Multicast Dissemination Protocol (MDP) Developer's Guide

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1.0 Introduction

This document serves as a guide for developing reliable multicast applications using the MDP Software Development Kit (SDK). The SDK consists of object libraries and header files which allow developer's to create applications using the MDP reliable multicast protocol.

2.0 MDP Application Programming Interface (API) Overview

MDP is a transport protocol which allows data to be reliably transmitted from a source (server) to a set of receivers. Normally, as its name implies, MDP is intended to use network multicast transport, but it should be noted that the destination of data transmitted by an MDP server can also be a *unicast* (point-to-point) network address. In some cases, MDP's rate-controlled, selective negative acknowledgment protocol design or other special features may offer benefits for unicast transport of data. However, it is MDP's utilization of multicast service which allows the creation of very efficient one-to-many or many-to-many reliable data communication applications and this is how it is anticipated that MDP will usually be utilized. For more general information on multicast, please refer to [1].

To best understand how the MDP API is intended to be used, it is important to first establish some terminology which reflects the design of the MDP protocol engine and the corresponding API procedures. At the highest level, a call to the `MdpInit()` function returns a handle to an instance of the MDP API. Using this *MdpInstanceHandle*, the developer can then make other API calls to further init the API to operate within the context of the developer's application and go on to create and control instances of MDP reliable multicast transport sessions.

MDP is intended to be used as a *transport* protocol and so the semantics of the API design are centered around the notion of the transport of data from a server (source) node to one or more client (receiver) nodes. Note that a single node may act as both server and client, and that multiple servers may co-exist in the same MDP communications space allowing for the creation of many-to-many communication applications. The "communications space" in which the MDP protocol operates is defined by an IP network address (usually a Class D multicast address) and a system User Datagram Protocol (UDP) port number. It is assumed that the MDP developer has an *a priori* understanding of basic network communications programming, and for further description of the principles involved there, please refer to [2]. This "communications space" which defines a single instantiation of the MDP transport protocol is referred to in the MDP API as an *MdpSession*. Note the MDP API permits the existence of multiple *MdpSession* instances so that applications requiring data exchange on multiple, different multicast addresses or the creation of unicast/multicast or multicast/multicast gateway applications may be created.

Within the context of a single *MdpSession*, multiple participants, referred to as *MdpNode*s, exchange data using the reliability mechanisms of the underlying MDP protocol. Some (or all) *MdpNode*s within an *MdpSession*, may act as servers (sources) while others may act as clients (receivers). Data is transmitted from a server to the set of clients as a serialized stream of *MdpObject*s. Each *MdpObject* consists of a file or static block of memory-resident data which the server application has queued for transmission. Each *MdpObject* may also

optionally have a small amount of "out-of-band" *MdpInfo* associated with it to aid application operation. Potential uses of the *MdpInfo* attachment will be discussed in more detail later in this document.

The use of the API can be summarized with the following steps:

1) Initialize the MDP library and install appropriate callback functions for protocol engine timing, packet input/output, and protocol event notification. *(Note: The MDP library is designed to use whatever timing facilities and receive packet notification methodology the application designer specifies.)*

2) Create on or more MDP sessions with appropriate multicast (or unicast) destination addresses and port numbers.

3) Set any parameters for the newly created sessions which need to differ from default values and need to be set prior to session startup.

4) "Open" the session as an *MdpClient* and/or *MdpServer*. (After opening a session as a server, objects may be queued for transmission at any time)

5) Enter the application's primary event loop dispatching appropriate events to the `MdpDoTimers()` and `MdpReadSockets()` API calls (These are explained in detail later).

6) Handle notifications received from the MDP protocol engine with regards to newly received objects or to queue additional objects for transmission. API calls are available to retrieve information concerning *MdpObjects* received or queued for transmission.

3.0 MDP API Initialization

The MDP library must be properly initialized before any of the other API functions can be used. Also, as part of initialization, appropriate callback functions must be installed to facilitate the operation of the MDP protocol engine. These callbacks include application-defined functions for system timer usage and receive packet notification.

3.1 Use of `MdpInit()`

The first step is to place a call to the function `MdpInit()` to create and partially initialize and instance of the MDP API. This function has two optional parameters to allow the application to set a local ASCII *MdpNode* name identifier and a 32-bit identification number (*MdpNodeId*) for the local station. The *MdpNodeId* should be unique among all nodes in an *MdpSession*. The default (NULL) values provided for these parameters will cause the MdpInit() function to attempt to learn the local default IP address to use as the *MdpNodeId* and resolve that address and determine the login name to establish a default local name in the form of "*user@hostname*".

Function MdpInit()

SYNOPSIS

```
#include <mdpApi.h>

MdpInstanceHandle MdpInit(const char*   localName =
                                             (const char*)NULL,
                          MdpNodeId     localId = MDP_NULL_NODE,
                          MdpError*     error = NULL);
```

DESCRIPTION

The MdpInit() function creates and partially initializes an instance of the MDP API. This function should be only called once and must be called before any other MDP API functions are used. The `localName` parameter should be a pointer to a NULL-terminated string with a maximum length of `MDP_NODE_NAME_MAX` characters. Using the `MdpInit()` function in its default form (no arguments) will automatically pick a default *MdpNodeId* (using the local host's default IP address) and *MdpNode* name. The MDP library does this by making a call to `getlogin()` (or `cuserid()` in some cases) and `gethostname()` to retrieve the user's name and the machines name. The machine's name is resolved to an IP address with a call to `gethostbyname()` and the 32-bit IP address (converted to host byte order) is used as the local *MdpNodeId*. This technique *usually* produces a suitable default *MdpNodeId* assignment method resulting in unique node identification. Note that in the case of the tkMdp/winMdp/mdp example applications, the use of a *a priori* client positive acknowledgment list depends upon the names/addresses in the list resolving to the address picked by the client as its MdpNodeId. The *`localId`* parameter can be used to override this default method of *MdpNodeId* assignment. The optional `error` parameter allows the application to receive and error code if the call to MdpInit() is unsuccessful.

RETURN VALUES

`MdpInit()` will return a handle to the instance of the MDP API created of type *MdpInstanceHandle*. The appliation-provided `error` parameter will contain a value of MDP_ERROR_NONE if successful. A return value of MDP_NULL_INSTANCE and other error codes (TBD) are passed in the `error` parameter upon failure.

Function MdpGetLocalNodeId()

SYNOPSIS

```
#include <mdpApi.h>

MdpNodeId MdpGetLocalNodeId(MdpInstanceHandle instance);
```

DESCRIPTION

The `MdpGetLocalNodeId()` function retrieves the local *MdpNodeId* for the MDP instantiation designated by the `instance` parameter.

RETURN VALUES

`MdpGetLocalNodeId()` will return the local MdpNodeId upon success. A value of MDP_NULL_NODE is returned if the `instance` parameter is NULL (invalid).

Function MdpSetLocalNodeId()

SYNOPSIS

```
#include <mdpApi.h>

MdpError MdpSetLocalNodeId(MdpInstanceHandle instance,
                           MdpNodeId         nodeId);
```

DESCRIPTION

The `MdpSetLocalNodeId()` function sets the local *MdpNodeId* for the MDP instantiation designated by the `instance` parameter. The `nodeId` parameter indicates the value to be used as the local hosts node identifier. A value of MDP_NULL_NODE is may not be used as a node identifier.

RETURN VALUES

`MdpGetLocalNodeId()` will returns a value of MDP_ERROR_NONE upon success. A value of MDP_ERROR_INSTANCE_INVALID or MDP_ERROR_NODE_INVALID may be returned upon error.

3.2 Protocol Engine Callback Functions

After a successful call to `MdpInit()`, the next step the application should take is installing appropriate callback functions for the returned *MdpInstanceHandle* to provide timing and receive data event notification for the MDP protocol engine to function and to allow the MDP protocol to alert the application of important events (e.g. received object completion, etc). Different callback functions can be installed for different MDP API instances. The use of callback functions for these core aspects of the current MDP SDK allows MDP to be very portable to different operating systems and environments. Wherever possible, the MDP library attempts to allow the application to control memory allocation and interface with the operating system. (It is possible this will be further expanded in the future). While this "open-ended" approach may seem complex, it allows for flexibility as the MDP API is further refined. At some point in the future, it is possible that a higher level (less complex) API may be created (and optimized) for specific operating systems and environments.

There are three primary callbacks which need to be installed. One is for the maintenance of a

single operating system timer which the MDP protocol engine will use for protocol timing purposes. Although the MDP protocol implements multiple timeout events for operation, it manages these timeouts with a single (application-provided) system timer. The second callback function is used by MDP to notify the application of network socket file descriptor(s) MDP has opened (or closed) so that the application can install (or remove) appropriate "data-ready-to-be-read" monitors (e.g. for use with a select() system call or other asynchronous I/O notification mechanism). The third callback is a function pointer to an MdpNotifyFunc which is a user-defined function which MDP will call to notify the application of significant protocol events or errors.

Function MdpSetTimerInstallerCallback()

SYNOPSIS

```
#include <mdpApi.h>

void MdpSetTimerInstallCallback(
          MdpInstanceHandle         instance,
          TimerInstallCallback*     timerInstaller,
          void*                     userData);
```

DESCRIPTION

This function is used to install an application-provided *TimerInstallCallback* function for the MDP protocol engine to use. The *TimerInstallCallback* is used by MDP to request the application to install, modify, or remove the system timer which MDPv2 uses for protocol timing.

The `instance` parameter must be a value obtained by the application from a previous call to MdpInit().

The `timerInstaller` parameter is a pointer to the *TimerInstallCallback* the application wishes MDP to use.

The value passed by the `userData` parameter is stored by MDP and MDP will later pass a pointer to this stored value to the provided *TimerInstallCallback* for the application to use. This `userData` might be useful for an application to retrieve state associated with a specific timer which has been installed or for some other application-defined use. The usage is described below in more detail in the detailed description of the *TimerInstallCallback* function the application must provide.

RETURN VALUE

The `MdpSetTimerInstallerCallback()` function returns no value.

TimerInstallCallback Description

The prototype for this application-provided callback function is given by:

```
typedef bool (TimerInstallCallback)(
```

```
ProtocolTimerInstallCmd  cmd,
void**                   timerId,
double                   delay,
void*                    timerData,
void**                   userData);
```

The cmd parameter instructs the callback function on what action is to be taken. Possible values for the cmd parameter include PROTOCOL_TIMER_INSTALL, PROTOCOL_TIMER_MODIFY, and PROTOCOL_TIMER_REMOVE. These values correspond to whether the system timer used by MDPv2 is to be newly installed, it's timeout interval to be changed, or if the timer is to be removed (cancelled). *(Note: MDPv2 assumes the application-installed system timer is a "one-shot" timer which needs re-installation after it fires.)*

The timerId parameter is currently provided for convenience. One purpose is that the application may use it to store the value of a system-specific identifier for the timer which it has installed for MDP. On subsequent calls to *modify* or *remove* the timer, MDP will provide this parameter with the value previously set by the application.

IMPORTANT NOTE: It is recommended that new applications built with the MDP API do not use the timerId parameter. The userData parameter (described below) can be used for whatever purpose the timerId parameter might be used and future versions of the API will likely eliminate this parameter in this callback function.

The delay parameter is used by MDP to inform the application of the timeout interval value the application-installed system timer should use. The value is given in time units of seconds. This parameter is not applicable for the case of cmd = PROTOCOL_TIMER_REMOVE. Note that the value of delay can possibly equal zero.

The timerData parameter is a value used internally by the MDP protocol engine. This value is passed to the *TimerInstallCallback* because when the application-installed system timer fires, the application must call the MdpDoTimers() API function passing this timerData value as the parameter of the MdpDoTimers() function. In future versions of the API, it may be possible for multiple instances the MDP API to co-exist (primarily for simulation environments) so it is important to properly associate the timerData value provided in calls to the *TimerInstallCallback* function with the resultant system timer installed. The MdpDoTimers() function is used to dispatch MDP protocol timeout events to the underlying protocol engine.

The userData parameter of the *TimerInstallCallback* supplies a pointer to the value stored when the MdpSetTimerInstallCallback() function was called. Note that since a pointer to this value is provided, the application may currently change this value. An example use of userData is for the application to store a pointer to state that it needs to properly install and maintain system timer resources.

IMPORTANT NOTE: It is recommended that new applications built with the MDP API are

structured so as to not change the value of the `userData` *originally provided by the application. For code safety reasons, it is highly likely that future versions of this callback will provide the* `userData` *value directly and the application will be unable to change it other than through a call to* `MdpSetTimerInstallCallback()`. *(Moral of the story: Providing pointers to the guts of the protocol engine was a bad idea.)*

The *TimerInstallCallback* should return a value of *true* on success and a value of *false* on failure.

Function MdpDoTimers()

SYNOPSIS

```
#include <mdpApi.h>

double MdpDoTimers(void* timerData);
```

DESCRIPTION

The `MdpDoTimers()` function is used by the application to dispatch timeout events to the MDP protocol engine. The timerData value passed to the `MdpDoTimers()` function should equal the value passed to the application when the corresponding timer was "installed" or "modified". A call to `MdpDoTimers()` causes the MDP protocol engine to take whatever action is appropriate as a result of timeout events. These actions include sending data, installing other timeouts, and notifying the application (via the *MdpNotifyCallback*) of important protocol events or errors. Note that the MDP protocol engine assumes that the system timer which has fired (resulting in the current timeout event) was a one shot timer and MDP will install a new system timer as needed. If the application environment is not using one-shot timers, the application should take measures to remove or cancel the timer prior to placing the call to `MdpDoTimers()`.

RETURN VALUES

The `MdpDoTimers()` call returns a floating point value equal to the time interval until the next MDP system timer timeout event. A value of -1.0 is returned if no timeout event is pending after the call to `MdpDoTimers()`.

Function MdpSetSocketInstallerCallback()

SYNOPSIS

```
#include <mdpApi.h>

void MdpSetSocketInstallCallback(
          MdpInstanceHandle        instance,
          SocketInstallCallback*   socketInstaller,
          void*                    userData);
```

DESCRIPTION

This function installs a *SocketInstallCallback* which is used by MDP to request the host application to asynchronously "monitor" a socket file descriptor for received data to be read. This allows an application to use whatever socket/file descriptor monitoring/notification methodology that is appropriate for the given application's implementation architecture. The application-provided *SocketInstallCallback* is called whenever MDP "opens" or "closes" a UDP socket.

