exceed XXX bytes. Variables of this type should be used to store variable length VisibleStrings. Only the 7-bit ASCII characters minus the control characters (31 < char < 127) can be represented by a VisibleString. For instance, MMS Object Names are encoded as VisibleStrings but can only contain the **$** and **_** punctuation marks, and the alphanumeric characters. If you need to send non VisibleString data, use the octet string (OstringXXX) instead. The SISCO macro for the C language representation of **VstringXXX** is **`ST_CHAR [XXX+1]`**, where XXX is the number of characters in the string. The extra byte in the C language representation is used to store the null used by the C language. The null is not sent on the wire. The length of this type of variable, specified by the XXX, is the maximum length that the variable can be. MMS-EASE only sends or receives data up to a null or XXX bytes for variables of this type. For example, "Vstring24" specifies a VisibleString with no more than 24 characters.

TDL Structure Control

MMS-EASE TDL uses punctuation marks and other pre-defined sequences of characters to signal the beginning and end of structures and arrays. They provide other type related information such as pre-named types, and VMD names. The following is a description of the various structure control character sequences, and what they mean to the TDL:

{ } The pillow marks are used to signal the beginning "**{**" and the end "**}**" of complex structure definitions.

[ ] The brace marks signal the beginning "**[**" and the end "**]**" of array definitions. Immediately following the start of an array symbol "**[**", there should be either a "**p**" as described below, or a number indicating the number of elements in the array.

p This symbol immediately following the start of an array or structure indicates that all elements within the array or structure are to be packed. Note that MMS-EASE defaults to non-packed variables suitable for most applications. Non-packed means that all elements of a data structure will be placed on word, not byte boundaries. All the MMS-EASE defined data structures are not packed, and must remain on word boundaries. Only user defined named types and the corresponding named variables can be packed.

: A colon is used to separate various fields within a type specification such as the number of elements in an array from the type name for the members of the array, and the domain name from a pre-existing type name.

( ) Parenthesis are used to signal the start "**(**" and end "**)**" of the name of an individual element of a structure. All element names must be MMS Identifiers. These must be VisibleStrings no longer than 32 characters that exist only of numbers (0-9), upper and lower case letters (A-Z, a-z), the **_** and **$** marks.

< > The right and left angles are used to signal the start "<" and the end ">" of references to pre-named types. This allows you to cross-reference pre-existing named types already placed in the MMS-EASE database when building subsequent type definitions.

@ The "at" (@) symbol is used to reference pre-existing named types that are either VMD specific (@VMD) or Application-Association specific (@AA).

TDL Examples

Several examples are provided of how to build complex type definitions using the TDL.

Example #1:

Create the ASN.1 Type Definition for the following structure:

```
struct
  {
  ST_CHAR    name[33];          /*  Visible string containing name      */
  ST_INT16   tag_value;         /*  A short signed integer              */
  ST_INT32   time_array[32];    /*  An array of 1                       */
  } test1;
```

1. The TDL descriptor for this type is:

```
{ Vstring32, Short, [32:Long] }
```

2. If the individual element names were added into the type definition, the TDL descriptor becomes:

```
{ (name) Vstring32, (tag_value) Short, (time_array) [32:Long]}
```

Example #2:

Create the TDL descriptor for the following array of structures.

```
struct
  {
  ST_CHAR    mask[7];              /* 56 bit bitstring                  */
  struct     test1  sample1;
  struct     test2  sample2;
  struct     test3  sample3;
  ST_FLOAT   value;
  }  test4[16];
```

Assume:

The type definition for test1, test2, and test3 has already been created.

This results in the following TDL Descriptor:

```
[16:{Bstring56,<@VMD:test1>,<domain1:test2>,<@AA:test3>,Float}]
```

If adding names to the elements, the TDL Descriptor becomes:

```
[16:{(mask)Bstring56,(sample1)<@VMD:test1>,(sample2)<domain1:test2>,
(sample3)<@AA:test3>,(value)Float}]
```

The use of spaces is optional. They may be included to make the TDL descriptor easier to read.

Notes:

1. Care must be taken when using the Btime4 and Btime6 types. These types only specify time with respect to the local time zone, there may be problems if the data crosses a time zone. Also, Btime4 does not contain date information. This may add additional confusion. Although the Gtime type specifies time with respect to Greenwich Mean Time, it requires that your computer be set up with the proper time and time zone information in order for the operating system to supply you with time properly for Gtime. Remember, these types only exist on the network. The time format used by your application program is that of the C language for your system. MMS-EASE takes care of converting between the C time and the Gtime, Btime4, or Btime6.
2. Do not nest structures within arrays, arrays within structures, arrays within arrays, structures within structures more than 10 deep.

Appendix J

IEC GOOSE Example Application Framework

This appendix contains information on the IEC GOOSE Example Framework. The application framework is supplied "as is" and is intended to be used as an example. Maintenance of user modifications to this framework are the responsibility of the user.

The IEC GOOSE framework is built on Windows using the IEC GOOSE framework project file (**iecgoose.vcproj**) in the main MMS-Lite workspace.

The framework is supplied in the following files:

iec_comn.c	This file contains common routines for the manipulation of IEC GOOSE pools.
iec_tx.c	This file contains framework functions for the creation, transmission, and retransmission of IEC GOOSE messages.
iec_rx.c	This file contains framework functions for the subscription, decoding, and user callback for receiving IEC GOOSE messages.
iec_demo.h	This file includes the framework definitions (including log masks).
iec_demo.c	This file drives the framework for initial debug. This file should not be used as part of an overall embedded application.

