Inter-Client Exchange Library

X Consortium Standard

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Inter-Client Exchange Library: X Consortium Standard

by Ralph Mor

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Chapter 1. Overview of ICE

There are numerous possible inter-client protocols, with many similarities and common needs - authentication, version negotiation, byte order negotiation, and so on. The Inter-Client Exchange (ICE) protocol is intended to provide a framework for building such protocols, allowing them to make use of common negotiation mechanisms and to be multiplexed over a single transport connection.

Chapter 2. The ICE Library - C Language Interface to ICE

A client that wishes to utilize ICE must first register the protocols it understands with the ICE library. Each protocol is dynamically assigned a major opcode ranging from 1-255 (two clients can use different major opcodes for the same protocol). The next step for the client is either to open a connection with another client or to wait for connections made by other clients. Authentication may be required. A client can both initiate connections with other clients and be waiting for clients to connect to itself (a nested session manager is an example). Once an ICE connection is established between the two clients, one of the clients needs to initiate a `ProtocolSetup` in order to "activate" a given protocol. Once the other client accepts the `ProtocolSetup` (once again, authentication may be required), the two clients are ready to start passing messages specific to that protocol to each other. Multiple protocols may be active on a single ICE connection. Clients are responsible for notifying the ICE library when a protocol is no longer active on an ICE connection, although ICE does not define how each subprotocol triggers a protocol shutdown.

The ICE library utilizes callbacks to process incoming messages. Using callbacks allows `ProtocolSetup` messages and authentication to happen behind the scenes. An additional benefit is that messages never need to be buffered up by the library when the client blocks waiting for a particular message.

Chapter 3. Intended Audience

This document is intended primarily for implementors of protocol libraries layered on top of ICE. Typically, applications that wish to utilize ICE will make calls into individual protocol libraries rather than directly make calls into the ICE library. However, some applications will have to make some initial calls into the ICE library in order to accept ICE connections (for example, a session manager accepting connections from clients). But in general, protocol libraries should be designed to hide the inner details of ICE from applications.

Chapter 4. Header Files and Library Name

The header file <X11/ICE/ICElib.h> defines all of the ICElib data structures and function prototypes. `ICElib.h` includes the header file <X11/ICE/ICE.h>, which defines all of the ICElib constants. Protocol libraries that need to read and write messages should include the header file <X11/ICE/ICEmsg.h>.

Applications should link against ICElib using -lICE.

Chapter 5. Note on Prefixes

The following name prefixes are used in the library to distinguish between a client that initiates a `ProtocolSetup` and a client that responds with a `ProtocolReply`

- `IcePo` - Ice Protocol Originator
- `IcePa` - Ice Protocol Acceptor

Chapter 6. Protocol Registration

In order for two clients to exchange messages for a given protocol, each side must register the protocol with the ICE library. The purpose of registration is for each side to obtain a major opcode for the protocol and to provide callbacks for processing messages and handling authentication. There are two separate registration functions:

- One to handle the side that does a `ProtocolSetup`
- One to handle the side that responds with a `ProtocolReply`

It is recommended that protocol registration occur before the two clients establish an ICE connection. If protocol registration occurs after an ICE connection is created, there can be a brief interval of time in which a `ProtocolSetup` is received, but the protocol is not registered. If it is not possible to register a protocol before the creation of an ICE connection, proper precautions should be taken to avoid the above race condition.

The `IceRegisterForProtocolSetup` function should be called for the client that initiates a `ProtocolSetup`

`int` **`IceRegisterForProtocolSetup`**`(` *`*protocol_name`*`,` *`*vendor`*`,` *`*release`*`,` *`version_count`*`,` *`*version_recs`*`,` *`auth_count`*`,` *`**auth_names`*`,` *`*auth_procs`*`,` *`io_error_proc`*`);`

protocol_name	A string specifying the name of the protocol to register.
vendor	A vendor string with semantics specified by the protocol.
release	A release string with semantics specified by the protocol.
version_count	The number of different versions of the protocol supported.
version_recs	List of versions and associated callbacks.
auth_count	The number of authentication methods supported.
auth_names	The list of authentication methods supported.
auth_procs	The list of authentication callbacks, one for each authentication method.
io_error_proc	IO error handler, or NULL.