The `instance` parameter must be a value obtained by the application from a previous call to MdpInit(). The `socketInstaller` parameter is a pointer to the application-provided *SocketInstallCallback* function. The `userData` parameter allows the application to store an application-specific data value (e.g. pointer) which is passed back to the application when the *SocketInstallCallback* is called by MDP.

RETURN VALUE

The `MdpSetSocketInstallCallback()` function returns no value.

IMPORTANT NOTE: As of version 1.7a7 of the MDP code, the SocketInstallCallback is now required for Win32 operation. Win32 has a few differenent mechanisms which could be leveraged including a Berkeley Sockets-like "select()" call, Window messages (e.g. using the WSAAsyncSelect()" call - this is typical of many Win32 applications), or Events (e.g. where "WaitForMultipleEvents()" is used similar to a "select()" call). This API leaves all of these options open to the programmer. In the future, it is hoped we will be able to provide more tutorial information on use of the MDP API on different operating systems for different applications. For now, refer to the example application code we provide.

SocketInstallCallback Description

The *SocketInstallCallback* is defined by the following function prototype:

```
typedef bool (SocketInstallCallback)(
                    SocketInstallCmd    cmd,
                    int                 fd,
                    void*               socketData,
                    void**              userData);
```

The cmd parameter is used by MDP to indicate what action the application-provided *SocketInstallCallback* should take. Possible cmd parameter values include `SOCKET_INSTALL` and `SOCKET_REMOVE`. The *SocketInstallCallback* is called with cmd equal to `SOCKET_INSTALL` after MDP has opened a socket for which it would like notification for reading received data. The callback function will be called and the cmd parameter will have value of `SOCKET_REMOVE` when the corresponding socket has been closed. The purpose is that the application begin monitoring the socket for possible received data when the `SOCKET_INSTALL` "command" is issued. The host application must call the MDP API MdpReadSocket() function when data is available for reading on a given socket file descriptor. This will cause the MDP protocol engine to read and process the received data,

taking whatever action is necessary.

The fd parameter passes the integer file descriptor value for the network socket for which MDP is requesting monitoring to the *SocketInstallCallback*. Example uses of the file descriptor include adding the file descriptor to a file descriptor set (FD_SET) for use with the select() call. Other application synchronous input/output (I/O) notification mechanisms can make similar use of socket file descriptors.

The value passed in the socketData parameter is for internal use by the MDP protocol engine. When the application's synchronous I/O notification mechanism detects that there is received data ready to be read on one of the MDP-installed socket file descriptors, it should call the MdpReadSocket() API function passing the corresponding value of the socketData. Note that each socket opened by MDP will use its own unique value of socketData so it is important that an application opening multiple *MdpSessions* (which will in turn open multiple sockets) maintain the relationship between a given socket file descriptor and the corresponding MDP-provided socketData value.

The userData parameter passes the a pointer to the stored value the application specified as user data in its initialization call to MdpSetSocketInstallCallback(). Note that since a pointer to this value is provided, the application may currently change this value. An example use of userData is for the application to store a pointer to state that it needs in order to properly install and maintain system timer resources.

IMPORTANT NOTE: It is recommended that new applications built with the MDP API are structured so as to not change the value of the userData *originally provided by the application. For code safety reasons, it is highly likely that future versions of this callback will provide the* userData *value directly and the application will be unable to change it other than through a call to* MdpSetSocketInstallCallback(). *(Moral of the story: Providing pointers to the guts of the protocol engine was a bad idea.)*

The application-provided SocketInstallCallback should return a value of *true* upon success and a value of *false* upon failure.

Function MdpReadSocket()

SYNOPSIS

```
#include <mdpApi.h>

void MdpReadSocket(void* socketData);
```

DESCRIPTION

The MdpReadSocket() function is used by the application to notify MDP of received data ready to be read on a socket which MDP has previously opened and, through a call to the application's *SocketInstallCallback*, installed for input notification. The socketData value passed to the MdpReadSocket() function must equal the value passed to the application

when the corresponding socket was "installed". A call to `MdpReadSocket()` causes the MDP protocol engine to read the received message from the socket and process it, taking whatever action is appropriate. These actions include sending data in response, installing timeouts, and notifying the application (via the *MdpNotifyCallback*) of important protocol events or errors.

RETURN VALUES

The `MdpReadSocket()` returns no value.

Function MdpSetNotifyCallback()

SYNOPSIS

```
#include <mdpApi.h>

void MdpSetNotifyCallback(
          MdpNotifyCallback*  notifyFunc,
          void*               userData);
```

DESCRIPTION

This function allows the application to install a *MdpNotifyCallback* function which will be called when the MDP protocol engine needs to inform the application of important protocol events or errors. The *MdpNotifyCallback* (described in detail elsewhere) is used by MDPv2 to "notify" the host application of protocol events such as updated *MdpSession* or *MdpObject* (transmit or receive) status. This allows the host application to update user interface displays as needed, kick off post-processing of received data, be prompted for additional data to transmit, and be notified of errors.

The `notifyFunc` parameter is a function pointer to an application-provided *MdpNotifyCallback* function.

The `userData` parameter is an application—provided value which is stored by MDP and later passed back to the application when the *MdpNotifyCallback* function is called. This parameter allows the user to retrieve information necessary to perform whatever actions the application requires upon notification of significant MDP protocol events.

RETURN VALUES

`MdpSetNotifyCallback()` returns no values.

MdpNotifyCallback Description

The MDP protocol engine calls the application-provided *MdpNotifyCallback* function when different important protocol events or errors occur. This allows the user to take different actions such as to allow the application to process a received file or data object, enqueue additional file or data objects for transmission, receive notification of transmit or receive progress, get updated status on other nodes within the MDP multicast session, etc. The

MdpNotifyCallback function is described with the following prototype:

```
typedef bool (MdpNotifyCallback)(
                    MdpNotifyCode       notifyCode,
                    MdpSessionHandle    sessionHandle,
                    MdpNodeId           nodeId,
                    MdpObjectHandle     objectHandle,
                    MdpError            errorCode,
                    void*               userData);
```

The notifyCode parameter indicates the nature of the MDP protocol event which has occurred. There are a number of possible events which cause the *MdpNotifyCallback* to be invoked. Possible values of the notifyCode include:

```
MDP_NOTIFY_ERROR,
MDP_NOTIFY_TX_OBJECT_START,
MDP_NOTIFY_TX_OBJECT_FIRST_PASS,
MDP_NOTIFY_TX_OBJECT_ACK_COMPLETE,
MDP_NOTIFY_TX_OBJECT_FINISHED,
MDP_NOTIFY_TX_QUEUE_EMPTY,
MDP_NOTIFY_SERVER_CLOSED,
MDP_NOTIFY_RX_OBJECT_START,
MDP_NOTIFY_RX_OBJECT_UPDATE,
MDP_NOTIFY_RX_OBJECT_COMPLETE,
MDP_NOTIFY_REMOTE_SERVER_INACTIVE,
MDP_NOTIFY_OBJECT_DELETE.
```

Each of these possible *MdpNotifyCallback* events will be described in detail below. The sessionHandle parameter identifies the *MdpSession* for which the event is applicable. This is significant for applications which may manage multiple *MdpSessions*. This sessionHandle parameter can be used in other MDP API calls to manipulate the state of the corresponding *MdpSession*.

The nodeId parameter identifies the *MdpNodeId* to which the notification is applicable. If the notification is with regards to an *MdpObject* being received, the nodeId identifies the source of the *MdpObject*. When the *MdpObject* is an object being transmitted, the value of nodeId will be MDP_NULL_NODE. Also, the nodeId will be a value of MDP_NULL_NODE for notifications not directly related to remote *MdpServer* status changes or *MdpObject* reception.

The objectHandle parameter indicates the transmit or receive file or data *MdpObject* for which the notification event is applicable. It is important to note that the value of the objectHandle parameter provided here is only valid during execution of the *MdpNotifyCallback* and the value should not be saved for future reference outside the specific instance of the current *MdpNotifyCallback* function call. *MdpObjectHandles* apply only to the identification of data or file objects during the course of their transport by the MDP protocol. However, note that *MdpObjectHandle* values returned with a call to `MdpSessionQueueTxFile()` or `MdpSessionQueueTxData()` are valid until the receipt of a `MDP_NOTIFY_TX_OBJECT_FINISHED` notification event (or a fatal error

event) for that *MdpObject*. Specific examples of the use of the objectHandle parameter will be provided in the description of the individual *MdpNotifyCallback* event types.

The errorCode parameter is used to provide an indication of the error type when the notifyCode value is equal to `MDP_NOTIFY_ERROR`. As in other events the sessionHandle and objectHandle parameters will provide additional information as appropriate to the errorCode type. Possible values for the errorCode currently include:

`MDP_ERROR_FILE_OPEN`
: This indicates that the MDP protocol engine was unable to open a file for transmission (or possibly reception).

`MDP_ERROR_FILE_EMPTY`
: This indicates that a file enqueued for transmission had zero contents.

`MDP_ERROR_FILE_LOCKED`
: This indicates that file could not be opened because it was locked.

`MDP_ERROR`
: This generic error condition occurs when an MdpDataObject enqueued for transmission has a NULL data pointer value.

`MDP_ERROR_MEMORY`
: This indicates MDP was unable to allocate memory for maintaining state on a transmit or receive object.

The `userData` parameter contains the value the application specified when installing the *MdpNotifyCallback* with the `MdpSetNotifyCallback()` function. This `userData` value is for the application's private use. For example, a pointer value might be stored so the application can retrieve context information when the *MdpNotifyCallback* is called.

MdpNotifyCallback Guidelines *(Rules of Implementation)*

IMPORTANT NOTE: The user's MDPv2 application should not spend much time in the MdpNotifyCallback *function since it blocks the thread of execution of the MDPv2 protocol. The user of this API should consider burying the MDPv2 protocol engine in a separate thread or process if needed. Also note that the application-installed Notification Callback may be re-entrantly called from the result of other MDP API calls made within the Notification Callback routine.*

A better long term approach will be to embed MDPv2 protocol operation in its own thread and provide an API using an inter-thread (or inter-process) communications model. But meanwhile, to simplify cross-platform portability (and until we think of a better approach) we'll allow developers using MDPv2 for applications (or simulations) to do that however they like. These callback mechanisms can currently be "buried" by developers however they see fit for the platforms for which they are concerned.

(This section is unfinished - RBA)

MdpNotifyCallback Notification Events

This section describes each of the different types of *MdpNotifyCallback* events. Each event is associated with a specific `notifyCode` value.

MDP_NOTIFY_ERROR

This notification event occurs when the MDP protocol engine encounters an error during the process of transmitting or receiving files and/or data. In the current implementation of the MDP API, there are only a few error events which result in this notification event. These primarily include indications when MDP is unable to open a file to read for transmission, an opened transmit file is found to have no content, or an MdpDataObject was enqueued for transmission with an invalid (NULL) pointer. Additionally, an errorCode equal to MDP_ERROR_MEMORY might be indicated when MDP is unable to allocate sufficient memory to maintain state on new transmit or receive objects. Currently, the application needs to take no action upon receipt of these notifications other than if the application wishes to provide logging of these events. In the future, the API error notification procedure may be further refined and additional error conditions added.

MDP_NOTIFY_TX_OBJECT_START

This notification event occurs when a file or data object which has previously been enqueued for transmission by the application (See the descriptions of `MdpSessionQueueTxFile()` or `MdpSessionQueueTxData()`) begins to be transmitted by the MDP protocol engine. Since the application is allowed to enqueue multiple objects for transmission and MDP's transmission rate is governed, this provides an indication to the application when an object's actual transport begins. The `sessionHandle` and `objectHandle` parameters identify the *MdpSession* and *MdpObject* for which the notification is relevant. Note that the `sessionHandle` and `objectHandle` values will be the same as those returned in the application's previous respective calls to `MdpNewSession()` and `MdpSessionQueueTxFile() or MdpSessionQueueTxData()`.

MDP_NOTIFY_TX_OBJECT_FIRST_PASS

This notification event occurs after MDP has completed a "first pass" transmission of an entire MdpObject. This does not occur until all data (including an "auto parity" has been transmitted. This is intended primarily for use in applications where only silent clients (all clients are silent ("EMCON") with no repair requests) are present. Since no clients will be requesting repair transmissions, it is not necessary for the MdpServer to maintain state for the transmitted MdpObject. Thus any resources used by that MdpObject can be freed after this notification occurs. Note that additional strategies can be implemented around this notification (e.g. the application may maintain a timeout to limit the amount of time that repairs are available for a transmitted object) or this notification may be useful in updating graphical user interfaces in applicable applications.

MDP_NOTIFY_TX_OBJECT_ACK_COMPLETE

The *MdpNotifyCallback* is called with this notification code when the server has completed the positive acknowledgement process for a given object. If no clients are providing positive

acknowledgement, this notification will occur immediately after the initial transmission of the indicated object. Otherwise, this notification occurs after the server has completed the positive acknowledgement cycle for an enqueued transmit object. This can mean either that the positive acknowledgement cycle fully succeeded, or that it timed out for one, some or all clients providing positive acknowledgement. The MDP API will be expanded in the future to allow the application to determine the positive acknowledgement status of individual clients.

MDP_NOTIFY_TX_OBJECT_FINISHED

This notification event occurs when the MDP server is completely finished with an object the application has previously enqueued for transmission. At this time, the client may wish to free resources associated with that object (e.g. close and/or delete an associated file or free associated memory). The "transmit cache depth" with which MDP has been configured determines how long MDP will keep state on transmit objects before `MDP_NOTIFIY_TX_OBJECT_FINISHED` events occur. If a limited number of objects are enqueued for transmission, the MDP protocol engine will indefinitely keep state for the last objects queued within the constraints of the "transmit cache depth". Note the application may prematurely de-queue (or abort) transmit objects with a call to the `MdpSessionRemoveTxObject()` API function. However, note that it is not safe to call this function from within the *MdpNotifyCallback*. Transmit objects may be safely removed at any other time. When the `MDP_NOTIFIY_TX_OBJECT_FINISHED` notification event occurs, the indicated object will be automatically de-queued and the application should not attempt to refer to that object after this notification event has occurred. Note that the `MDP_NOTIFY_OBJECT_DELETE` notification will also occur after this `MDP_NOTIFY_TX_OBJECT_FINISHED` notification.