The framework functions make use of GOOSE API, MMS-*Lite*, and other framework functions in order to accomplish the requisite work.

A call to the function **`demo_init`** in **iec_demo.c** is required in order to initialize the demo.

Framework functions contained within iec_rx.c

The general flow of the framework, for GOOSE reception, is:

- The framework allows the reception of an IEC GOOSE packet (**`clnp_snet_read`**).
- The packet is checked to see if it is an Ethertype packet.
  If so, the Ethertype header is decoded for further examination. If not, the packet is discarded.
- The packet Ethertype ID is checked to see if it matches with the Ethertype ID being used for IEC GOOSE (currently defined as **`ETYPE_TYPE_GOOSE`**).

  If the Ethertype ID does not match, the packet is discarded.
- If the Ethertype ID matches, then the subscribed for MAC Addresses are checked (see the function **`iecGooseSubscribe`**).

If **`GOOSE_DEC_MODE_LAST_RX`** is the **`decode_method`** specified, then there may be only one MAC_Address/GCRef pair. This is due to the fact that only the last received IEC GOOSE message for each MAC address is saved for later decoding. If there is more than one gcRef for the same MAC, then some GOOSE messages would not be saved.

If **`GOOSE_DEC_MODE_IMMEDIATE`** is the **`decode_mode`** specified, then there may be multiple GCRefs associated with a single MAC_Address.

- If the **`decode_mode`** is **`GOOSE_DEC_MODE_IMMEDIATE`**, the decode function **`iecGooseDecode`** is called.

  The decode function finds the appropriate MAC/GCRef combination based upon a header decode.

  If there is a **`stNum`** change detected, the decode continues.

  The subscribed for the received **`DataEntry`** list is then scanned to see if any of the information received is to be delivered to the application (based upon the function **`gse_iec_data_init`**).

The databuffer is then marked as **`GOOSE_CALLBACK_REASON_STATECHANGE_DATA_UPDATED`**. This allows the application to determine which buffers have been updated.

Note: It is a general philosophy of the framework that the DataSet being published may be a superset of the information needed by the application. Therefore, the subscription process allows a subset of the published information to be subscribed for.

The user callback function is called indicating the appropriate status and information.

- If the **`decode_mode`** is **`GOOSE_DEC_MODE_LAST_RX`**, then the application must call the function **`iecGooseLastRxDecode`** in order to decode the last received GOOSE for each MAC address.

  Note: This decode mode may improve performance (less CPU time) for implementations that desire to have the GOOSE information be synchronized with the internal Input I/O scan.

  The maximum number of GEESE that can be received is specified by **`MAX_RXD_GOOSE`**.

iecGooseSubscribe

Usage: This function is used by a framework user to subscribe for an IEC GOOSE.

Function Prototype:

```
IEC_GOOSE_SEND_USER_INFO  *iecGooseSubscribe (ST_UCHAR         *DstAddress,
                                              ST_CHAR          *gcRef,
                                              ST_CHAR          *DataSetRef,
                                              ST_CHAR          *AppID,
                                              ST_INT           ConfRevNum,
                                              ST_INT           numDataEntries,
                                              ST_TYPE_ARRAY    *rt_array,
                ST_VOID (*usr_fun)(IEC_GOOSE_SEND_USER INFO    *info,
                                              GSE_IEC_CTRL     *gptr,
                                              ST_VOID          *usr,
                                              ST_UINT16        reason),
                                              ST_INT           decode_mode);
```

Parameters:

`DstAddress` A pointer to a buffer that contains the six byte MAC Address to which the expected IEC GOOSE message is being sent. This parameter is used to configure the MAC filtering. The buffer need not be persistent.

`gcRef` A pointer to a buffer that contains the GOOSE Control Block Reference that is to be expected. The buffer must be persistent. If this value does not match with the value supplied by the received GOOSE, a error will be indicated and no further processing of that GOOSE packet will occur (see the static function **`iecGooseDecode`** if this check needs to be removed).

`DataSetRef` A pointer to a buffer that contains the Data Set Reference that is to be expected. The buffer must be persistent. If this value does not match with the value supplied by the received GOOSE, a error will be indicated and no further processing of that GOOSE packet will occur (see the static function **`iecGooseDecode`** if this check needs to be removed).

`AppID` A pointer to a buffer that contains the Application ID that is to be expected. The buffer must be persistent. If this value does not match with the value supplied by the received GOOSE, a error will be indicated and no further processing of that GOOSE packet will occur (see the static function **`iecGooseDecode`** if this check needs to be removed).

`ConfRevNum` This value represents the Configuration Revision Number that is to be expected. If this value does not match with the value supplied by the received GOOSE, a error will be indicated and no further processing of that GOOSE packet will occur (see the static function **`iecGooseDecode`** if this check needs to be removed).

`numDataEntries` This specifies the number of Data Entries to be configured. This value determines the size of the **`rt_array`**.

iecGooseSubscribe (cont'd)

Parameters (cont'd):

`rt_array` Is an array (size of **`numDataEntries`**) of **`RT_TYPE_ARRAY`**:

```
typedef struct rt_type_array{
  ST_INT   num_rts; /* number of runtime type elements that   */
                    /* define actual data type for the entry  */
  RUNTIME_TYPE *rt; /*pointer to the head of the runtime type */
}RT_TYPE_ARRAY;
```

`usr_fun` This is the callback function desired to be called when an incoming GOOSE that matches all filter criteria (e.g., **`DstAddress`**, **`gcRef`**, etc.) is met.