`IceRegisterForProtocolSetup` returns the major opcode reserved or -1 if an error occurred. In order to actually activate the protocol, the `IceProtocolSetup` function needs to be called with this major opcode. Once the protocol is activated, all messages for the protocol should be sent using this major opcode.

A protocol library may support multiple versions of the same protocol. The version_recs argument specifies a list of supported versions of the protocol, which are prioritized in decreasing order of preference. Each version record consists of a major and minor version of the protocol as well as a callback to be used for processing incoming messages.

```
typedef struct {
 int major_version;
 int minor_version;
 IcePoProcessMsgProc process_msg_proc;
} IcePoVersionRec;
```

The `IcePoProcessMsgProc` callback is responsible for processing the set of messages that can be received by the client that initiated the `ProtocolSetup` For further information, see Callbacks for Processing Messages

Authentication may be required before the protocol can become active. The protocol library must register the authentication methods that it supports with the ICE library. The auth_names and auth_procs arguments are a list of authentication names and callbacks that are prioritized in decreasing order of preference. For information on the `IcePoAuthProc` callback, see Authentication Methods

The `IceIOErrorProc` callback is invoked if the ICE connection unexpectedly breaks. You should pass NULL for io_error_proc if not interested in being notified. For further information, *Error Handling*

The `IceRegisterForProtocolReply` function should be called for the client that responds to a `ProtocolSetup` with a `ProtocolReply`

`Bool` **`IceRegisterForProtocolReply`**`(` *`*protocol_name`*`,` *`*vendor`*`,` *`*release`*`,` *`version_count`*`,` *`*version_recs`*`,` *`auth_count`*`,` *`**auth_names`*`,` *`*auth_procs`*`,` *`host_based_auth_proc`*`,` *`protocol_setup_proc`*`,` *`protocol_activate_proc`*`,` *`io_error_proc`*`);`

protocol_name	A string specifying the name of the protocol to register.
vendor	A vendor string with semantics specified by the protocol.
release	A release string with semantics specified by the protocol.
version_count	The number of different versions of the protocol supported.
version_recs	List of versions and associated callbacks.
auth_count	The number of authentication methods supported.
auth_names	The list of authentication methods supported.
auth_procs	The list of authentication callbacks, one for each authentication method.
host_based_auth_proc	Host based authentication callback.
protocol_setup_proc	A callback to be invoked when authentication has succeeded for a `ProtocolSetup` but before the `ProtocolReply` is sent.
protocol_activate_proc	A callback to be invoked after the `ProtocolReply` is sent.

io_error_proc	IO error handler, or NULL.

`IceRegisterForProtocolReply` returns the major opcode reserved or -1 if an error occurred. The major opcode should be used in all subsequent messages sent for this protocol.

A protocol library may support multiple versions of the same protocol. The version_recs argument specifies a list of supported versions of the protocol, which are prioritized in decreasing order of preference. Each version record consists of a major and minor version of the protocol as well as a callback to be used for processing incoming messages.

```
typedef struct {
 int major_version;
 int minor_version;
 IcePaProcessMsgProc process_msg_proc;
} IcePaVersionRec;
```

The `IcePaProcessMsgProc` callback is responsible for processing the set of messages that can be received by the client that accepted the `ProtocolSetup` For further information, see Callbacks for Processing Messages

Authentication may be required before the protocol can become active. The protocol library must register the authentication methods that it supports with the ICE library. The auth_names and auth_procs arguments are a list of authentication names and callbacks that are prioritized in decreasing order of preference. For information on the `IcePaAuthProc`, See Authentication Methods

If authentication fails and the client attempting to initiate the `ProtocolSetup` has not required authentication, the `IceHostBasedAuthProc` callback is invoked with the host name of the originating client. If the callback returns `True` the `ProtocolSetup` will succeed, even though the original authentication failed. Note that authentication can effectively be disabled by registering an `IceHostBasedAuthProc` which always returns `True` If no host based authentication is allowed, you should pass NULL for host_based_auth_proc.