MDP_NOTIFY_TX_QUEUE_EMPTY

This notification event occurs once each time the MDP protocol engine determines it has no more objects pending transmission. The application can use this opportunity to enqueue additional objects for transmission. Otherwise, the application will need to provide its own mechanism for adding additional objects to the *MdpSession* transmit queue as needed. This notification is useful to allow the MDP protocol engine, which is transmitting data at a controlled rate, to control the flow of queuing objects for transmission.

MDP_NOTIFY_SERVER_CLOSED

This notification event occurs when local server operation has fully terminated after the application has initiated a "soft" close of MdpServer operation. The expected procedure is that the application will initate server shutdown with the MdpSessionCloseServer() API function (with appropriate arguments). After this notification, is received, the application can free up state the MDP library has kept for the corresponding MdpSession with confidence that the protocol has robustly notified receivers of its intention to terminate server operation.

MDP_NOTIFY_RX_OBJECT_START

This notification event occurs when a new object is received at an MDP client node. This is useful for updating user interface displays or for the application to log information on receive status.

Additionally, in the case of *MdpDataObjects*, it is at this time that the application needs to provide memory space for the MDP protocol engine to store the received data. The amount

of memory required to store the new receive object can be obtained with a call to the `MdpObjectGetSize()` API function. If the application does not provide the memory space for the object (with a call to `MdpObjectSetData()`), the object will not be received.

MDP_NOTIFY_RX_OBJECT_INFO

This notification event occurs when the MDP_INFO message associated with the indicated *MdpObject* is received. As described elsewhere, the MDP_INFO message can be used to provide a small amount (less than or equal to the MDP server *segment_size* for the *MdpSession*) timely context information for each object transmitted by an MDP server. Note that the use of the MDP_INFO feature is optional so different applications may or may not choose to utilize this protocol feature. The MDP_INFO received can be retrieved with a call to the `MdpObjectGetInfo()` API function.

MDP_NOTIFY_RX_OBJECT_UPDATE

This notification event occurs whenever new data content is received for an *MdpObject*. This allows the application to monitor the receive progress of individual objects. The `MdpObjectGetRecvBytes()` API function can be used by the application to get an indication of what portion of the object has been received up to that point in time.

MDP_NOTIFY_RX_OBJECT_COMPLETE

This notification event occurs when a object transmitted from a remote MDP server has been completely received at the local node. This includes the optional MDP_INFO, if it is available for the indicated object. At this point in t time, the application may wish to process the received object since it has been received in its entirety and/or potentially free resources the application has allocated for that object. Note that the `MDP_NOTIFY_OBJECT_DELETE` notification will also occur after this `MDP_NOTIFY_RX_OBJECT_COMPLETE` notification.

MDP_NOTIFY_REMOTE_SERVER_INACTIVE

This notification event occurs when an individual remote server MdpNode has been timed out and determined to be inactive (I.e. no messages at all have been received from that server in some sufficiently long period of time). The value of this inactivity timeout is (2.0*ROBUST_FACTOR*GRTT) seconds. The default ROBUST_FACTOR is 20 (the API contains a call to override this default) and the GRTT is the current estimate of group round trip time advertised by the server in question. The application may use this notification as a cue to make API calls which release resources (memory) used to maintain buffering and state for the indicated MdpServer node. The applicable API calls include MdpSessionDeactivateNode() which only frees buffering resources (the most significant quantity of memory resources for servers) and MdpSessionDeleteNode() which frees all resources and state associated with a remote server MdpNode. *Note that in the current MDP implementation (version 1.7a9), the state for a remote MdpServer is dropped when it goes inactive AND there are no pending receive objects requiring repair (This responsibility will be placed in the application's domain in a future release).*

MDP_NOTIFY_OBJECT_DELETE

This notification event occurs when the MDP protocol engine is "deleting" state for objects which have either fully completed the reception or transmission process or have failed. This notification allows the application to reclaim or free any resources (e.g. memory) which have been allocated for the indicated object. Note that if the indicated object has not been

previously been associated with an MDP_TX_OBJECT_FINISHED or MDP_RX_OBJECT_COMPLETE notification event, it is possible the transmission/reception of the object has failed for some reason. Note that this can occur if the application prematurely de-queues a transmit object or "closes" an *MdpSession* (as client, server, or both) while objects are pending reception or transmission.

4.0 MDP API Variable Types

A number of different variable types and constants are defined for use with the MDP API function calls. The constants should be referred to by name as the actual values may change (usually for good reason) in future versions of the SDK.

4.1 MDP API Variable Type Definitions

The following variable types are defined for use with the MDP API function calls. These types are defined in the "mdpApi.h" header file.

`MdpSessionHandle`

Values of type *MdpSessionHandle* are used to uniquely identify a specific *MdpSession* which has been created. *MdpSessions* are associated with a specific destination IP address and port number. There are a number of protocol parameters associated with an individual *MdpSession* and the API provides functions to set these parameters. The *MdpSessionHandle* is used as an argument to these API functions to identify the *MdpSession* to which the functions are applied. A value of MDP_NULL_SESSION indicates an invalid (nonexistent) *MdpSessionHandle*.

MdpNodeId

Values of type MdpNodeId are used within the MDP API to uniquely identify nodes participating within a given MdpSession. In general, all nodes participating within an MdpSession should use unique MdpNodeId. The default behavior of the MDP protocol engine is to automatically assign the local MdpNodeId based on the host platform's default IP address. A value of MDP_NULL_NODE indicates an invalid (nonexistent) *MdpSessionHandle*.

MdpObjectHandle

Values of type MdpObjectHandle are used to uniquely identify a specific MdpObject which is currently being transported (transmitted or received) by the MDP protocol engine. These values. A value of MDP_NULL_OBJECT indicates an invalid (nonexistent) *MdpSessionHandle*.

MdpObjectTransportId

Values of type MdpObjectTransportId are used to identify the 32-bit number which uniquely identifies an object associated with a server *during* transport (I.e. active transmission). It is very important to note that these numbers are valid only during actual transport with respect to a specific server node. In MDP, an object being actively transported within the context of

an *MdpSession* is uniquely identified among the session participants by concatenating the server's (object source) *MdpNodeId* and the object's *MdpObjectTransportId*. Within the MDP API, the intended use of the MdpObjectTransportId is for function calls which allow an application to establish sessions with alternative emission-controlled (EMCON) clients (silent client nodes) message transmission modes of operation. At the time of this writing, these API calls are not fully defined or documented. More information on this feature will be provided in a future iteration of this document.

MdpObjectType

Values of type MdpObjectType are used to identify the type of object being transported. The type information is generally used by the application at the receiver to provide proper handling of notification events related to a specific object. The application may wish to process files differently than received data or applications may restrict the type of objects they support. (E.g. the example "tkMdp" application is intended for file transfer/broadcast and only supports reception of objects of type MDP_OBJECT_FILE). The types of objects currently supported in MDP are MDP_OBJECT_FILE and MDP_OBJECT_DATA.

The type MDP_OBJECT_FILE is used for transmission of storage device based files where MDP servers can use the large capacity of the storage device as extended buffering for repair retransmissions. The MDP protocol engine currently handles transmit/receive file I/O directly for files. This is primarily because the API is currently designed for the protocol running in an "application space" environment (as opposed to within an operating system's "kernel space") and this allowed for efficient operation. In the future, it is possible that the MDP API may be more generalized and that application's will be responsible for their own file-specific I/O and MDP will provide programming interfaces in a manner more analogous to that of a TCP socket.

The type MDP_OBJECT_DATA is used for "static" memory-resident objects. The API allows MDP applications (via pointers) to indicate blocks of memory for server transmission and client reception. The MDP protocol engine directly reads from and writes to the indicated blocks of memory which allows for selective repair across potentially large blocks of memory. This allows applications to transfer memory resident data with relatively little participation by the application outside of the MDP protocol. However, as with file I/O, it is possible that this API model may change in the future if the MDP protocol engine is embedded within an operating system kernel or in a separate thread or process. These application programming issues for reliable multicast are under continued investigation.

4.2 MDP Defaults and Constants

The following constants are defined for use in the MDP API. In some cases, these constants are default parameter values provided for information purposes.

(1)	MDP_SESSION_NAME_MAX:	Maximum string length for an *MdpSession* name.
(2)	MDP_NODE_NAME_MAX	Maximum string length for an *MdpNode* name.

(3)	MDP_DEFAULT_TTL	Default multicast TTL value.
(4)	MDP_DEFAULT_TX_RATE	Default transmit rate (bits/sec)
(5)	MDP_DEFAULT_SEGMENT_SIZE	Default MDP payload size (bytes)
(6)	MDP_DEFAULT_BLOCK_SIZE	Default data packets per FEC coding block.
(7)	MDP_DEFAULT_NPARITY	Default parity packets per FEC coding block
(80	MDP_DEFAULT_BUFFER_SIZE	Default receiver buffer size (in bytes) per server.
(9)	MDP_DEFAULT_TX_CACHE_COUNT_MIN	Default minimum object count kept in server repair queue.
(10)	MDP_DEFAULT_TX_CACHE_COUNT_MAX	Default maximum object count kept in server repair queue.
(11)	MDP_DEFAULT_TX_CACHE_SIZE_MAX	Default maximum object content (in bytes) kept in server repair queue.

5.0 MdpSession Management Functions

TThe MDP API allows multiple *MdpSession*s to be created and opened to operate as server (sender) and/or client (receiver) participants. The general use of the API calls listed in this section (after the API has been properly initialized and appropriate callback functions installed as previously described) is to create one or more instances of an *MdpSession (referenced by a variable of type* `MdpSessionHandle`*)* and then open the session for protocol operation as a client and/or server node as required by the application.

5.1 MdpSession Creation and Destruction

MdpSession instances must be created before any protocol operation begins. Each MdpSession instance defines a specific destination address (including IP address and host port number) to which the local MdpNode will communicate.

Function MdpNewSession()

SYNOPSIS

```
#include <mdpApi.h>

MdpSessionHandle MdpNewSession(
                     MdpInstance*        instance,
                     const char*         address,
                     unsigned short      port,
                     unsigned char       ttl = MDP_DEFAULT_TTL,
                     MdpError            error = NULL);
```

DESCRIPTION

The `MdpNewSession()` function is used by the application to create a new *MdpSession* instance. Memory is allocated to maintain state for the session and default values are established for *MdpSession* parameters where applicable. A number of parameters for an *MdpSession* can be manipulated with function calls described below. The newly created *MdpSession* will not be active (no packets are sent or processed) until the *MdpSession* is

opened as a server and/or client participant through use of the MdpSessionOpenServer() or MdpSessionOpenClient() functions respectively.

The instance parameter must be value obtained by the application from a previous call to MdpInit(). The address parameter must be a pointer to a string containing a valid dotted-decimal IP address or resolvable host name. The port parameter is a valid system UDP port number to use for the session. The ttl (time-to-live) parameter is the network hop count which will scope (limit) the propagation of IP multicast packets sent. The optional error parameter allows the application to retrieve any error indication which occurs upon failure of this API call.

RETURN VALUES

An *MdpSessionHandle* value is returned for future use with other API calls to control the operation of the corresponding MdpSession. A value of MDP_NULL_SESSION is returned upon error and, if the application provided a pointer for the error parameter, an error indication will be passed here.

Function MdpDeleteSession()

SYNOPSIS

```
#include <mdpApi.h>

void  MdpDeleteSession(MdpInstanceHandle     instance,
                       MdpSessionHandle      sessionHandle)
```

DESCRIPTION

This function is the complement of the MdpNewSession() function. Call this function to delete state for an existing *MdpSession* as identified by the sessionHandle parameter. The session will be closed and state for all pending objects will be deleted as the session shuts down. The instance parameter must be an appropriate value obtained from a previous call to MdpInit() and the sessionHandle must be a value returned from a a previous call to MdpNewSession() for the same given instance.

RETURN VALUES

The MdpDeleteSession() function returns no values..

5.2 MdpSession General Control

While a single *MdpSession* can play a role as a server (source) and/or a client (receiver), there are some parameters of operation which apply to the *MdpNode* independently to its mode(s) of participation within an *MdpSession*. For example, the data transmission rate of an *MdpNode* within an *MdpSession* will not exceed application-controlled limits regardless of its operation as a server and/or client. This section describes function calls which generally apply to an *MdpSession* (referenced by an MdpSessionHandle within the API).

Table Z - Summary of MdpSession General Parameter Control Functions	
`MdpSessionSetTxRate()`	Controls peak transmission rate for the specific MdpSession.
`MdpSessionSetStatusReporting()`	Enables/Disables transmission of periodic status/ statistic reports.
`MdpSessionSetTOS()`	Sets value for IP TOS field for transmitted packets.
`MdpSessionSetMulticast-InterfaceAddress()`	Determines which network interface will be used for multicast packet transmission/ reception.
`MdpSessionSetMulticastLoopback()`	Enables/disables loopback of multicast packets for session.
`MdpSessionSetRobustFactor()`	Set the "robustness" (number of repeat attempts) MDP uses in transmission of MDP_CMD_FLUSH messages and requests for positive acknowledgement.

Function MdpSessionSetTxRate*()*

SYNOPSIS

```
#include <mdpApi.h>

MdpError MdpSessionSetTxRate(MdpSessionHandle     sessionHandle,
                             double               txRate);
```

DESCRIPTION

The `MdpSessionSetTxRate()` function sets the maximum transmission rate in bits per second (bps) for the identified MDP session. This `sessionHandle` parameter identifies a valid MdpSession previously created with a call to MdpNewSession() and the `txRate` parameter establishes the transmission rate for that session. This function may be called at *any* time. Note that in cases where the previous transmission rate was very low, there might be a noticeable delay before transmission at the new data rate begins. When MDP's congestion control algorithm is operating (see `MdpSessionSetCongestionControl()`), the rate automatically determined by the MDP protocol will change the rate if it is set by the application.