The callback is supplied the following information:

`GOOSE_SEND_USER INFO *` the handle created for this subscription

`GSE_IEC_CTRL *` pointer to the GOOSE control created.

`ST_VOID *` user information stored after creation in the handle structure.

`ST_UINT16` reason for callback. The set of defined reasons may be found in **iec_demo.h**, but include the following:

```
GOOSE_CALLBACK_REASON_STATECHANGE_DATA_UPDATED
GOOSE_CALLBACK_REASON_TIMEALLOWED_TO_LIVE_TIMEOUT
GOOSE_CALLBACK_REASON_OUT_OF_SEQUENCE_DETECTED
GOOSE_CALLBACK_REASON_CONFREV_MISMATCH
GOOSE_CALLBACK_REASON_NEED_COMMISSIONING
GOOSE_CALLBACK_REASON_TEST_MODE
GOOSE_CALLBACK_REASON_GCREF_MISMATCH
GOOSE_CALLBACK_REASON_APPID_MISMATCH
GOOSE_CALLBACK_REASON_DATSET_MISMATCH
```

The values are or'd together to form a reason mask.

`decode_mode` This parameter specifies the processing directive for a GOOSE that matches the filter criteria. The allowed values are:

`GOOSE_DEC_MODE_LAST_RX` decode occurs by application calling the function **`iecGooseLastRxDecode`**.

`GOOSE_DEC_MODE_IMMEDIATE` decode occurs immediately when message is message is received.

Return Value: `IEC_GOOSE_SEND_USER_INFO *` A handle to the user info or **Null** means an error occurred in subscription.

Comments: This function makes calls to the following GOOSE API functions:

`gse_iec_control_create` Creates a GOOSE control block

`gse_iec_data_init` Creates Data Entries that can be searched and also the storage for the decoded data buffers.

`clnp_snet_set_multicast_filter` Sets the MAC filtering within the driver.

iecGooseSubscribeExtRefAll

Usage: This function subscribes for all GOOSE messages for the specified IED. It examines all ExtRef elements in the SCL file for this IED, and subscribes for GOOSE accordingly. This function requires an IEC 61850 Edition 2 SCL file.

Function Prototype:

```
ST_RET iecGooseSubscribeExtRefAll (SCL_INFO          *scl_info,
                                   ST_CHAR           *iedName,
                                   ST_CHAR           *apName,
                                   ST_VOID (*usr_fun)(IEC_GOOSE_RX_USER_INFO *info,
                                          GSE_IEC_CTRL      *gptr,
                                          ST_VOID           *usr,
                                          ST_UINT16         reason));
```

Parameters:

`sclInfo`	Pointer to structure where the parser stored all information extracted from the SCL file
`iedname`	Pointer to the IED name of the subscriber.
`apname`	Pointer to the Access Point name of the subscriber.
`usr_fun`	This is the callback function desired to be called when an incoming GOOSE that matches all filter criteria (e.g., **`DstAddress`**, **`gcRef`**, etc.) is met. See **`iecGooseSubscribe`** for more details.

Return Value:	`ST_RET`	`SD_SUCCESS`	All GOOSE subscriptions succeeded
		`<>0`	Error code. Some subscriptions failed. If logging is enabled, the log file may contain more details.

iecGooseUnSubscribe

Usage: This function destroys resources allocated for an IEC GOOSE subscription (by **iecGooseSubscribe**).

Function Prototype:

```
ST_RET iecGooseUnSubscribe(IEC_GOOSE_SEND_USER_INFO *goosehandle);
```

Parameters:

goosehandle — The handle value returned by the function **iecGooseSubscribe**.

Return Value:

ST_RET	SD_SUCCESS	IEC GOOSE sent successfully.
	<>0	Error code.

Comments: This function makes calls to the following GOOSE API functions:

gse_iec_control_destroy Destroys a GOOSE control block.

clnp_snet_set_multicast_filter Sets the MAC filtering within the driver.

iecGooseUnSubscribeAll

Usage: This function destroys resources allocated for all IEC GOOSE subscriptions. The subscriptions may have been created by **iecGooseSubscribe**, **iecGooseSubscribeExtRef**, or **iecGooseSubscribeExtRefAll**.

Function Prototype: `ST_RET iecGooseUnSubscribeAll(ST_VOID);`

Parameters: None

Return Value:

ST_RET	SD_SUCCESS	All IEC GOOSE subscriptions destroyed.
	<>0	Error code.

Comments: This function makes calls to the following GOOSE API functions:

gse_iec_control_destroy Destroys a GOOSE control block.

clnp_snet_set_multicast_filter Sets the MAC filtering within the driver.

iecGooseLastRxDecode

Usage: This function is used to drive the decodes of received GEESE that were subscribed to as **`GOOSE_DEC_MODE_LAST_RX`** (see the function **`iecGooseSubscribe`**).

Function Prototype: `ST_RET iecGooseLastRxDecode (ST_VOID);`

Parameters: None

Return Value: **`SD_SUCCESS`** if the GOOSE decoding was successful; otherwise **`SD_FAILURE`**.

Comments: This function searches for a LAST_RX subscription and then calls the function **`iecGooseDecode`**. This function makes GOOSE API calls to:

`gse_iec_hdr_decode` Decodes the IEC GOOSE header

`ms_asn1_to_local` Converts GOOSE data into local memory representation.

get_goose_messages

Usage: This function is used to receive IEC GOOSE messages from the driver, It then process them according to the decode mode specified by the function **`iecGooseSubscribe`**.

Function Prototype:

```
ST_RET get_goose_messages(ST_VOID);
```

Parameters: None

Return Value: **`SD_SUCCESS`** if a packet was received from the driver; otherwise **`SD_FAILURE`**.