`Bool` **`HostBasedAuthProc`**`(` *`*host_name`*`);`

protocol_name The host name of the client that sent the `ProtocolSetup`

The host_name argument is a string of the form *protocol/hostname*, where *protocol* is one of {tcp, decnet, local}.

Because `ProtocolSetup` messages and authentication happen behind the scenes via callbacks, the protocol library needs some way of being notified when the `ProtocolSetup` has completed. This occurs in two phases. In the first phase, the `IceProtocolSetupProc` callback is invoked after authentication has successfully completed but before the ICE library sends a `ProtocolReply` Any resources required for this protocol should be allocated at this time. If the `IceProtocolSetupProc` returns a successful status, the ICE library will send the `ProtocolReply` and then invoke the `IceProtocolActivateProc` callback. Otherwise, an error will be sent to the other client in response to the `ProtocolSetup`

The `IceProtocolActivateProc` is an optional callback and should be registered only if the protocol library intends to generate a message immediately following the

`ProtocolReply` You should pass NULL for protocol_activate_proc if not interested in this callback.

`Status` **`ProtocolSetupProc`**`(` *`ice_conn`*`,` *`major_version`*`,` *`minor_version`*`,` *`*vendor`*`,` *`*release`*`,` *`*client_data_ret`*`,` *`**failure_reason_ret`*`);`

protocol_name	The ICE connection object.
major_version	The major version of the protocol.
minor_version	The minor version of the protocol.
vendor	The vendor string registered by the protocol originator.
release	The release string registered by the protocol originator.
client_data_ret	Client data to be set by callback.
failure_reason_ret	Failure reason returned.

The pointer stored in the client_data_ret argument will be passed to the `IcePaProcessMsgProc` callback whenever a message has arrived for this protocol on the ICE connection.

The vendor and release strings should be freed with `free` when they are no longer needed.

If a failure occurs, the `IceProtocolSetupProc` should return a zero status as well as allocate and return a failure reason string in failure_reason_ret. The ICE library will be responsible for freeing this memory.

The `IceProtocolActivateProc` callback is defined as follows:

`void` **`ProtocolActivateProc`**`(` *`ice_conn`*`,` *`client_data`*`);`

ice_conn	The ICE connection object.
client_data	The client data set in the `IceProtocolSetupProc` callback.

The `IceIOErrorProc` callback is invoked if the ICE connection unexpectedly breaks. You should pass NULL for io_error_proc if not interested in being notified. For further information, see *Error Handling*

Callbacks for Processing Messages

When an application detects that there is new data to read on an ICE connection (via `select` it calls the `IceProcessMessages` function *Processing Messages* When `IceProcessMessages` reads an ICE message header with a major opcode other than zero (reserved for the ICE protocol), it needs to call a function that will read the rest of the message, unpack it, and process it accordingly.

If the message arrives at the client that initiated the `ProtocolSetup` the `IcePoProcessMsgProc` callback is invoked.

`void` **`PoProcessMsgProc`**`(` *`ice_conn`*`,` *`client_data`*`,` *`opcode`*`,` *`length`*`,` *`swap`*`,` *`*reply_wait`*`,` *`*reply_ready_ret`*`);`

ice_conn	The ICE connection object.
client_data	Client data associated with this protocol on the ICE connection.
opcode	The minor opcode of the message.
length	The length (in 8-byte units) of the message beyond the ICE header.
swap	A flag that indicates if byte swapping is necessary.
reply_wait	Indicates if the invoking client is waiting for a reply.
reply_ready_ret	If set to `True` a reply is ready.