RETURN VALUES

The `MdpSessionSetTxRate()` function will return a value of MDP_ERROR_NONE if

successful. The value MDP_ERROR_SESSION_INVALID is returned upon failure.

Function MdpSessionSetStatusReporting()

SYNOPSIS

```
#include <mdpApi.h>

MdpError MdpSessionSetStatusReporting(
                    MdpSessionHandle    sessionHandle,
                    bool                state);
```

DESCRIPTION

The `MdpSessionSetStatusReporting()` function controls whether the local *MdpNode* will send out regular status reports as it participates in an *MdpSession*. The status report messages are special MDP protocol messages, which are periodically (once per 90 seconds) sent out by enabled *MdpNodes*. The default behavior, if this function is not called, is that the report messages are not sent. The primary purpose of these messages is to provide debugging and performance status information. In some cases, these reports might be useful in identifying multicast routing problems within a network. Currently, the content of reports received are not available to the application via the API. This feature may be provided in the future. The `sessionHandle` parameter identifies the *MdpSession* for which status reports should be sent and the `state` parameter controls the status of reporting. When the `state` parameter is set to a value of *true*, status reports are transmitted (after a 90 second interval) and when it is set to *false*, no reports are sent.

RETURN VALUES

The `MdpSessionSetStatusReporting()` function will return a value of MDP_ERROR_NONE if successful. The value MDP_ERROR_SESSION_INVALID is returned upon failure.

Function MdpSessionSetTOS()

SYNOPSIS

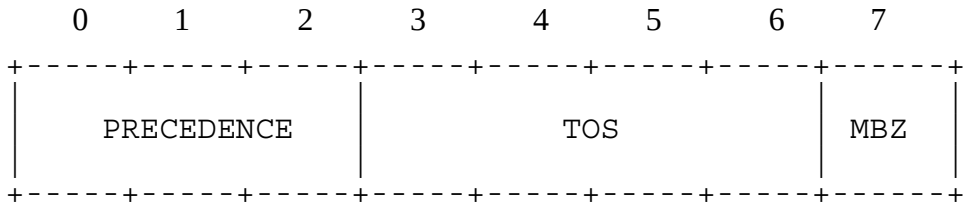
```
#include <mdpApi.h>

bool MdpSessionSetTOS(MdpSessionHandle       sessionHandle,
                      unsigned char          theTOS);
```

DESCRIPTION

This function allows the application to set the value of the IP type-of-service (TOS) field for any packets transmitted for the MdpSession indicated by the `sessionHandle` parameter. The `tos` parameter corresponds to what the TOS byte in the IP header will be set for transmitted packets. It should be noted that use of TOS is still considered experimental and different networks and devices may treat traffic differently. Therefore, the following discussion should be treated as a general guideline only.

The TOS byte in the IP header is divided into three sections: the PRECEDENCE field (the 3 high-order bits), the Type-of-Service (TOS) field (next 4 bits), and a reserved bit (the low order bit). Any one or none of the TOS bits can be set t(5 different settings including the default setting of 0000), while the PRECEDENCE bits can be set to 8 different values including the default 000.



The table below gives examples of how the TOS field can be set to achieve different service. The listed "shifted integer value" represent the corresponding value that should be used in the call to `MdpSessionSetTOS()`. These values should be "OR'd" with the desired shifted integer value for the PRECEDENCE field.

Table Q - TOS Field Values

Bit Pattern	Definition	Shifted integer Value
1000	IPTOS_LOWDELAY	16
0100	IPTOS_THROUGHPUT	8
0010	IPTOS_RELIABILITY	4
0001	IPTOS_LOWCOST	2
0000	normal service	0

Table R - PRECEDENCE Field Values

Bit Pattern	Definition	Shifted Integer Value
111	IPTOS_PREC_NETCONTROL	224
110	IPTOS_PREC_INTERNETCONTROL	192
101	IPTOS_PREC_CRITIC_ECP	160
100	IPTOS_PREC_FLASHOVERRIDE	128
011	IPTOS_PREC_FLASH	96
010	IPTOS_PREC_IMMEDIATE	64
001	IPTOS_PREC_PRIORITY	32
000	IPTOS_PREC_ROUTINE	0

Example:

If the value of tos parameter was set equal to 164, the PRECEDENCE would be IPTOS_PREC_CRITIC_ECP, the TOS would be IPTOS_RELIABILITY and the IP TOS byte would be set with the bit pattern: 10100100.

RETURN VALUES

A value of *true* is returned if the system call to set the TOS field value is successful. Note that if the MdpSession is not yet open when this call is made, this function will always return *true*. However, if the set TOS is invalid, the subsequent call to open the session for client or server operation will fail with an error. Some operating systems require super-user privileges in order to set certain TOS values (e.g. IPTOS_PREC_NETCONTROL).

Function MdpSessionSetMulticastInterfaceAddress()

SYNOPSIS

```
#include <mdpApi.h>

MdpError MdpSessionSetMulticastInterfaceAddress(
                    MdpSessionHandle    sessionHandle,
                    const char*         interfaceAddr);
```

DESCRIPTION

This function allows the application to select which network interface is used for multicast transmission and reception for the multicast group possibly associated with a given MdpSession. Internet Group Management Protocol (IGMP) messages for the group will use the specified interface. This allows MDP operation to be properly supported on multi-homed hosts. For hosts with a single network interface or configured to route multicast traffic on a designated interface, use of this API function is not necessary. The sessionHandle parameter identifies the applicable *MdpSession* and the interfaceAddr parameter is a pointer to a fixed string containing an IP address in dotted notation (e.g. "132.250.95.8").

RETURN VALUES

The MdpSessionSetStatusReporting() function will return a value of MDP_ERROR_NONE if successful. The value MDP_ERROR_SESSION_INVALID is returned upon failure. While no specific errors are returned by this function, if the interface is improperly specified, multicast operation may not occur on the expected network interface.

Function MdpSessionSetMulticastLoopback()

SYNOPSIS

```
#include <mdpApi.h>

MdpError MdpSessionSetMulticastLoopback(
                    MdpSessionHandle    sessionHandle,
```

```
                        bool                    state);
```

DESCRIPTION

This function enables (`state` = *true*) and disables (`state` = *false*) the loopback of multicast packets transmitted for the session identified by the `sessionHandle` parameter. This function is useful for debugging MDP applications (I.e. a single host can act as a client and server to itself) or for applications where it is necessary that the client receive local server transmissions.

RETURN VALUES

A value of `MDP_ERROR_NONE` is returned if successful. The value `MDP_ERROR_SESSION_INVALID` if the indicated session is invalid. Note that on some operating systems (e.g. Win32) it appears impossible to disable multicast loopback. Also note that on some operating systems, loopback must be enabled for multiple processes to receive multicast traffic from each other.

Function MdpSessionSetRobustFactor()

SYNOPSIS

```
#include <mdpApi.h>

MdpError MdpSessionSetRobustFactor(
                          MdpSessionHandle    sessionHandle,
                          unsigned int        value);
```

DESCRIPTION

This function controls the "robustness" with which certain MDP server commands are sent and timeout behavior of MDP clients. The `value` parameter determines the number of transmissions of `MDP_CMD_FLUSH` messages which occur at the end of server transmission and the number of attempts made to collect positive acknowledgement from ACKing clients. Note that is very important to efficient protocol operation that all clients and servers operating in the same MdpSession use the same "robustness"`value`. Since the MDP protocol does not advertise server "robustness", the application is responsible for assuring that all participated MdpNodes are set to the same "robustness"`value`.

If the `value` is set to zero, no MDP_CMD_FLUSH messages will be sent at the endo of server transmission, but at least one attempt to collect positive acknowledgement from all ACKing receivers when positive acknowledgement is applicable. The default "robustness" `value` used by MDP is 20. This value is estimated to provide greater than 90% reliability even in cases of roughly 50% packet loss.

RETURN VALUES

A value of `MDP_ERROR_NONE` is returned if successful. The value `MDP_ERROR_SESSION_INVALID` if the indicated session is invalid.

5.3 MdpSession Server Operation

As indicated previously, the MDP API provides functions to open (start) and close (stop) an *MdpSession* for both server and client operation. Even for the same *MdpSession* within an application, the "server" and the "client" operations are somewhat independent of each other. This section describes function calls related to the *MdpSession*'s operation as a server (source of data transfers). For an application to participate as a server in a previously-created *MdpSession*, it must make a call to `MdpSessionOpenServer()`. However, there a number of API calls controlling parameters applicable to server operation which may be called before server operation is activated with a call to `MdpSessionOpenServer()`. And there are some function calls which can be made only before server operation is started. After a session has been opened for server operation, the application my enqueue file and/or static data objects for transmission. Table X summarizes the API routines applicable to server operation. Detailed descriptions of each of these functions is provided below.

Table X - Summary of MdpSession Server Management Functions

Server parameter control routines which can be called at *any* time:	
`MdpSessionSetCongestionControl()`	Turn MDP congestion control on/off.
`MdpSessionSetAutoParity()`	Set amount of "auto parity" transmitted per MDP FEC coding block.
`MdpSessionSetServerEmcon()`	Turn server EMCON mode on/off.
`MdpSessionServerAddAckingClient()`	Add specific client host to positive acknowledgement list.
`MdpSessionServerRemoveAckingClient()`	Remove specific client host from positive acknowledgement list.
`MdpSessionSetTxCacheDepth()`	Set size of object history cache kept for repair transmissions.
`MdpSessionGetServerGrttEstimate()`	Gets the current estimate of group greates roundtrip delay time maintained by the server.
`MdpSessionSetServerGrttEstimate()`	Sets current estimate of group greatest roundtrip delay time maintained by the server.
`MdpSessionSetServerGrttMax()`	Set the maximum value the server will use and advertise as its GRTT estimate.

Table X - Summary of MdpSession Server Management Functions	
`MdpSessionSetGrttProbeInterval()`	Set the time interval ranges used by the MDP server for GRTT probing.
`MdpSessionSetGrttProbing()`	Enable/disable MDP GRTT probing. Disabling allows complete manual setting of server GRTT estimate.
Server parameter control routines to be called only *before* starting server operation:	
MdpSessionSetBaseObjectTransportId()	Set initial transport object identifier value.
Server start/stop control:	
`MdpSessionOpenServer()`	Start server operation.
`MdpSessionCloseServer()`	Stop server operation.

Table X - Summary of MdpSession Server Management Functions	
Server management routines for use only *after* server start:	
`MdpSessionQueueTxFile()`	Enqueue file object for transmission by the server.
`MdpSessionQueueTxData()`	Enqueue static data object for transmission by the server.
`MdpSessionRemoveTxObject()`	Abort transmission of currently active transmit object (or one being held for potential repair transmissions)

Function MdpSessionOpenServer()

SYNOPSIS

```
#include <mdpApi.h>

MdpError MdpSessionOpenServer(
          MdpSessionHandle sessionHandle,
          int              segmentSize = MDP_DEFAULT_SEGMENT_SIZE,
          int              blockSize = MDP_DEFAULT_BLOCK_SIZE,
          int              nparity = MDP_DEFAULT_NPARITY,
          unsigned long    bufferSize = MDP_DEFAULT_BUFFER_SIZE);
```

DESCRIPTION

The `MdpSessionOpenServer()` function opens a session for operation as a server (sender) within an *MdpSession*. The `sessionHandle` identifies the MdpSession to be opened for server operation. Default values are provided for the other parameters which can be overridden at the application designer's discretion. These parameters include:

`segmentSize`	Maximum payload size (in bytes) of MDP protocol messages. MDP protocol messages are encapsulated within UDP/IP packets and some messages contain as much as ?25 bytes of MDP-specific overhead in addition to the payload content. The “normal” amount of MDP overhead in addition to the payload is 21 bytes. The `segmentSize` parameter allows the application additional control for protocol efficiency so that MDP operation can be properly matched to expected network conditions and maximum transmission unit (MTU) sizes.
`blockSize`	Number of “data” payload packets per MDP forward error correction (FEC) coding block. This must be a value from 1 to 255. The product

nparity	Number of "parity" packets the server calculates and maintains for potential repair transmission per MDP FEC coding block. Note that these packets are simply calculated and not actually transmitted except in response to repair requests by clients or to satisfy the current server "auto parity" (discussed later) setting.
bufferSize	Amount of memory the MDP protocol engine allocates as buffer space for holding parity for repair transmissions to clients. A large bufferSize setting allows an MDP server to operate most efficiently in terms of processing demand. However, MDP will re-calculate parity as needed for retransmission within the bounds of the transmission "cache depth" set with the MdpSessionSetTxCacheDepth() function.

During the call to MdpSessionOpenServer(), the application-installed *TimerCallbackFunction* will be called as timers critical to server operation are installed. Immediately after opening an *MdpSession* for server operation (and after returning to your application's event loop), the MDP protocol engine will begin transmission of MDP protocol messages appropriate to server operation. After the MdpSession is opened as a server, the application may begin queuing objects for transmission with calls to MdpSessionQueueTxFile() and MdpSessionQueueTxData().

RETURN VALUES

On success, a value of MDP_ERROR_NONE is returned. Otherwise, an MDP error code indicative of the problem opening server operation is returned.

Function MdpSessionCloseServer()

SYNOPSIS

```
#include <mdpApi.h>

void   MdpSessionCloseServer(
                MdpSessionHandle    sessionHandle,
                bool                hardShutdown = false);
```

DESCRIPTION

The function MdpSessionCloseServer() is used to close (stop) server operation for a session which was previously opened. The sessionHandle parameter identifies the session to close. Note that the same session may be re-opened with another call to MdpSessionOpenServer(). However, any objects previously queued for transmission are purged when server operation is closed. The hardShutdown parameter is used to control the serv'er's behavior as it exits the *MdpSession*. By default (hardShutdown = *false*), the server will "gracefully" exit the session by transmitting an MDP_CMD_FLUSH message with the End-of-Transmission flag set. This notifies clients within the group that the server is terminating operation and it will not process further repair requests for any pending objects. An MDP_NOTIFY_SERVER_CLOSED notification occurs when this end-of-transmission flushing is complete. *The session should not be re-opened as a server until this*

notification has occurred. The period of time for the graceful close process to complete is a function of the server's current estimate of GRTT and the "robust factor" set for the session. If the hardShutdown parameter is set to a value of *true*, the server immediately halts with no notification to clients. In the future, a function to temporarily halt or pause server operation might be provided.