Comments: This function makes calls to the following GOOSE API functions:

`clnp_snet_read` Obtains a GOOSE packet

`chk_for_goose_msg` This function is where detection of the destination Ethertype ID occurs. It will need to be modified in order to extend the framework to support SampledValues, GSE Management, GSSE (formerly UCA GOOSE), and other link level messages.

chk_for_goose_msg

Usage: This function is called in order to process GOOSE, GSSE, or GSE Management functions.

Function Prototype:

```
ST_RET chk_for_goose_msg (ST_UCHAR   *loc_mac,
                          ST_UCHAR   *rem_mac,
                          ST_INT     pdu_len,
                          ST_CHAR    *pdu);
```

Parameters:

`loc_mac` Pointer to the destination MAC. This MAC address should be the local unicast address.

`rem_mac` Pointer to the source MAC of the sending node.

`pdu_len` This is the length of the Link Protocol Data Unit (LPDU) to be processed. This length should be the Virtual LAN Type ID (0x8100) which signals an Ethertype frame. The actual length of the LPDU can be obtained with a call to the function **`etype_hdr_decode`**.

`pdu` This is a pointer to the LPDU data buffer minus the two MAC addresses.

Return Value: **`SD_SUCCESS`** if a packet was processed; otherwise **`SD_FAILURE`**.

chk_iec_goose_timeout

Usage: This function is used to detect when a received/subscribed GOOSE has an expired TAL (Time Allowed to Live).

Function Prototype:

```
ST_VOID chk_iec_goose_timeout (ST_INT32 elapsed_msec);
```

Parameters:

`elapsed_msec` Value of elapsed time in msec since function was called last.

Return Value: `ST_VOID`

Framework functions contained within iec_tx.c

iecGoosePubCreate

Usage: This function is used by a framework user to create publishing GEESE.

Function Prototype:

```
IEC_GOOSE_SEND_USER_INFO  *iecGoosePubCreate (ST_CHAR          *gcRef,
                                              ST_CHAR          *DataSetRef,
                                              ST_CHAR          *AppID,
                                              ST_ULONG         ConfRevNum,
                                              ST_BOOLEAN       NeedsComm,
                                              ST_UINT16        tci,
                                              ST_UINT16        etypeID
                                              ST_UINT16        appID);
```

Parameters:

`gcRef`	A pointer to a buffer that contains the GOOSE Control Block Reference that is to the value to be sent in the IEC GOOSE. The referenced control need not exist locally. The value must be persistent.
`DataSetRef`	A pointer to a buffer that contains the DataSet Reference that is to be the value to be sent in the IEC GOOSE. The referenced DataSet must be defined and present within the server. The value must be persistent.
`AppID`	A pointer to a buffer that contains the Application ID that is to be sent in the IEC GOOSE. The buffer must be persistent
`ConfRevNum`	This value represents the Configuration Revision Number that is to be sent.
`NeedComm`	This flag represents the value of the IEC GOOSE NeedsCommissioning parameter. A value of **`SD_TRUE`** indicates that commissioning is required.
`tci`	The value of the Virtual LAN's Tag Control Information. These values are predefined in **ethertyp.h**.
`etypeID`	The value of the Ethertype ID, as defined in **ethertyp.h**.
`appID`	The value of the Application Identifier. If no **`appID`** is configured in the application, the default value of 0x0000 should be passed into this function.

Return Value: `IEC_GOOSE_SEND_USER_INFO *` A handle to the user info or **Null** if an error occured.

Comments: This function makes calls to the following GOOSE API functions:

`gse_iec_control_create`	Creates a GOOSE control block.
`gse_iec_data_init`	Creates Data Entries that can be searched and the storage for the decoded data buffers.

iecGooseSubscriberFind

Usage: This function is used to find an IEC GOOSE subscriber control structure matching the ObjectReference **`GoCBRef`**.

Function Prototype:

```
IEC_GOOSE_RX_USER_INFO *iecGooseSubscriberFind(ST_CHAR *GoCBRef);
```

Parameters:

`GoCBRef`	A string containing the GOOSE Control Block Reference. This should match the GoCBRef specified when the control structure was created. If the control structure was created by **`iecGooseSubscribeExtRef`**, the GoCBRef was generated from ExtRef attributes in the SCL file

Return Value:	`IEC_GOOSE_RX_USER_INFO *`	A pointer to the IEC GOOSE subscriber control structure or **NULL** if an error occured.

iecGoosePubDestroy

Usage: This function destroys resources allocated with a created IEC GOOSE publication.

Function Prototype:

```
ST_RET iecGoosePubDestroy (IEC_GOOSE_SEND_USER_INFO *goosehandle);
```

Parameters:

`goosehandle` The handle value of type **`IEC_GOOSE_SEND_USER_INFO`** returned by the function **`iecGoosePubCreate`**.

Return Value: `ST_RET` This function always returns **`SD_SUCCESS`**.

Comments: This function makes calls to the following GOOSE API function:

`gse_iec_control_destroy`	Destroys a GOOSE control block

iecGoosePublish

Usage: This function polls for the GOOSE data by invoking the MMS-*Lite* **`read_ind`** functions. After the poll is complete, it updates the data in the GOOSE Control Data Entries and then starts the sequence of transmission.

Function Prototype:

```
ST_VOID iecGoosePublish (IEC_GOOSE_SEND_USER_INFO *goosehandle);
```

Parameters:

`goosehandle` The handle value of type **`IEC_GOOSE_SEND_USER_INFO`** returned by the function **`iecGoosePubCreate`**.