If the message arrives at the client that accepted the `ProtocolSetup` the `IcePaProcessMsgProc` callback is invoked.

`void` **`IcePaProcessMsgProc`**`(` *`ice_conn`*`,` *`client_data`*`,` *`opcode`*`,` *`length`*`,` *`swap`*`);`

ice_conn	The ICE connection object.
client_data	Client data associated with this protocol on the ICE connection.
opcode	The minor opcode of the message.
length	The length (in 8-byte units) of the message beyond the ICE header.
swap	A flag that indicates if byte swapping is necessary.

In order to read the message, both of these callbacks should use the macros defined for this purpose (see Reading ICE Messages.). Note that byte swapping may be necessary. As a convenience, the length field in the ICE header will be swapped by ICElib if necessary.

In both of these callbacks, the client_data argument is a pointer to client data that was registered at `ProtocolSetup` time. In the case of `IcePoProcessMsgProc` the client data was set in the call to `IceProtocolSetup` In the case of `IcePaProcessMsgProc` the client data was set in the `IceProtocolSetupProc` callback.

The `IcePoProcessMsgProc` callback needs to check the reply_wait argument. If reply_wait is NULL , the ICE library expects the function to pass the message to the client via a callback. For example, if this is a Session Management "Save Yourself" message, this function should notify the client of the "Save Yourself" via a callback. The details of how such a callback would be defined are implementation-dependent.

However, if reply_wait is not NULL , then the client is waiting for a reply or an error for a message it previously sent. The reply_wait is of type `IceReplyWaitInfo`

```
typedef struct {
 unsigned long sequence_of_request;
 int major_opcode_of_request;
 int minor_opcode_of_request;
 IcePointer reply;
} IceReplyWaitInfo;
```

`IceReplyWaitInfo` contains the major/minor opcodes and sequence number of the message for which a reply is being awaited. It also contains a pointer to the reply message to be filled in (the protocol library should cast this `IcePointer` to the appropriate reply type). In most cases, the reply will have some fixed-size part, and the client waiting for the reply will have provided a pointer to a structure to hold this fixed-size data. If there is variable-length data, it would be expected that the `IcePoProcessMsgProc` callback will have to allocate additional memory and store pointer(s) to that memory in the fixed-size structure. If the entire data is variable length (for example., a single variable-length string), then the client waiting for the reply would probably just pass a pointer to fixed-size space to hold a pointer, and the `IcePoProcessMsgProc` callback would allocate the storage and store the pointer. It is the responsibility of the client receiving the reply to free any memory allocated on its behalf.

If reply_wait is not NULL and `IcePoProcessMsgProc` has a reply or error to return in response to this reply_wait (that is, no callback was generated), then the reply_ready_ret argument should be set to `True` Note that an error should only be returned if it corresponds to the reply being waited for. Otherwise, the `IcePoProcessMsgProc` should either handle the error internally or invoke an error handler for its library.

If reply_wait is NULL, then care must be taken not to store any value in reply_ready_ret, because this pointer may also be NULL.

The `IcePaProcessMsgProc` callback, on the other hand, should always pass the message to the client via a callback. For example, if this is a Session Management "Interact Request" message, this function should notify the client of the "Interact Request" via a callback.

The reason the `IcePaProcessMsgProc` callback does not have a reply_wait, like `IcePoProcessMsgProc` does, is because a process that is acting as a server should never block for a reply (infinite blocking can occur if the connecting client does not act properly, denying access to other clients).

Authentication Methods

As already stated, a protocol library must register the authentication methods that it supports with the ICE library. For each authentication method, there are two callbacks that may be registered:

- One to handle the side that initiates a `ProtocolSetup`
- One to handle the side that accepts or rejects this request

`IcePoAuthProc` is the callback invoked for the client that initiated the `ProtocolSetup` This callback must be able to respond to the initial "Authentication Required" message or subsequent "Authentication Next Phase" messages sent by the other client.