RETURN VALUES

MdpSessionCloseServer() returns no value.

Function MdpSessionQueueTxFile()

SYNOPSIS

```
#include <mdpApi.h>

MdpObjectHandle MdpSessionQueueTxFile(
                MdpSessionHandle    sessionHandle,
                const char*         path,
                const char*         name,
                MdpError*           error = NULL);
```

DESCRIPTION

The function MdpSessionQueueTxFile() is used to enqueue an MdpObject of type MDP_OBJECT_FILE for transmission by the server. The current MDP protocol implementation supported by this API handles all file I/O directly. The sessionHandle parameter identifies the MdpSession to which the file object is transmitted. The server transmits the file from the local file system of the name corresponding to the concatenation of the path and name text provided in this call. Additionally, the name information is transmitted as a single MDP_INFO packet with a name length limited to the segment size set when the server was opened. The file data content is transmitted and repaired as MDP_DATA. In the future, an option may be provided to suppress the transmission of MDP_INFO for MDP_OBJECT_FILE objects or allow the application to override the behavior of encapsulating the file name information (e..g using MDP_INFO content for MIME-type information may be useful for some envisioned applications)

RETURN VALUES

If the file is successfully queued, the return value contains a unique MdpObjectHandle which may be used to reference the object in other API calls. For example, if the application needs to prematurely de-queue (abort) the file transmission before MDP is completely finished with it, the MdpObjectHandle returned can be used with the MdpSessionRemoveTxObject() function call. A value of MDP_NULL_OBJECT is returned if the attempt to queue the file for transmission fails. An MdpError value indicating the reason for failure is returned in the memory space indicated by the application-provided error pointer parameter. Possible errors include:

MDP_ERROR_SESSION_INVALID	sessionHandle refers to an non-existent *MdpSession*

MDP_ERROR_MEMORY	Unable to allocate sufficient memory to maintain transmit *MdpObject* state.
MDP_ERROR_TX_QUEUE_FULL	MdpSession transmit queue (cache) is full. See `MdpSessionSetTxCacheDepth()` description for information on controlling the transmit queue depth.
MDP_ERROR_FILE_OPEN	The file name specified by the `path`/`name` parameters is not valid.

Function MdpSessionQueueTxDataObject()

SYNOPSIS

```
#include <mdpApi.h>

MdpError MdpSessionQueueTxDataObject(
               MdpSessionHandle    sessionHandle,
               const char*    infoPtr,
               unsigned short infoSize,
               const char*    dataPtr,
               unsigned long  dataSize,
               MdpError*      error);
```

DESCRIPTION

The `MdpSessionQueueTxData()` function enqueues an *MdpObject* of type `MDP_OBJECT_DATA` for transmission in the *MdpSession* indicated by the `sessionHandle` parameter. The data to be sent is a static (unchanging) block of data in the application's memory space or a short (single segment/packet) message as described below. The `sessionHandle` referenced must correspond to an MdpSession which has previously been successfully opened for operation as a server. The remaining parameters allow the application to specify the content to be transmitted for enqueued *MdpObject*.

As described in the MDP protocol documentation, there are two possible components to *MdpObjects* transmitted. These include *optional*, "out-of-band" information which must be capable of being encapsulated in a payload size less than or equal to the `segmentSize` for the transmitting MDP server (see `MdpSessionOpenServer()` for a description of the `segmentSize` server parameter). This information is transmitted as a message of type `MDP_INFO` within the MDP protocol. `MDP_INFO` packets (related to the fact that there is no fragmentation of content) are repaired more rapidly by the protocol so some applications may have use for this capability in their context of operation. Additionally, it may be useful for applications to transmit data messages which are known to be one `segmentSize` in length or smaller simply as *MdpObjects* with *only* `MDP_INFO` content (I.e. `dataPtr` = NULL).

This can speed up the transmission/repair process for small application messages. Note that MDP_INFO message are *not* included in MDP's FEC coding so MDP_INFO messages cannot utilize the benefits of the `autoParity` option for server transmissions. The `infoPtr` parameter points to an application memory location containing the data the application wishes to be transmitted as MDP_INFO for the newly queued object and the `infoSize` indicates the length of the *info* data. The `infoSize` parameter must be less than or equal to the `segmentSize` specified in the previous call to MdpSessionOpenServer(). Note that the underlying MDP protocol engine allocates storage for the indicate *info* data and copies the data into the newly allocated storage. Therefore, the application may free or reuse the memory referenced by the `infoPtr` without disrupting protocol operation after a call to this function. (As described below, his is not the case for the data referenced by the `dataPtr` parameter) No MDP_INFO message is sent for the transmit *MdpObject* if the `infoPtr` parameter is equal to NULL.

The `dataPtr` parameter must point to a valid memory location that the application wishes the MDP protocol to transmit as MDP static data content. The `dataSize` parameter specifies the length of the data to be transmitted. *IMPORTANT: The MDP protocol engine may reference this data storage location for future repair transmissions so it is crtical that the application not free or modify the memory indicated by the `dataPtr` parameter until the transmit* MdpObject *is removed from the transmission queue via a call to the `MdpSessionRemoveTxObject()`) API function, or a notification event of type* MDP_NOTIFY_TRANSMIT_OBJECT_FINISHED *or* MDP_NOTIFY_OBJECT_DELETE *is received via the the application-installed* MdpNotifyCallback.

RETURN VALUES

If the data object is successfully queued, the return value contains a unique `MdpObjectHandle` which may be used to reference the object in other API calls. For example, if the application needs to prematurely de-queue (abort) the data object transmission before MDP is completely finished with it, the `MdpObjectHandle` returned can be used with the `MdpSessionRemoveTxObject()` function call. A value of MDP_NULL_OBJECT is returned if the attempt to queue the data for transmission fails. An `MdpError` value indicating the reason for failure is returned in the memory space indicated by the application-provided `error` pointer parameter. Possible errors include:

MDP_ERROR_SESSION_INVALID	`sessionHandle` refers to an non-existent *MdpSession*
MDP_ERROR_MEMORY	Unable to allocate sufficient memory to maintain transmit *MdpObject* state. This error code may also occur if the `infoSize` parameter exceeds the segmentSize specified for server transmissions.

MDP_ERROR_TX_QUEUE_FULL	MdpSession transmit queue (cache) is full. See `MdpSessionSetTxCacheDepth()` description for information on controlling the transmit queue depth.

Function MdpSessionRemoveTxObject()

SYNOPSIS

```
#include <mdpApi.h>

MdpError MdpSessionRemoveTxObject(
               MdpSessionHandle    sessionHandle,
               MdpObjectHandle     objectHandle);
```

DESCRIPTION

This function is used to remove (abort transmission of) *MdpObjects* which have been previously queued for transmission from the *MdpSession's* transmit queue. The `sessionHandle` indicates the applicable *MdpSession* and the `objectHandle` parameter specifies the object to be removed. Note that this function should not be called from with the application installed MDP MdpNotifyCallback function when the notification event pertains to the same object referenced by the `objectHandle` parameter.

RETURN VALUES

A value of MDP_ERROR_NONE is returned upon success. Otherwise a value of MDP_ERROR_SESSION_INVALID or MDP_ERROR_OBJECT_INVALID may be returned upon error.

Function MdpSessionSetCongestionControl()

SYNOPSIS

```
#include <mdpApi.h>

MdpError MdpSessionSetCongestionControl(
               MdpSessionHandle    sessionHandle,
               bool                state);
```

DESCRIPTION

This function enables (and disables) the operation of an experimental congestion control algorithm built into the MDP protocol. The goal of this congestion control algorithm is to automatically control the transmission rate of an MDP server such that its transmissions maximally utilize available network throughput while fairly sharing the capacity with other MDP and TCP flows. This feature of MDP is still under development and is not yet recommended for widespread use. The `sessionHandle` parameter specifies the applicable *MdpSession* and the `state` parameter set to values of *true* and *false* will enable and disable

congestion control operation, respectively. Congestion control operation is controlled by individual server nodes. Client nodes will automatically appropriately respond to servers running with congestion control enabled.

RETURN VALUES

A value of MDP_ERROR_NONE is returned upon success. Otherwise a value of MDP_ERROR_SESSION_INVALID may be returned upon error.

Function MdpSessionSetAutoParity()

SYNOPSIS

```
#include <mdpApi.h>

MdpError MdpSessionSetAutoParity(
               MdpSessionHandle    sessionHandle,
               unsigned char       autoParity);
```

DESCRIPTION

This function controls how many FEC parity repair packets are automatically sent with each MDP FEC coding block. The default is zero where parity repair packets are sent only on demand in response to requests from clients. Setting some non-zero amount of "auto" parity may yield performance benefits over long delay network connections where there is some a priori known amount of expected packet loss. The sessionHandle parameter identifies the applicable *MdpSession* and the autoParity parameter sets the number of automatic repair packets. The value of the autoParity parameter must be less than or equal to the nparity parameter set when the MdpSession was opened for server operation.

RETURN VALUES

A value of MDP_ERROR_NONE is returned upon success. Otherwise a value of MDP_ERROR_SESSION_INVALID or MDP_ERROR_PARAMETER_INVALID may be returned upon error.

Function MdpSessionSetServerEmcon()

SYNOPSIS

```
#include <mdpApi.h>

MdpError MdpSessionSetServerEmcon(
               MdpSessionHandle    sessionHandle,
               bool                state);
```

DESCRIPTION

This function enables (and disables) special protocol features to support emissions-controlled (EMCON) transmissions by an *MdpSession* operating as a server. EMCON modes of

operation for MDP are under continued development so the specific protocol details relative to EMCON operation are not yet finalized. However, at the current time, use of EMCON operation causes a server to redundantly transmit objects' MDP_INFO messages at the end of each transmitted coding block in addition to sending MDP_INFO at the start of object transmission. This is because MDP_INFO messages do not benefit from MDP's FEC coding structure. In general, MDP applications wishing to provide EMCON operation should not use the optional MDP_INFO messages for object transmission in order to achieve the full gain of MDP's FEC coding. The `sessionHandle` parameter specifies the applicable *MdpSession* and the `state` parameter set to values of *true* and *false* will enable and disable EMCON operation, respectively.

RETURN VALUES

A value of `MDP_ERROR_NONE` is returned upon success. Otherwise a value of `MDP_ERROR_SESSION_INVALID` may be returned upon error.

Function MdpSessionAddAckingClient()

SYNOPSIS

```
#include <mdpApi.h>

MdpError MdpSessionAddAckingClient(
               MdpSessionHandle    sessionHandle,
               const char*         host);
```

DESCRIPTION

This function adds a specific client (identified by its host name or IP address) to the list of clients from which the server expects to receive positive receipt acknowledgement during protocol operation. If MDP status reporting is used, it is important that the clients in this list be appropriately configured for positive acknowledgement operation so that the clients' status reports do not cause them to be removed from the server's positive acknowledgement list. Controls over positive acknowledgement operation will be further refined in the future. The `sessionHandle` parameter identifies the applicable *MdpSession* and the `host` parameter points to a string containing the client's resolvable host name or IP address in dotted notation (e.g. "132.250.95.7").

IMPORTANT NOTE: Identifying clients by their host names or IP addresses will lead to problems for MDP applications which use an alternate MdpNodeId convention. And, even if IP addresses are user as MdpNodeIds, multi-homed hosts can add to confusion here. Therefore, in the future, this API call will be changed to use a type of MdpNodeId for the second parameter to this function to be more consistent with the general utility of the MDP API.

RETURN VALUES

A value of `MDP_ERROR_NONE` is returned upon success. Otherwise a value of `MDP_ERROR_SESSION_INVALID` or `MDP_ERROR_DNS_FAIL` may be returned upon

error.

Function MdpSessionRemoveAckingClient()

SYNOPSIS

```
#include <mdpApi.h>

MdpError MdpSessionServerRemoveAckingClient(
               MdpSessionHandle    sessionHandle,
               const char*         host);
```

DESCRIPTION

This function *removes* a specific client (identified by its host name or IP address) from the list of clients from which the server expects to receive positive receipt acknowledgement during protocol operation. See the description of `MdpSessionAddAckingClient()` for more information.

RETURN VALUES

A value of `MDP_ERROR_NONE` is returned upon success. Otherwise a value of `MDP_ERROR_SESSION_INVALID` may be returned upon error.

Function MdpSessionSetTxCacheDepth()

SYNOPSIS

```
#include <mdpApi.h>

MdpError MdpSessionSetTxCacheDepth(
               MdpSessionHandle    sessionHandle,
               unsigned long       minCount,
               unsigned long       maxCount,
               unsigned long       maxSize);
```

DESCRIPTION

This function sets the properties of the *MdpSession's* server transmit cache. The transmit cache acts as a “hold queue” for repairing previously-transmitted *MdpObjects*. Larger transmit cache settings allow an MDP server to repair previously transmitted objects over a longer time/bandwidth window. This is particularly important when using MDP as a purely NACK-based protocol without any positive acknowledgements. The transmit cache does not directly use much memory since MDP will pull information from the application's disk storage or memory as needed to recover repair information. When new objects are queued for transmission, MDP will remove state for old objects in the transmit cache as needed to make room for state for the new objects. The following parameters govern the behavior of the transmit cache:

`minCount` Smallest number of objects (files or data) for which state is kept (regardless of

the size of the individual objects.

maxCount — Maximum number of objects (files or data) for which state is kept although the maxCount may not be reached if the total size of the individual objects exceed the maxSize parameter value.

maxSize — Maximum total size (in bytes) of objects for which state is kept in the transmit cache. However, the total size can exceed the maxSize parameter value if there are minCount or less objects in the cache.