Return Value: `ST_VOID`

Comments: This function calls the following internal framework functions:

`mvlu_rpt_scan_read`	Polls for the data (from the MMS-LITE API).
`gse_iec_data_update`	Updates the GOOSE information with the polled data.
`gse_iec_encode`	Encodes the GOOSE.
`gse_iec_send`	Sends the GOOSE.

start_trans_goose

Usage: This function is used to encode/transmit a state changed GOOSE. It increments the **stNum** and **sqNum**. It does not change the event timestamp (This must be set by the application).

Function Prototype:

```
ST_RET start_trans_goose (GSE_IEC_CTRL *gptr, RETRANS_CURVE *retrans_curve);
```

Parameters:

`gptr` The handle value of type **GSE_IEC_CTRL** returned by the function **gse_iec_control_create**.

`RETRANS_CURVE` Pointer of type **RETRANS_CURVE** to the retransmission curve specification.

```
typedef struct retrans_curve{
   ST_UINT   num_retrans; /*number of active entries in array */
   ST_UINT32 retrans[MAX_NUM_RETRANS];  /* msec retrans       */
}RETRANS_CURVE;
```

Return Value: `ST_RET`

`SD_SUCCESS`	IEC GOOSE sent successfully.
`<>0`	Error

Comments: This function makes calls to the following GOOSE API functions:

gse_iec_encode	Encodes the GOOSE
gse_iec_send	Sends the GOOSE

retrans_goose

Usage: This function is used to detect when a GOOSE needs to be retransmitted.

Function Prototype:

```
ST_VOID retrans_goose (ST_INT32 elapsed_msec);
```

Parameters:

`elapsed_msec` Value of elapsed time (in msec) since function was called last.

Return Value: `ST_VOID`

Comments: This function makes calls to the following GOOSE API functions:

gse_iec_encode	Encodes the GOOSE.
gse_iec_send	Sends the GOOSE.

Appendix K

IEC61850 Product PICS

This appendix contains information the Conformance Statement for MMS-*Lite*.

Conformance Statement Key and Notes

Table Entry	Description
Y	Supported with MMS services and objects necessary for implementing this capability.
U	Supported but not used in IEC 61850.
N	Not Supported. Can be implemented by user.
E	Not in product scope. Supportable but determined by user implementation.
–	Not Applicable

Basic ACSI conformance statement

	Basic ACSI conformance	Client/ subscriber	Server/ publisher	Value/ comments
Client-server roles				
B11	**Server** side (of TWO-PARTY-APPLICATION-ASSOCIATION)	–	Y	1000 total associations maximum
B12	**Client** side of (TWO-PARTY-APPLICATION-ASSOCIATION)	Y	–	1000 total associations maximum
SCSMs supported				
B21	**SCSM**: IEC 61850-8-1 used	Y	Y	
B22	**SCSM**: IEC 61850-9-1 used	N	N	
B23	**SCSM**: IEC 61850-9-2 used	Y	Y	MMS-LITE-802-001 versions only
B24	**SCSM**: other	N	N	
Generic substation event model (GSE)				
B31	**Publisher** side	–	Y	MMS-LITE-802-001 versions only
B32	**Subscriber** side	Y	–	MMS-LITE-802-001 versions only
Transmission of sampled value model (SVC)				
B41	**Publisher** side	–	Y	MMS-LITE-802-001 versions only
B42	**Subscriber** side	Y	–	MMS-LITE-802-001 versions only

ACSI models conformance statement

ACSI Model Conformance		Client/ subscriber	Server/ publisher	Value/ comments
M1	**Logical device**	Y	Y	
M2	**Logical node**	Y	Y	
M3	**Data**	Y	Y	
M4	**Data set**	Y	Y	
M5	**Substitution**	Y	Y	
M6	**Setting group control**	Y	Y	
	Reporting			
M7	**Buffered report control**	Y	Y	
M7-1	sequence-number	Y	Y	
M7-2	report-time-stamp	Y	Y	
M7-3	reason-for-inclusion	Y	Y	
M7-4	data-set-name	Y	Y	
M7-5	data-reference	Y	Y	
M7-6	buffer-overflow	Y	Y	
M7-7	entryID	Y	Y	
M7-8	BufTm	Y	Y	
M7-9	IntgPd	Y	Y	
M7-10	GI	Y	Y	
M8	**Unbuffered report control**	Y	Y	
M8-1	sequence-number	Y	Y	
M8-2	report-time-stamp	Y	Y	
M8-3	reason-for-inclusion	Y	Y	
M8-4	data-set-name	Y	Y	
M8-5	data-reference	Y	Y	
M8-6	BufTm	Y	Y	
M8-7	IntgPd	Y	Y	
M8-8	GI	Y	Y	
	Logging			
M9	**Log control**	Y	Y	
M9-1	IntgPd	Y	Y	
M10	**Log**	Y	Y	
M11	**Control**	Y	Y	
	GOOSE	Y	Y	
M12-1	entryID	Y	Y	
M12-2	DataRefInc	Y	Y	
M13	**GSSE**	Y	Y	