`IcePoAuthStatus` **`IcePoAuthStatus`** `(` *`ice_conn`*`,` *`client_data`*`,` *`opcode`*`);`

ice_conn	The ICE connection object.
auth_state_ptr	A pointer to state for use by the authentication callback procedure.

clean_up	If `True` authentication is over, and the function should clean up any state it was maintaining. The last 6 arguments should be ignored.
swap	If `True` the auth_data may have to be byte swapped (depending on its contents).
auth_datalen	The length (in bytes) of the authenticator data.
auth_data	The data from the authenticator.
reply_datalen_ret	The length (in bytes) of the reply data returned.
reply_data_ret	The reply data returned.
error_string_ret	If the authentication procedure encounters an error during authentication, it should allocate and return an error string.

Authentication may require several phases, depending on the authentication method. As a result, the `IcePoAuthProc` may be called more than once when authenticating a client, and some state will have to be maintained between each invocation. At the start of each `ProtocolSetup` *auth_state_ptr is NULL, and the function should initialize its state and set this pointer. In subsequent invocations of the callback, the pointer should be used to get at any state previously stored by the callback.

If needed, the network ID of the client accepting the `ProtocolSetup` can be obtained by calling the `IceConnectionString` function.

ICElib will be responsible for freeing the reply_data_ret and error_string_ret pointers with `free`

The auth_data pointer may point to a volatile block of memory. If the data must be kept beyond this invocation of the callback, be sure to make a copy of it.

The `IcePoAuthProc` should return one of four values:

- `IcePoAuthHaveReply` - a reply is available.
- `IcePoAuthRejected` - authentication rejected.
- `IcePoAuthFailed` - authentication failed.
- `IcePoAuthDoneCleanup` - done cleaning up.

`IcePaAuthProc` is the callback invoked for the client that received the `ProtocolSetup`

`IcePoAuthStatus` **PoAuthStatus** (*ice_conn*, **auth_state_ptr*, *swap*, *auth_datalen*, *auth_data*, **reply_datalen_ret*, **reply_data_ret*, ***error_string_ret*);

ice_conn	The ICE connection object.
auth_state_ptr	A pointer to state for use by the authentication callback procedure.

swap	If `True` auth_data may have to be byte swapped (depending on its contents).
auth_datalen	The length (in bytes) of the protocol originator authentication data.
auth_data	The authentication data from the protocol originator.
reply_datalen_ret	The length of the authentication data returned.
reply_data_ret	The authentication data returned.
error_string_ret	If authentication is rejected or fails, an error string is returned.

Authentication may require several phases, depending on the authentication method. As a result, the `IcePaAuthProc` may be called more than once when authenticating a client, and some state will have to be maintained between each invocation. At the start of each `ProtocolSetup` auth_datalen is zero, *auth_state_ptr is NULL, and the function should initialize its state and set this pointer. In subsequent invocations of the callback, the pointer should be used to get at any state previously stored by the callback.

If needed, the network ID of the client accepting the `ProtocolSetup` can be obtained by calling the `IceConnectionString` function.

The auth_data pointer may point to a volatile block of memory. If the data must be kept beyond this invocation of the callback, be sure to make a copy of it.

ICElib will be responsible for transmitting and freeing the reply_data_ret and error_string_ret pointers with `free`

The `IcePaAuthProc` should return one of four values:

- `IcePaAuthContinue` - continue (or start) authentication.
- `IcePaAuthAccepted` - authentication accepted.
- `IcePaAuthRejected` - authentication rejected.
- `IcePaAuthFailed` - authentication failed.

Chapter 7. ICE Connections

In order for two clients to establish an ICE connection, one client has to be waiting for connections, and the other client has to initiate the connection. Most clients will initiate connections, so we discuss that first.