If minCount and maxCount are set to zero, state for the object will be deleted immediately after its transmission and no repair transmissions will be sent in response to requests from clients.

RETURN VALUES

A value of MDP_ERROR_NONE is returned upon success. Otherwise a value of MDP_ERROR_SESSION_INVALID may be returned upon error.

Function MdpSessionServerSetGrttEstimate()

SYNOPSIS

```
#include <mdpApi.h>

MdpError MdpSessionServerSetGrttEstimate(
               MdpSessionHandle    sessionHandle,
               double              initialGrtt);
```

DESCRIPTION

This function sets the value of the estimate of group greatest roundtrip delay time (GRTT) maintained by the server. As an integral part of the MDP protocol, MDP servers collect a long term estimate of the worst case roundtrip packet transmission delay time among active members in the MdpSession. This function allows an application to override the current estimate at any time. If an application had a good *a priori* idea of expected GRTT at session startup (obtained from previous runs as a server, or from side information), it could use this function to initialize the server's starting GRTT estimate to an appropriate value. The server will then update this value with its own estimation and averaging process. The sessionHandle parameter indicates the applicable *MdpSession* and the initialGrtt parameter sets the server's GRTT estimate in units of *seconds*. Also note that the GRTT estimate maintained by an MDP server is currently limited to a range of MDP_GRTT_MIN to MDP_GRTT_MAX (currently 1 msec and 15 sec, respectively).

RETURN VALUES

A value of MDP_ERROR_NONE is returned upon success. Otherwise a value of MDP_ERROR_SESSION_INVALID may be returned upon error.

Function MdpSessionServerGetGrttEstimate()

SYNOPSIS

```
#include <mdpApi.h>

MdpError MdpSessionSetGrttEstimate(
               MdpSessionHandle    sessionHandle,
               double*             grttEstimate);
```

DESCRIPTION

This function returns the MDP server's current estimate of GRTT for the *MdpSession* indicated by the `sessionHandle` parameter. The estimate is returned (in units of seconds) to the space pointed to by the `grttEstimate` parameter. Note that the estimate returned is subject to the limits imposed by the MDP protocol engine and might not reflect actual GRTT in extreme cases (See the description of the `MdpSessionSetGrttMax()` function).

RETURN VALUES

A value of `MDP_ERROR_NONE` is returned upon success. Otherwise a value of `MDP_ERROR_SESSION_INVALID` may be returned upon error. The MDP server's current estimate of GRTT is passed back via the `grttEstimate` pointer.

Function MdpSessionServerSetGrttMax()

SYNOPSIS

```
#include <mdpApi.h>

MdpError MdpSessionSetGrttEstimate(MdpSessionHandle    sessionHan
                                                       dle,
                                   double         grttMax);
```

DESCRIPTION

This function sets the maximum value the server will use and advertise as its estimate of group greatest roundtrip delay time (GRTT). The default value (I.e. don't call this function) is generally recommended as it represents a trade-off in the protocol's ability to adapt to extreme network conditions and maintain responsiveness. While the MDP protocol's quantization and encapsulation of advertised GRTT can support values up to 1000 seconds, the code currently limits the maximum which can be set to 120 seconds. (The normal default maximum is 15 seconds).

RETURN VALUES

A value of `MDP_ERROR_NONE` is returned upon success. Otherwise a value of `MDP_ERROR_SESSION_INVALID` may be returned upon error.

Function MdpSessionSetGrttProbeInterval()

SYNOPSIS

```
#include <mdpApi.h>

MdpError MdpSessionSetGrttProbeInterval(MdpSessionHandle
sessionHandle,
double      intervalMin,
                                        double      intervalMax);
```

DESCRIPTION

This function sets the time intervals (in seconds) the MDP server uses in its algorithm for collecting an estimate of group greatest round trip time (GRTT) for the *MdpSession* indicated by the `sessionHandle` parameter. The intervalMin parameter is the probing interval used when MDP begins probing. Subsequently, the probe interval is exponentially increased (by doubling) until the steady-state interval specified by `intervalMax` is reached. If the values of `intervalMin` and `intervalMax` are equal, the probe interval is constant. The value of `intervalMin` must be greater than or equal to 0.10 seconds and the value of `intervalMax` must be greater than or equal to 5.0 seconds.

RETURN VALUES

A value of `MDP_ERROR_NONE` is returned upon success or `MDP_ERROR_PARAMETER_INVALID` if the intervals are not in an acceptable range (or if `intervalMax` is less than `intervalMin`). Otherwise a value of `MDP_ERROR_SESSION_INVALID` may be returned upon error.

Function MdpSessionSetGrttProbing()

SYNOPSIS

```
#include <mdpApi.h>

MdpError MdpSessionSetGrttProbing(MdpSessionHandle sessionHandle,
                                  bool        state);
```

DESCRIPTION

This function enables or disables the MDP servers algorithm for collecting a GRTT estimate from the group. The `sessionHandle` parameter is used to specify the applicable *MdpSession* and the `state` parameter is set to a value of `true` or `false` to enable or disable GRTT probing, respectively. Normally (and by default) GRTT probing should be enabled for most efficient protocol operation. The ability to disable GRTT probing is only provide for cases where network capacity is extremely limited (and a reasonable estimate of actual GRTT is known a priori) or for cases when *no* clients are providing feedback (all clients configured for EMCON operation).

RETURN VALUES

A value of `MDP_ERROR_NONE` is returned upon success. Otherwise a value of `MDP_ERROR_SESSION_INVALID` may be returned upon error.

Function MdpSessionSetBaseObjectTransportId()

SYNOPSIS

```
#include <mdpApi.h>

MdpError MdpSessionSetBaseObjectTransportId(
               MdpSessionHandle              sessionHandle,
               MdpObjectTransportId     baseId);
```

DESCRIPTION

This function sets the starting transport object identifier for the series of objects to be transmitted by an MDP server. MDP servers transmit objects with monotonically increasing transport object identifiers during the course of an MdpSession. MDP client nodes "synchronize" to an MDP server based on the transport object identifier of the first received message from the specific MDP server. This is part of what allows multicast receivers to "come and go" as they please within the context of an MDP session. Because the clients use these transport object identifiers to uniquely identify an object from a server, ***it is very important*** that, when a server application is stopped and restarted, it begins the subsequent transmission with a base object transport identifier sufficiently out-of-range of the identifier of the last object transmitted. There are different methods applications may use to achieve this goal. The "tkMdp" example application randomly selects a base object transport identifier at startup. Because the probability of selecting a number too close in range (currently 256) of the previous transport identifier is very low, this was deemed an acceptable method for the demonstration application. More robust schemes where the application logs the most recent object transport identifier in non-volatile storage (e.g. on a disk file) and then picks an appropriate restart value after the server is exited (because of a system failure or other reason) can also be implemented. The API function call `MdpObjectGetTransportId()` can be used to retrieve the transport object identifier of a newly-queued transmit object to serve this purpose. While the current object transport identifier range "window" over which a client tracks synchronization with a given server is 256, this value may be controlled via the API in the future. More information on the "synchronization window" will be provided then.

RETURN VALUES

A value of `MDP_ERROR_NONE` is returned upon success. Otherwise a value of `MDP_ERROR_SESSION_INVALID` may be returned upon error.

5.4 MdpSession Client Operation

This section describes functions related to the MDP protocol engine's capabilities to participate as a client within an *MdpSession*. The general order of operation is that an application may open an *MdpSession* for client operation. At this point, the MDP protocol is open to receiving transmissions from any server(s) transmitting to the *MdpSession*. The *MdpNotifyCallback* installed by the application will be called as *MdpObjects* are received from servers. Additional API calls to retrieve information about the *MdpObjects* being received are described later. Currently, there are no controls within the MDP API to restrict

reception of any data or from any specifc server(s). In the near future, it is likely the API will be expanded to allow MDP client applications to "pick and choose" which portions of data transmitted to an *MdpSession* they wish to receive. Also, as a client receives transmissions from a new server within the session, it allocates memory to buffer reliable reception for each individual server. So while in principle an *MdpSession* may have an arbitrary number of sources of data, the practical number of sources is limited by the clients' ability to allocate buffer space for multiple sources. In the future, the API will be extended to allow client applications to "timeout" or explicitly "close" specific sources (thus freeing allocated memory resources) in addition to the receive data object filtering ability previously described. This will allow applications to create more flexible paradigms to support "many-to-many" communications. Meanwhile, the basic capabilities of the API allow an application to participate as a receiver in an MdpSession with relatively simple code. The functions related to participate as a client simply consist of functions to open (start) client participation, and control a few parameters of client operation. After this, it is primarily the code within the the *MdpNotifyCallback* which allows the application to receive transmissions from servers and process the received objects properly. Table Y summarizes the functions specifically related to controlling client operation.

Table Y - Summary of MdpSession Client Management Funcitons

Client parameter control routines which can be called at *any* time:	
`MdpSessionSetClientAcking()`	Causes client to set positive acknowledgment indicator flag in transmitted status reports.
`MdpSessionSetClientUnicastNacks()`	Client-generated NACK messages will be unicast routed to applicable server instead of multicast to group if set true.
`MdpSessionSetClientNackingMode()`	Determines client nacking behavior for newly-received or missing objects in the series of object transmission from servers.
`MdpSessionSetClientStreamIntegrity()`	Determines if client will NACK for repair of *MdpObjects* in the series of server transmissions for which the client has received no content (info or data) at all.
`MdpSessionSetClientMulticastAcks()`	Client-generated ACK messages wil be multicasted to group instead of unicast routed to applicable server.

Table Y - Summary of MdpSession Client Management Funcitons	
`MdpSessionSetArchiveDirectory()`	Specifies directory where client stores received objects of type MDP_OBJECT_FILE.
`MdpSessionSetArchiveMode()`	Specificies whether client should permanently archive or temporarily caches received file objects. (Affects naming of received files and overwrite policy).
Client parameter control routines which should be called *before* client start:	
`MdpSessionSetClientEmcon()`	Controls optional emission-controlled (silent client) mode of operation for client.
Client control	
`MdpSessionOpenClient()`	Start client operation.
`MdpSessionCloseClient()`	Stop client operation.
`MdpSessionAbortRxObject()`	Terminate reception of a specific *MdpObject*.
`MdpSessionGetNodeAddress()`	Get the current source IP address and port number for a remote server node in the *MdpSession*.
`MdpSessionGetNodeGrttEstimate()`	Get the current GRTT estimate for a remote server in the *MdpSession*.
`MdpSessionGetNodeNextRxObject()`	Allows caller to retrieve the list of pending receive *MdpObjects* being received from a remote server.
`MdpSessionDeactivateNode()`	Frees buffering resources allocated for a remote server, dropping state on pending receive *MdpObjects*.
`MdpSessionDeleteNode()`	Drops all state and free all resources for a remote server *MdpNode*.

Function MdpSessionOpenClient()

SYNOPSIS

```
#include <mdpApi.h>
```

```
MdpError MdpSessionOpenClient(
                MdpSessionHandle    sessionHandle,
                unsigned long       bufferSize =
                                    MDP_DEFAULT_BUFFER_SIZE);
```

DESCRIPTION

The `MdpSessionOpenClient()` function opens a session for operation as a client (receiver) within an *MdpSession*. The `sessionHandle` parameter specifies the applicable session and the `bufferSize` parameter indicates how much memory (in bytes) the client should allocate for each server which is detected transmitting to the session. A default value of approximately 1 Mbyte for the `bufferSize` parameter is provided. After the session is opened for client operation, the client will begin waiting for transmissions from server nodes within the *MdpSession*. The client will also generate MDP status reports once per 90 seconds if it has been configured to do so.

RETURN VALUES

On success a value of MDP_ERROR_NONE. A value of MDP_ERROR_SESSION_INVALID or MDP_ERROR_MEMORY will returned upon failure.

Function MdpSessionCloseClient()

SYNOPSIS

```
#include <mdpApi.h>

MdpError MdpSessionCloseClient(MdpSessionHandle sessionHandle);
```

DESCRIPTION

The `MdpSessionCloseClient()` function closes (stops) client operation for the MdpSession identified by the *`sessionHandle`* parameter.

RETURN VALUES

A value of MDP_ERROR_NONE is returned upon success. MDP_ERROR_SESSION_INVALID is returned otherwise.

Function MdpSessionAbortRxObject()

SYNOPSIS

```
#include <mdpApi.h>

MdpError MdpSessionAbortRxObject(MdpSessionHandle sessionHandle,
                                 MdpObjectHandle  objectHandle);
```

DESCRIPTION

The MdpSessionAbortRxObject() terminates reception of an MdpObject being received by a client. This function may be called at any time during the interval during which a given MdpObjectHandle is valid (I.e. from the time of MDP_NOTIFY_RX_OBJECT_START until MDP_NOTIFY_OBJECT_DELETE). The sessionHandle and objectHandle parameters indicate the applicable *MdpSession* and *MdpObject*, respectively. Note that even though the application may abort reception of an object, if a subsequent positive acknowledgement request for that object is sent by the server, the aborting receiver will acknowledge (ACK) that reception was completed. The positive acknowledgement mechanism in MDP is designed with respect to the successful transport of the object. Application layer needs for positive acknowledgement need to be addressed separately by the application.

RETURN VALUES

A value of MDP_ERROR_NONE is returned upon success.
MDP_ERROR_SESSION_INVALID is returned if the sessionHandle is invalid, or MDP_ERROR_OBJECT_INVALID is returned if the objectHandle value is equal to MDP_NULL_OBJECT. It is critical that only valid non-null *MdpObjectHandle*'s are passed to this function call.

Function MdpSessionGetNodeAddress()

SYNOPSIS

```
#include <mdpApi.h>

MdpError MdpSessionGetNodeAddress(
                    MdpSessionHandle    sessionHandle,
                    MdpNodeId           nodeId,
                    unsigned long*      address,
                    unsigned short*     port);
```

DESCRIPTION

This function retrieves the IP source address and port number for the *MdpNode* identified by the nodeId parameter. The nodeId value may have been previously obtained with a call to MdpObjectGetSourceNodeId(). The sessionHandle parameter identifies the applicable *MdpSession* and the address and port parameters point to storage locations for the respective retrieved values.