ACSI service conformance statement

ACSI Service Conformance		Client/ subscriber	Server/ publisher	Comments
Server (Clause 6)				
S1	ServerDirectory	Y	Y	
Application association (Clause 7)				
S2	Associate	Y	Y	
S3	Abort	Y	Y	
S4	Release	Y	Y	
Logical device (Clause 8)				
S5	LogicalDeviceDirectory	Y	Y	
Logical node (Clause 9)				
S6	LogicalNodeDirectory	Y	Y	
S7	GetAllDataValues	Y	Y	
Data (Clause 10)				
S8	GetDataValues	Y	Y	
S9	SetDataValues	Y	Y	
S10	GetDataDirectory	Y	Y	
S11	GetDataDefinition	Y	Y	
Data set (Clause 11)				
S12	GetDataSetValues	Y	Y	
S13	SetDataSetValues	Y	Y	
S14	CreateDataSet	Y	Y	
S15	DeleteDataSet	Y	Y	
S16	GetDataSetDirectory	Y	Y	
Substitution (Clause 12)				
S17	SetDataValues	Y	Y	
Setting group control (Clause 13)				
S18	SelectActiveSG	Y	Y	
S19	SelectEditSG	Y	Y	
S20	SetSGValues	Y	Y	
S21	ConfirmEditSGValues	Y	Y	
S22	GetSGValues	Y	Y	
S23	GetSGCBValues	Y	Y	
Reporting (Clause 14)				
Buffered report control block (BRCB)				
S24	Report	Y	Y	
S24-1	data-change (dchg)	Y	Y	
S24-2	qchg-change (qchg)	Y	Y	
S24-3	data-update (dupd)	Y	Y	
S25	GetBRCBValues	Y	Y	
S26	SetBRCBValues	Y	Y	
Unbuffered report control block (URCB)				
S27	Report	Y	Y	

ACSI Service Conformance		Client/ subscriber	Server/ publisher	Comments
S27-1	data-change (dchg)	Y	Y	
S27-2	qchg-change (qchg)	Y	Y	
S27-3	data-update (dupd)	Y	Y	
S28	GetURCBValues	Y	Y	
S29	SetURCBValues	Y	Y	
Logging (Clause 14)				
Log control block				
S30	GetLCBValues	Y	Y	
S31	SetLCBValues	Y	Y	
Log				
S32	QueryLogByTime	Y	Y	
S33	QueryLogAfter	Y	Y	
S34	GetLogStatusValues	Y	Y	
Generic substation event model (GSE) (Clause 14.3.5.3.4)				
GOOSE-CONTROL-BLOCK				
S35	SendGOOSEMessage	Y	Y	MMS-LITE-802-001 versions only
S36	GetGoReference	Y	Y	MMS-LITE-802-001 versions only
S37	GetGOOSEElementNumber	Y	Y	MMS-LITE-802-001 versions only
S38	GetGoCBValues	Y	Y	
S39	SetGoCBValues	Y	Y	
GSSE-CONTROL-BLOCK				
S40	SendGSSEMessage	Y	Y	MMS-LITE-802-001 versions only
S41	GetGsReference	Y	Y	MMS-LITE-802-001 versions only
S42	GetGSSEElementNumber	Y	Y	MMS-LITE-802-001 versions only
S43	GetGsCBValues	Y	Y	
S44	SetGsCBValues	Y	Y	
Transmission of sampled value model (SVC) (Clause 16)				
Multicast SVC				
S45	SendMSVMessage	Y	Y	MMS-LITE-802-001 versions only
S46	GetMSVCBValues	Y	Y	
S47	SetMSVCBValues	Y	Y	
Unicast SVC				
S48	SendUSVMessage	N	N	
S49	GetUSVCBValues	Y	Y	
S50	SetUSVCBValues	Y	Y	

Control (17.5.1)				
S51	Select	Y	Y	
S52	SelectWithValue	Y	Y	
S53	Cancel	Y	Y	
S54	Operate	Y	Y	
S55	Command-Termination	Y	Y	
S56	TimeActivated-Operate	Y	Y	
File transfer (Clause 20)				
S57	GetFile	Y	Y	
S58	SetFile	Y	Y	
S59	DeleteFile	Y	Y	
S60	GetFileAttributeValues	Y	Y	
Time (5.5)				
T1	Time resolution of internal clock	E	E	
T2	Time accuracy of internal clock	E	E	
T3	Supported TimeStamp resolution	E	E	

Protocol Implementation Conformance Statement (PICS) for A-Profile support

A-Profile Description		Client	Server	Value/Comment
A1	Client/Server A-Profile	Y	Y	
A2	GOOSE/GSE Management A-Profile	Y	Y	MMS-LITE-802-001 versions only
A3	GSSE A-Profile	Y	Y	MMS-LITE-802-001 versions only
A4	TimeSync A-Profile	E	E	

PICS for T-Profile support

T-Profile Description		Client	Server	Value/Comment
T1	TCP/IP T-Profile	Y	Y	TCP/IP Stack is not included
T2	OSI T-Profile	Y	Y	MMS-LITE-802-001 versions only
T3	GOOSE/GSE T-Profile	Y	Y	MMS-LITE-802-001 versions only
T4	GSSE T-Profile	Y	Y	MMS-LITE-802-001 versions only
T5	TimeSync T-Profile	E	E	

MMS Initiate request general parameters

Initiate Request	Client	Server	Comments
InitiateRequest			
LocalDetailCalling	Y	Y	
proposedMaxServOutstandingCalling	Y	Y	Product tested @ 5
proposedMaxServOustandingCalled	Y	Y	Product tested @ 5
InitRequestDetail	Y	Y	
InitiateRequestDetail			
ProposedVersionNumber	Y	Y	
ProposedParameterCBB	Y	Y	
ServicesSupportedCalling	Y	Y	
AdditionalSupportedCalling	N	N	
additionalCbbSupportedCalling	N	N	
PrivilegeClassIdentityCalling	N	N	