RETURN VALUES

This function will return a value of MDP_ERROR_NONE if successful. A value of MDP_ERROR_SESSION_INVALID is returned upon failure.

Function MdpSessionGetNodeGrttEstimate()

SYNOPSIS

```
#include <mdpApi.h>

MdpError MdpSessionGetNodeGrttEstimate(
                    MdpSessionHandle    sessionHandle,
                    MdpNodeId           nodeId,
                    double*             grttEstimate);
```

DESCRIPTION

This function retrieves the current estimate of GRTT advertised by the remote server node indicated by the `nodeId` parameter in the *MdpSession* identified by the `sessionHandle` parameter. The estimate of GRTT is returned to the storage space indicated by the `grttEstimate` pointer parameter in units of seconds. A valid *MdpNodeId* can be retrieved using the `MdpObjectGetSourceNodeId()` function given a valid *MdpObjectHandle* for a current object being received. The retrieved *MdpNodeId* is guaranteed to be valid only during the period of time for which *MdpObjectsIds* associated with the same source are valid.

RETURN VALUES

A value of MDP_ERROR_NONE is returned upon success. If the `nodeId` parameter is not valid, a value of MDP_ERROR_NODE_INVALID will be returned.

Function MdpSessionGetNodeNextRxObject()

SYNOPSIS

```
#include <mdpApi.h>

MdpObjectHandle MdpSessionGetNodeNextRxObject(
                    MdpSessionHandle    sessionHandle,
                    MdpNodeId           nodeId,
                    MdpObjectHandle*    previousObject,
                    MdpError*           error = NULL);
```

DESCRIPTION

This function allows the application to retrieve the list of pending receive objects for a particular remote server *MdpNode* one at a time. The `sessionHandle` parameter identifies the applicable *MdpSession* and the `nodeId` parameter identifies the remote server of interest. The `previousObject` parameter is used to start the list iteration (using a value of MDP_NULL_OBJECT) and to prompt the API for the next pending receive object using previously returned values. Thus, this function can be used to iterated over the list of pending receive *MdpObjects*.

RETURN VALUES

If the `previousObject` parameter is set to a value of MDP_NULL_OBJECT (or an

invalid *MdpObjectHandle*), the identifying handle of the first receive-pending *MdpObject* is returned. If the `previousObject` parameter is a valid *MdpObjectHandle*, the handle of the next following receive-pending *MdpObject* is returned. A value of MDP_NULL_OBJECT may also be returned upon error. The storage identified by the error parameter will contain a value indicating the error status of MDP_ERROR_NONE, MDP_ERROR_SESSION_INVALID, or MDP_ERROR_NODE_INVALID.

Function MdpSessionDeactivateNode()

SYNOPSIS

```
#include <mdpApi.h>

MdpError MdpSessionDeactivateNode(
                    MdpSessionHandle    sessionHandle,
                    MdpNodeId           nodeId);
```

DESCRIPTION

This function releases buffering resources allocated for a remote server *MdpNode*, dropping state on receive pending *MdpObjects* for that server, but maintains the server's state with regards to which *MdpObjects* have been received and other factors. The bulk of memory resources used by the MDP library for client operation is for receive buffering. This function allows the application to manage receive buffering memory resources in a timely manner.

RETURN VALUES

A value of MDP_ERROR_NONE is returned upon success. A value of MDP_ERROR_SESSION_INVALID or MDP_ERROR_NODE_INVALID may be returned if inappropriate (e.g. MDP_NULL_SESSION) values are supplied.

Function MdpSessionDeleteNode()

SYNOPSIS

```
#include <mdpApi.h>

MdpError MdpSessionDeleteNode(
                    MdpSessionHandle    sessionHandle,
                    MdpNodeId           nodeId);
```

DESCRIPTION

This function releases all memory resources and state allocated by a MDP client for a remote server *MdpNode*. No state on the remote server is retained and when the client receive new messages from that server, it will re-allocate state for the server and begin reception as if it were a newly detected server.

RETURN VALUES

A value of MDP_ERROR_NONE is returned upon success. A value of MDP_ERROR_SESSION_INVALID or MDP_ERROR_NODE_INVALID may be returned if inappropriate (e.g. MDP_NULL_SESSION) values are supplied.

Function MdpSessionSetClientAcking()

SYNOPSIS

```
#include <mdpApi.h>

MdpError MdpSessionSetClientAcking(
                          MdpSessionHandle    sessionHandle,
                          bool                state);
```

DESCRIPTION

The `MdpSessionSetClientAcking()` function controls the client node's willingness to participate in positive acknowledgement of the receipt of *MdpObjects* transmitted by servers. When MDP status reporting is used (see `MdpSessionSetStatusReporting()`), a flag in the report indicates the client's ACKing status. It is important to note that this flag must be properly set when a server has included the client in question in its positive acknowledgement list. Even though the client is in the list at startup, the client will be removed from the list if the server receives a report from the client with its ACKing status flag unset. Controls of the positive acknowledgement process will be further refined in the future as the need for this functionality in different reliable multicast applications is better defined. The `sessionHandle` parameter indicates the applicable *MdpSession* and the `state` parameter set to a value of *true* or *false*, enables or disables client ACKing, respectively.

RETURN VALUES

A value of `MDP_ERROR_NONE` is returned upon success.
`MDP_ERROR_SESSION_INVALID` is returned otherwise.

Function MdpSessionSetClientUnicastNacks()

SYNOPSIS

```
#include <mdpApi.h>

MdpError MdpSessionSetClientUnicastNacks(
                          MdpSessionHandle    sessionHandle,
                          bool                state);
```

DESCRIPTION

This function controls how MDP NACK messages are transmitted by a client. Normally, it is anticipated that MDP NACK messages will be multicast to the session to promote NACK

suppression among MDP clients. However, in some asymmetric network topologies without reciprocal multicast routing, it may be necessary for some clients to unicast NACK messages directly to the server source address(es). The sessionHandle parameter indicates the applicable *MdpSession* and the state parameter set to a value of *true* causes the client to unicast NACK messages to the server source address(es), while a value of *false* causes the client to send NACK messages to the *MdpSession* destination address (which may be a multicast or unicast address).

RETURN VALUES

A value of MDP_ERROR_NONE is returned upon success.
MDP_ERROR_SESSION_INVALID is returned otherwise.

Function MdpSessionSetClientNackingMode()

SYNOPSIS

```
#include <mdpApi.h>

MdpError MdpSessionSetClientNackingMode(
                    MdpSessionHandle    sessionHandle,
                    MdpNackingMode      mode);
```

DESCRIPTION

This function controls the default client nacking behavior for the *MdpSession* indicated by the sessionHandle parameter. The possible values for the mode parameter include MDP_NACKING_NORMAL, MDP_NACKING_INFOONLY, and MDP_NACKING_NONE. This default behavior applies to newly-received objects and objects "missing" from the series of server object transmissions. When the client's MdpNackingMode is set to MDP_NACKING_NORMAL, the client will request repair retransmission of the entire content of any missing or newly received MdpObjects as necessary. When the client *MdpNackingMode* is set to MDP_NACKING_INFOONLY, the client will request retransmission only for missing MdpObject info content, if applicable. And when the client *MdpNackingMode* is set to MDP_NACKING_NONE, the client will not request any repair for missing data (Note that the client may possibly still receive the object in question as a result of other client's repair requests).

The *MdpNackingMode* may be set for individual *MdpObjects* (see the MdpObjectSetNackingMode() function) to allow a client to selectively choose which objects it wishes to reliably receive. For example, the *info* content of objects transmitted by an *MdpServer* application may contain information the client application can use as criteria to make a decision on whether to reliably receive (or receive at all) particular MdpObjects. The MdpObject sender *MdpNodeId* could also be used as criteria. Other MDP API calls including MdpObjectGetSourceNodeId(), MdpObjectSetNackingMode(), and MdpSessionAbortRxObject() may be used in conjunction with this function to achieve desired application behavior.

By default, *MdpSessions* will operate with a *MdpNackingMode* of MDP_NACKING_NORMAL, unless this function is called. The client *MdpNackingMode* may be changed at any time and will apply on future newly-received or entirely missing objects. Parially-received *MdpObjects* will retain the *MdpNackingMode* behavior prior to the call to MdpSessionSetClientNackingMode(). The application can manage the nacking behavior of these receive pending objects separately with the MdpObjectSetNackingMode() function.

RETURN VALUES

A value of `MDP_ERROR_NONE` is returned upon success.
`MDP_ERROR_SESSION_INVALID` is returned otherwise.

Function MdpSessionSetClientStreamIntegrity()

SYNOPSIS

```
#include <mdpApi.h>

MdpError MdpSessionSetClientStreamIntegrity(
                          MdpSessionHandle    sessionHandle,
                          bool                state);
```

DESCRIPTION

This function controls the client's behavior with regard to requesting repair for *MdpObjects* "missing" in the sequential series of *MdpObjects* transmitted by *MdpServer* nodes. When the value of `state` is *true*, the client will request retransmission of *MdpObjects* it detects "missing" in the series of objects received. This behavior guarantees that every *MdpObject* transmitted by an *MdpServer* will be received by the client. If the value of the `state` parameter is *false*, "stream integrity" is disabled such that the client will only request repairs for *MdpObjects* for which it has received at least some content (in the form of an `MDP_INFO`, `MDP_DATA`, or `MDP_PARITY` message). However, if the *MdpServer* subsequently requests positive acknowledgement for a missing object, the client will not acknowledge, even if "stream integrity" is disabled.

When client "stream integrity" is disabled, the probability of reception of MdpObjects of small size becomes very dependent on the packet loss characteristics of the network. By default, client "stream integrity" is enabled, and it is only recommended that it be disabled to meet very special application requirements.

RETURN VALUES

A value of `MDP_ERROR_NONE` is returned upon success.
`MDP_ERROR_SESSION_INVALID` is returned otherwise.

Function MdpSessionSetClientMulticastAcks()

SYNOPSIS

```
#include <mdpApi.h>

MdpError MdpSessionSetMulticastAcks(
                    MdpSessionHandle    sessionHandle,
                    bool                state);
```

DESCRIPTION

This function controls how MDP ACK messages are transmitted by a client. Normally, ACK messages are unicast directly to the server node(s) since there is currently no benefit to group-wide reception of ACK messages. However, in cases where unicast routing is unavailable (and we have a network like that!) or where, because of asymmetry, it is important that ACKs are transmitted to the *MdpSession* destination address instead of the server source address(es), this function can be used to achieve that capability. The `sessionHandle` parameter indicates the applicable *MdpSession* and the `state` parameter set to a value of *true* causes the client to send ACK messages to the *MdpSession* destination address (which may be a multicast or unicast address), while a value of *false* causes the client to send NACK messages to the server source address(es).

RETURN VALUES

A value of `MDP_ERROR_NONE` is returned upon success.
`MDP_ERROR_SESSION_INVALID` is returned otherwise.

Function MdpSessionSetArchiveDirectory()

SYNOPSIS

```
#include <mdpApi.h>

MdpError MdpSessionSetArchiveDirectory(
                    MdpSessionHandle    sessionHandle,
                    const char*         path);
```

DESCRIPTION

This function sets the file name "path" to indicate the directory to which the MDP client should store received *MdpObjects* of type `MDP_OBJECT_FILE`. This "path" ***must be set*** for an MDP client application to receive files. However, if the application is only handling MdpObjects of type MDP_OBJECT_DATA, it is not necessary to set the archive directory path. The `sessionHandle` parameter indicates the applicable *MdpSession* and the `path` parameter is a pointer to a string (`PATH_MAX` maximum length) containing the name of the directory in which to store received files. The behavior of how received files are names

and/or overwritten is governed by the "archive mode" (see `MdpSessionSetArchiveMode()`).

Note: In the future, application-specific features such as file archiving/cacheing will be removed from the MDP protocol engine core code base. As a transport protocol, application-specific features such as this are better handled by applications and the MDP protocol engine will provide more general handling of transport objects, likely requiring applications to be responsible for file I/O. The current MDP code contains these functions as a result of the history of its development.

RETURN VALUES

A value of `MDP_ERROR_NONE` is returned upon success. If the MDP protocol engine detects it is unable to write to the indicated directory, an error code of `MDP_ERROR_FILE_OPEN` is returned and `MDP_ERROR_SESSION_INVALID` is returned if the `sessionHandle` is not valid.

Function MdpSessionSetArchiveMode()

SYNOPSIS

```
#include <mdpApi.h>

MdpError MdpSessionSetArchiveMode(
                    MdpSessionHandle    sessionHandle,
                    bool                state);
```

DESCRIPTION

This function is used to determine whether the MDP will treat received files as those to be permanently stored or as files to be temporarily cached. The `sessionHandle` parameter identifies the applicable *MdpSession* and a value of true enables file archiving while false disables those features. When file archiving is ***enabled***, two things happen:

1) If the file name in the MDP_INFO packet associated with the file contains directory path delimiters, the directory structure will recreated within the local MDP archive directory.

2) If a file with the same name is subsequently received, MDP will overwrite the first file.

When file archiving is disabled (default), the corresponding change in behavior is such that:

1) If the file name in the MDP_INFO packet associated with the file contains directory path delimiters, the file name is "flattened" by replacing the directory delimiters with an underscore character ('_'). Thus, files to be "cached" are all contained within the single, flat archive directory.

2) When a file with a matching name is received, the new file is given a different name (a concatenation of a temporary file name from the system and the files actual name, so that the file's extension is preserved).

See the "Note" under the description of `MdpSessionSetArchiveDirectory()` concerning the longevity of this type of functionality within the MDP transport protocol code base.

RETURN VALUES

A value of `MDP_ERROR_NONE` is returned upon success or `MDP_ERROR_SESSION_INVALID` is returned if the `sessionHandle` is not valid.