MMS Initiate response general parameters

Initiate Response	Client	Server	Comments
InitiateResponse			
localDetailCalled	Y	Y	
negotiatedMaxServOutstandingCalling	Y	Y	Product tested @ 5
negotiatedMaxServOustandingCalled	Y	Y	Product tested @ 5
initResponseDetail	Y	Y	
InitiateResponseDetail			
negotiatedVersionNumber	Y	Y	
negotiatedParameterCBB	Y	Y	
servicesSupportedCalled	Y	Y	
additionalSupportedCalled	N	N	
additionalCbbSupportedCalled	N	N	
privilegeClassIdentityCalled	N	N	

MMS service supported conformance table

MMS Service Supported CBB	Client	Server	Comments
Status	Y	Y	
GetNameList	Y	Y	
Identify	Y	Y	
Rename	Y	Y	
Read	Y	Y	
Write	Y	Y	
GetVariableAccessAttributes	Y	Y	
DefineNamedVariable	Y	Y	
DefineScatteredAccess	N	N	Deprecated in ISO9506 2002
GetScatteredAccessAttributes	N	N	Deprecated in ISO9506 2002
DeleteVariableAccess	Y	Y	
DefineNamedVariableList	Y	Y	
GetNamedVariableListAttributes	Y	Y	
DeleteNamedVariableList	Y	Y	
DefineNamedType	U	U	
GetNamedTypeAttributes	U	U	
DeleteNamedType	U	U	
Input	U	U	
Output	U	U	
TakeControl	U	U	
RelinquishControl	U	U	
DefineSemaphore	U	U	
DeleteSemaphore	U	U	
ReportPoolSemaphoreStatus	U	U	
ReportSemaphoreStatus	U	U	
InitiateDownloadSequence	U	U	
DownloadSegment	U	U	
TerminateDownloadSequence	U	U	
InitiateUploadSequence	U	U	
UploadSegment	U	U	
TerminateUploadSequence	U	U	
RequestDomainDownload	U	U	
RequestDomainUpload	U	U	
LoadDomainContent	Y	Y	
StoreDomainContent	Y	Y	
DeleteDomain	U	U	
GetDomainAttributes	Y	Y	
CreateProgramInvocation	U	U	
DeleteProgramInvocation	U	U	
Start	U	U	
Stop	U	U	

MMS Service Supported CBB	Client	Server	Comments
Resume	U	U	
Reset	U	U	
Kill	U	U	
GetProgramInvocationAttributes	U	U	
ObtainFile	Y	Y	
DefineEventCondition	U	U	
DeleteEventCondition	U	U	
GetEventConditionAttributes	U	U	
ReportEventConditionStatus	U	U	
AlterEventConditionMonitoring	U	U	
TriggerEvent	U	U	
DefineEventAction	U	U	
DeleteEventAction	U	U	
DefineEventEnrollment	U	U	
DeleteEventEnrollment	U	U	
AlterEventEnrollment	U	U	
ReportEventEnrollmentStatus	U	U	
GetEventEnrollmentAttributes	U	U	
AcknowledgeEventNotification	U	U	
GetAlarmSummary	U	U	
GetAlarmEnrollmentSummary	U	U	
ReadJournal	Y	Y	
WriteJournal	U	U	
InitializeJournal	Y	Y	
ReportJournalStatus	U	U	
CreateJournal	U	U	
DeleteJournal	U	U	
FileOpen	Y	Y	
FileRead	Y	Y	
FileClose	Y	Y	
FileRename	U	U	
FileDelete	Y	Y	
FileDirectory	Y	Y	
UnsolicitedStatus	U	U	
InformationReport	Y	Y	
EventNotification	U	U	
AttachToEventCondition	U	U	
AttachToSemaphore	U	U	
Conclude	Y	Y	
Cancel	Y	Y	
GetDataExchangeAttributes	N	N	
ExchangeData	N	N	
DefineAccessControlList	N	N	

MMS Service Supported CBB	Client	Server	Comments
GetAccessControlListAttributes	N	N	
ReportAccessControlledObjects	N	N	
DeleteAccessControlList	N	N	
AlterAccessControl	N	N	
ReconfigureProgramInvocation	N	N	

MMS Parameter CBB

MMS Parameter CBB	Client	Server	Comments
STR1	Y	Y	
STR2	Y	Y	
NEST	10	10	Maximum
VNAM	Y	Y	
VADR	Y	Y	
VALT	Y	Y	
bit 5	N	N	Deprecated in ISO9506 2002
TPY	Y	Y	
VLIS	Y	Y	
bit 8	U	U	
bit 9	U	U	
CEI	U	U	
ACO	N	N	
SEM	N	N	
CSR	N	N	
CSNC	N	N	
CSPLC	N	N	
CSPI	N	N	

GetNameList Conformance Statement

GetNameList	Client	Server	Comments
Request			
ObjectClass	Y	Y	
ObjectScope	Y	Y	
DomainName	Y	Y	
ContinueAfter	Y	Y	
Response+			
List Of Identifier	Y	Y	
MoreFollows	Y	Y	
Response-			
Error Type	Y	Y	

AlternateAccessSelection Conformance Statement

AlternateAccessSelection	Client	Server	Comments
AccessSelection	Y	Y	
Component	Y	Y	
Index	U	U	
IndexRange	U	U	
AllElements	U	U	
AlternateAccess	Y	Y	
SelectAccess	Y	Y	
Component	Y	Y	
Index	U	U	
IndexRange	U	U	
AllElements	U	U	
VariableAccessSpecification Conformance statementVariableAccessSpecification	**Client**	**Server**	**Comments**
ListOfVariable	Y	Y	
VariableSpecification	Y	Y	
AlternateAccess	Y	Y	
VariableListName	Y	Y	