Function MdpSessionSetClientEmcon()

SYNOPSIS

```
#include <mdpApi.h>

MdpError MdpSessionSetClientEmcon(
                     MdpSessionHandle    sessionHandle,
                     bool                state);
```

DESCRIPTION

This function enables or disables an MDP client from operating in an EMCON (emissions-controlled, or uni-directional server->client transmission) mode of operation. The `sessionHandle` parameter identifies the applicable *MdpSession* and the `state` parameter enables EMCON operation if set to a value of *true* or disables it if set to a value of *false*. When EMCON operation is enabled, the following changes in MDP client behavior occur:

1) The client will not make *any* packet transmissions. Thus in EMCON mode, the client is entirely dependent upon robust transmissions by the server (through use of "auto parity" or redundant object transmission) as the client is prevented from sending NACK messages, ACK messages or any other kind of report. Therefore, servers should be carefully configured when operating in MdpSessions where clients may be operating in EMCON mode. Node that a mixture of clients operating with EMCON operation enabled or disabled is acceptable.

2) The MDP client changes the way it manages memory for buffering received objects. In normal (NACK-based) operation, an MDP client will buffer older received data in favor of new data when buffer space is limited under the presumption that the server will eventually respond to its NACK messages with repair (or send a SQUELCH command if repair of the object in question is no longer supported). However, when EMCON operation is enabled, the client buffers new data in favor of old data under the presumption that the server will not be retransmitting the old object data (since the client is unable to request repairs).

These capabilities allow for rudimentary support of EMCON operation among MDP servers and clients within an MdpSession. As concepts of operation for EMCON mature, the API and functionality in support of this capability will evolve.

RETURN VALUES

A value of MDP_ERROR_NONE is returned upon success or MDP_ERROR_SESSION_INVALID is returned if the sessionHandle is not valid.

6.0 MdpObject Management Functions

This section describes functions related to controlling and retrieving information concerning *MdpObjects* which are being transmitted or received. Most of these functions are most applicable during the reception of *MdpObjects* and are intended for use within the *MdpNotifyCallback* which the application installs for the MDP protocol engine. In general, the state referenced by MdpObjectHandles within the API is only valid during the actual transport of an MdpObject. For transmitted objects, this is from the time the object is queued for transmission until the MDP_NOTIFY_TX_OBJECT_FINISHED (or MDP_NOTIFY_OBJECT_DELETE) for the corresponding MdpObjectHandle notification occurs. For received objects, the MdpObjectHandle is valid from the time the MDP_RX_OBJECT_START notification occurs until the MDP_NOTIFY_RX_OBJECT_COMPLETE (or MDP_NOTIFY_OBJECT_DELETE) occurs. Use of these MDP API calls at inappropriate times can lead to a system error.

Table Q - Summary of MdpObject Management Functions

General routines:	
MdpObjectGetType()	Retrieves *MdpObject* type (MDP_DATA_OBJECT or MDP_FILE_OBJECT)
MdpObjectGetInfo()	Copies payload of MDP_INFO data associated with a given object.
MdpObjectGetSize()	Retrieves size of object in bytes.
MdpObjectGetRecvBytes()	Retrieves number of bytes currently received for a given object.
MdpObjectGetTransportId()	Retrieves the 32-bit transport identifier for an *MdpObject*.
MdpObjectGetSourceNodeId()	Retrieves the *MdpNodeId* of the source of an *MdpObject* being received.
MdpObjectSetNackingMode()	Set the client nacking behavior for the indicated *MdpObject*.
MDP_DATA_OBJECT routines:	

Table Q - Summary of MdpObject Management Functions	
MdpObjectSetData()	Assigns a data buffer to be used for reception of data content of an MDP_DATA_OBJECT.
MdpObjectGetData()	Retrieves pointer to the data content of an MDP_DATA_OBJECT.
MDP_FILE_OBJECT routines:	
MdpObjectGetFileName()	Retrieves the full file name, including path, of an MDP_FILE_OBJECT.

Function MdpObjectGetType()

SYNOPSIS

```
#include <mdpApi.h>

MdpObjectType MdpObjectGetType(MdpObjectHandle objectHandle);
```

DESCRIPTION

This function returns the object type for *MdpObject* indicated by the `objectHandle` parameter. The types currently supported include:

MDP_DATA_OBJECT	Static memory-resident block of data to be transported by the MDP protocol.
MDP_FILE_OBJECT	*MdpObject* representing a disk-based file to be transported by the MDP protocol.
MDP_SIM_OBJECT	Null object used for representation of transport objects of different sizes for simulations conducted with the ns-2 or OPNET network simulation models supported in the MDP code base.

RETURN VALUES

The type of *MdpObject* is returned. If an invalid `MdpObjectHandle` is used, a system error may occur. Thus, caution care must be taken to use this function at only the appropriate time as described in the introduction to this section.

Function MdpObjectGetInfo()

SYNOPSIS

```
#include <mdpApi.h>
```

```
bool MdpObjectGetInfo(MdpObjectHandle        objectHandle,
                      char*                  buffer,
                      unsigned short*        bufLen);
```

DESCRIPTION

This function copies the MDP_INFO (if available) associated with the *MdpObject* indicated by the objectHandle into the buffer provided by the caller. The value the bufLen parameter points to should be preset to contain the amount of space available (in bytes) in the buffer when the function is called. Upon return, the bufLen parameter will be adjusted to how many bytes were copied. Note: A function will be added to the API in the future so that the application may determine how many bytes of MDP_INFO are available for a given object.

RETURN VALUES

A value of *true* is return if MDP_INFO is available for the object and was copied. A value of *false* is returned if no MDP_INFO is available.

Function MdpObjectGetSize()

SYNOPSIS

```
#include <mdpApi.h>

unsigned long MdpObjectGetSize(MdpObjectHandle    objectHandle);
```

DESCRIPTION

This function returns the total size (in bytes) of the data content of the *MdpObject*. Identified by the objectHandle parameter.

RETURN VALUES

The total size of the *MdpObject* in bytes is returned. *MdpObjects* consisting of solely MDP_INFO will return a data content of size zero.

Function MdpObjectGetRecvBytes()

SYNOPSIS

```
#include <mdpApi.h>

unsigned long MdpObjectGetSize(MdpObjectHandle    objectHandle);
```

DESCRIPTION

This function returns the number of bytes of the data content currently received for the *MdpObject*. Identified by the objectHandle parameter. This function can be used by an application to monitor the reception progress of an object in transit. The returned value can

be compared with the value obtained using `MdpObjectGetSize()` to calculate the percentage of receive completion.

RETURN VALUES

The number of current received bytes for the *MdpObject* is returned.

Function MdpObjectGetTransportId()

SYNOPSIS

```
#include <mdpApi.h>

MdpObjectTransportId MdpObjectGetTransportId(
                        MdpObjectHandle     objectHandle);
```

DESCRIPTION

This function returns the MdpObjectTransportId for the MdpObject indicated by the `objectHandle` parameter. The intended use of this information is for use with the `MdpSessionRequeueTxObject()` function (this function is not yet implemented or documented) to allow redundant transmission of an *MdpObject* as part of a robust one-way, EMCON transmission scheme. This function may also be useful for application debugging when used in conjunction with the debug logging of the MDP protocol engine. More information will be provided as EMCON modes of operation for MDP are better defined in the future.

RETURN VALUES

The 32-bit `MdpObjectTransportId` for the *MdpObject* is returned.

Function MdpObjectGetSourceNodeId()

SYNOPSIS

```
#include <mdpApi.h>

MdpNodeId MdpObjectGetSourceNodeId(MdpObjectHandle     objectHand
                                                       le);
```

DESCRIPTION

This function returns the MdpNodeId of the source of the *MdpObject* indicated by the `objectHandle` parameter. The returned *MdpNodeId* is guaranteed to be valid only for the time during which *MdpObjectHandles* of *MdpObjects* being received from that source are valid (I.e. until MDP_NOTIFY_OBJECT_DELETE notifications are received for all *MdpObjects* pending reception from the *MdpServer*).

RETURN VALUES

The 32-bit *MdpNodeId* for the source of the *MdpObject* is returned. If the objectHandle value corresponds to an *MdpObject* being transmitted by the local *MdpServer*, a value of MDP_NULL_NODE is returned.

Function MdpObjectSetNackingMode()

SYNOPSIS

```
#include <mdpApi.h>

MdpError MdpObjectSetNackingMode(MdpObjectHandle       objectHand
                                                       le,
                                 MdpNackingMode   mode);
```

DESCRIPTION

This function controls the nacking behavior for a partially-received MdpObject indicated by the objectHandle parameter. Possible values for the MdpNackingMode include MDP_NACKING_NORMAL, MDP_NACKING_INFOONLY, and MDP_NACKING_NONE.

Setting the nacking behavior of individual receive MdpObjects allows the client application to customize its operation in an MDP multicast session. If receivers know they are not interested in reliably receiving some portion of the content of a transmitted object, they can reduce the overall level of traffic generated by the group by tuning their repair request behavior with this function call. If the client application is not at all interested (even unreliably) in receiving the indicated object, it should use the MdpSessionAbortRxObject() function.

The default *MdpNackingMode* for newly-received objects is determined from the client's *MdpNackingMode* value. See the MdpSessionSetClientNackingMode() description for more discussion on usage of these function calls.

RETURN VALUES

A value of MDP_ERROR_NONE is returned upon success. MDP_ERROR_OBJECT_INVALID is returned when the objectHandle parameter is MDP_NULL_OBJECT, but the application should take great care not to pass invalid *MdpObjectHandle's* to this (or other *MdpObject*) function calls.

Function MdpObjectSetData()

SYNOPSIS

```
#include <mdpApi.h>

MdpError MdpObjectSetData(MdpObjectHandle    objectHandle,
                          char*          dataPtr,
                          unsigned long dataSize);
```

DESCRIPTION

This function assigns a memory buffer for reception of an *MdpObject* of type MDP_DATA. This function can only be used for receive objects of type MDP_DATA. The appropriate use of this function is to assign a buffer to use for data reception when the MDP_NOTIFY_RX_OBJECT_START notification occurs. If a buffer is not assigned at this time, the MDP protocol will assume that the application does not wish to receive the object in question and will stop attempting to receive the data (state for the object will be deleted and no request for repairs will be made). The dataPtr parameter points to the block of memory in which to store the received MdpObject data content and the dataSize parameter is used to indicate the size of the memory block. If the value of the dataSize parameter is not of sufficient size to store the *MdpObject*, an error will be returned. Therefore, the application should first use the MdpObjectGetSize() function to determine the size of the object's data content. The application must not free this memory during object transport. Since the application is responsible for allocating and assigning the buffer space used for data reception, it is up to the application to manage this memory space after reception of the object has completed (or upon the MDP_NOTIFY_OBJECT_DELETE notification which occurs for both receive object completion or failure).

RETURN VALUES

A value of MDP_ERROR_NONE is returned upon success MDP_ERROR_OBJECT_INVALID is returned if the indicated object is not of type MDP_DATA_OBJECT and MDP_ERROR is returned if the dataSize is insufficient.

Function MdpObjectGetData()

SYNOPSIS

```
#include <mdpApi.h>

char* MdpObjectGetData(MdpObjectHandle       objectHandle,
                       unsigned long*        dataSize,
                       MdpError*             error);
```

DESCRIPTION

This function returns a pointer to the location of data content storage for an MdpObject of type MDP_DATA identified by the objectHandle parameter. The length (in bytes) of the object is copied to the location indicated by the dataSize parameter. This function is useful for applications wishing to take over management of the memory space after an MDP_NOTIFY_OBJECT_DELETE notification occurs or to make use of a received data object after the MDP_NOTIFY_RX_OBJECT_COMPLETE notification occurs. Note that the management of the memory space for objects of MDP_DATA_OBJECT is up to the application much the way the use of files sent or received is up to the application after reliable transport is complete.

RETURN VALUES

A pointer to the object data content storage is returned upon success. Otherwise, a value of NULL is returned and the error parameter is filled in with an appropriate MdpError code. This function is only applicable to *MdpObjects* of type MDP_DATA_OBJECT.

Function MdpObjectGetFileName()

SYNOPSIS

```
#include <mdpApi.h>

MdpError MdpObjectGetFileName(MdpObjectHandle     objectHandle,
                              char*               name,
                              int                 maxlen);
```

DESCRIPTION

This function copies the full file name for an object of type MDP_FILE_OBJECT. For received objects, this full name includes the path of the archive directory (see MdpSessionSetArchiveDirectory()) as well as the name received in the MDP_INFO content, if available. If no MDP_INFO was available for the object, the temporary name assigned by the MDP protocol engine is returned. This function may also be used for transmit objects if the application wishes. Again, the full name of the file is returned.

RETURN VALUES

A value of MDP_ERROR_NONE is returned upon success. This function is only applicable to *MdpObjects* of type MDP_FILE_OBJECT. A value of MDP_ERROR_OBJECT_INVALID is returned if this function is used on objects of other types.

7.0 Miscellaneous Functions

This section describes a number of functions which serve peripheral uses in the MDP API and do not clearly fit into the previous categories.

Function MdpSessionSetRecvDropRate()

SYNOPSIS

```
#include <mdpApi.h>

MdpError MdpSessionSetRecvDropRate(MdpSessionHandle    sessionHandle,
                                   double              percent);
```

DESCRIPTION

The MdpSessionSetRecvDropRate() function allows the application to specify the percent of artificially generated received packet loss (0-100%) in the *MdpSession* identified by sessionHandle. This is useful for testing purposes to simulate uncorrelated packet loss among receiving nodes. The default is zero artificial packet loss if this function is never called.

RETURN VALUES

The MdpSessionSetRecvDropRate() function will return a value of MDP_ERROR_NONE if successful. The value MDP_ERROR_SESSION_INVALID is returned upon failure.

Function MdpSessionSetSendDropRate()

SYNOPSIS

```
#include <mdpApi.h>

MdpError  MdpSessionSetSendDropRate(MdpSessionHandle   sessionHan
                                                       dle,
                                    double        percent);
```

DESCRIPTION

The MdpSessionSetSendDropRate() function is used to specify the percent of artificially generated transmit packet drops (0-100%) to simulate correlated packet loss among receiving nodes for the *MdpSession* identified by the sessionHandle parameter. This is useful for protocol testing purposes. The default is zero artificial packet loss if this function is never called.

RETURN VALUE

The MdpSessionSetSendDropRate() function will return a value of MDP_ERROR_NONE if successful. The value MDP_ERROR_SESSION_INVALID is returned upon failure.