VariableSpecification Conformance statement

VariableSpecification	Client	Server	Comments
Name	Y	Y	
Address	Y	U	
VariableDescription	Y	U	
ScatteredAccessDescription	N	N	Deprecated in ISO9506 2002
Invalidated	N	N	

Read conformance statement

Read	Client	Server	Comments
Request			
SpecificationWithResult	Y	Y	
VariableAccessSpecification	Y	Y	
Response			
VariableAccessSpecification	Y	Y	
ListOfAccessResult	Y	Y	

Write conformance statement

Write	Client	Server	Comments
Request			
VariableAccessSpecification	Y	Y	
ListOfData	Y	Y	
Response			
Failure	Y	Y	
Success	Y	Y	

InformationReport conformance statement

InformationReport	Client	Server	Comments
Request			
VariableAccessSpecification	Y	Y	
ListOfAccessResult	Y	Y	

GetVariableAccessAttributes conformance statement

GetVariableAccessAttributes	Client	Server	Comments
Request			
Name	Y	Y	
Address	U	U	
Response			
MMSDeletable	Y	Y	
Address	U	U	
TypeSpecification	Y	Y	

DefineNamedVariableList conformance statement

DefineNamedVariableList	Client	Server	Comments
Request			
VariableListName	Y	Y	
ListOfVariable	Y	Y	
variableSpecification	Y	Y	
AlternateAccess	U	Y	
Response	Y	Y	

GetNamedVariableListAttributes conformance statement

GetNamedVariableListAttributes	Client	Server	Comments
Request			
ObjectName	Y	Y	
Response			
MMSDeletable	Y	Y	
ListOfVariable	Y	Y	
variableSpecification	Y	Y	
alternateAccess	Y	U	

DeleteNamedVariableList conformance statement

DeleteNamedVariableList	F/S	F/S	Value/Range
Request			
Scope	Y	Y	
listOfVariableListName	Y	Y	
DomainName	Y	Y	
Response			
NumberMatched	Y	Y	
NumberDeleted	Y	Y	
DeleteNamedVariableList-Error	Y	Y	

Read Journal conformance statement

ReadJournal	Client	Server	Comments
Request			
InvokeID	Y	Y	
JournalName	Y	Y	
RangeStartSpecification	Y	Y	
StartingTime	Y	Y	
EntrytoStartAfter	Y	Y	
RangeStopSpecification	Y	Y	
EndingTime	Y	Y	
NumberOfEntries	Y	Y	
EntryToStartAfter	Y	Y	
TimeSpecification	Y	Y	
EntrySpecification	Y	Y	
Response			
InvokeID	Y	Y	
ListOfJournalEntry	Y	Y	
EntryIdentifier	Y	Y	
OriginatingApplication	Y	Y	
EntryContent	Y	Y	
MoreFollows	Y	Y	

JournalEntry conformance statement

Ref	Parameter	Client	Server	Comments
1	OccurenceTime	Y	Y	
2	AdditionalDetail	U	U	
3	EntryForm	Y	Y	
4	Data	Y	Y	
5	Event	Y	Y	
6	CurrentState	Y	Y	
7	ListOfVariable	Y	Y	
8	VariableTag	Y	Y	
9	ValueSpecification	Y	Y	
10	Annotation	Y	Y	

Initialize Journal conformance statement

InitializeJournal	Client	Server	Comments
Request			
JournalName	Y	Y	
LimitSpecification	Y	Y	
LimitingTime	Y	Y	
LimitingEntry	Y	Y	
Response+			
EntriesDeleted	Y	Y	

File Directory conformance statement

FileDirectory	Client	Server	Comments
Request			
Filespecification	Y	Y	
ContinueAfter	Y	Y	
Response+			
ListOfDirectoryEntry	Y	Y	
MoreFollows	Y	Y	

File Open conformance statement

FileOpen	Client	Server	Comments
Request			
Filename	Y	Y	
InitialPosition	Y	Y	
Response+			
FrsmID	Y	Y	
FileAttributes	Y	Y	

File Read conformance statement

FileRead	Client	Server	Comments
Request			
FrsmID	Y	Y	
Response+			
FileData	Y	Y	
MoreFollows	Y	Y	

File Close conformance statement

FileClose	Client	Server	Comments
Request			
FrsmID	Y	Y	
Response+	Y	Y	

SCL conformance degrees

degree	SCL Conformance	Client	Server	Comments
SCL.1	SCL File for Implementation Available (offline)	E	E	Implementer must create or provide the SCL file.
SCL.2	SCL File available from implementation online	E	E	
SCL.3	SCL implementation reconfiguration supported online	E	E	

Supported ACSI services for SCL.2 and SCL.3

SCL Conformance	Client	Server	Comments
ACSI Services			
GetFileAttributeValues	Y	Y	
GetFile	Y	Y	
SetFile	Y	Y	
DeleteFile	Y	Y	
GetDataValues	Y	Y	
SetDataValues	Y	Y	
SCL Control Block	Y	Y	
SCL File Structure	Y	Y	
Remote Creation of SCL File	E	E	

Additional MMS services for SCL.2 and SCL.3

SCL Conformance	Client	Server	Comments
MMS Services			
GetCapabilityList	Y	Y	
GetDomainAttributes	Y	Y	
LoadDomainContent	Y	Y	
StoreDomainContent	Y	Y	

Definition of SCL control block

IEC 61850-8-1 Component Name	Client	Server	Comments
validate	E	E	
valState	E	E	
activate	E	E	

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