Opening an ICE Connection

To open an ICE connection with another client (that is, waiting for connections), use `IceOpenConnection`

```
IceConn IceOpenConnection( *network_ids_list, context, must_authenticate, major_opcode_check, error_length, *error_string_ret);
```

network_ids_list	Specifies the network ID(s) of the other client.
context	A pointer to an opaque object or NULL. Used to determine if an ICE connection can be shared (see below).
must_authenticate	If `True` the other client may not bypass authentication.
major_opcode_check	Used to force a new ICE connection to be created (see below).
error_length	Length of the error_string_ret argument passed in.
error_string_ret	Returns a null-terminated error message, if any. The error_string_ret argument points to user supplied memory. No more than error_length bytes are used.

`IceOpenConnection` returns an opaque ICE connection object if it succeeds; otherwise, it returns NULL.

The network_ids_list argument contains a list of network IDs separated by commas. An attempt will be made to use the first network ID. If that fails, an attempt will be made using the second network ID, and so on. Each network ID has the following format:

tcp/<hostname>:<portnumber> or
decnet/<hostname>::<objname> or
local/<hostname>:<path>

Most protocol libraries will have some sort of open function that should internally make a call into `IceOpenConnection` When `IceOpenConnection` is called, it may be possible to use a previously opened ICE connection (if the target client is the same). However, there are cases in which shared ICE connections are not desired.

The context argument is used to determine if an ICE connection can be shared. If context is NULL, then the caller is always willing to share the connection. If context is not NULL, then the caller is not willing to use a previously opened ICE connection that has a different non-NULL context associated with it.

In addition, if major_opcode_check contains a nonzero major opcode value, a previously created ICE connection will be used only if the major opcode is not active on the connection. This can be used to force multiple ICE connections between two clients for the same protocol.

Any authentication requirements are handled internally by the ICE library. The method by which the authentication data is obtained is implementation-dependent. [1]

After `IceOpenConnection` is called, the client is ready to send a `ProtocolSetup` (provided that `IceRegisterForProtocolSetup` was called) or receive a `ProtocolSetup` (provided that `IceRegisterForProtocolReply` was called).

Listening for ICE Connections

Clients wishing to accept ICE connections must first call `IceListenForConnections` or `IceListenForWellKnownConnections` so that they can listen for connections. A list of opaque "listen" objects are returned, one for each type of transport method that is available (for example, Unix Domain, TCP, DECnet, and so on).

Normally clients will let ICElib allocate an available name in each transport and return listen objects. Such a client will then use `IceComposeNetworkIdList` to extract the chosen names and make them available to other clients for opening the connection. In certain cases it may be necessary for a client to listen for connections on pre-arranged transport object names. Such a client may use `IceListenForWellKnownConnections` to specify the names for the listen objects.

```
Status IceListenForConnections( *count_ret, **listen_objs_ret, error_length, *error_string_ret);
```

count_ret	Returns the number of listen objects created.
listen_objs_ret	Returns a list of pointers to opaque listen objects.
error_length	The length of the error_string_ret argument passed in.
error_string_ret	Returns a null-terminated error message, if any. The error_string_ret points to user supplied memory. No more than error_length bytes are used.

The return value of `IceListenForConnections` is zero for failure and a positive value for success.

```
Status IceListenForWellKnownConnections( *port_id, *count_ret, **listen_objs_ret, error_length, *error_string_ret);
```

port_id	Specifies the port identification for the address(es) to be opened. The value must not contain the slash ("/"> or comma (".") character; thse are reserved for future use.
count_ret	Returns the number of listen objects created.

---

[1] The X Consortium's ICElib implementation uses an .ICEauthority file (see Appendix A).

listen_objs_ret	Returns a list of pointers to opaque listen objects.
listen_objs_ret	Returns a list of pointers to opaque listen objects.
error_length	The length of the error_string_ret argument passed in.
error_string_ret	Returns a null-terminated error message, if any. The error_string_ret points to user supplied memory. No more than error_length bytes are used.

`IceListenForWellKnownConnections` constructs a list of network IDs by prepending each known transport to port_id and then attempts to create listen objects for the result. Port_id is the portnumber, objname, or path portion of the ICE network ID. If a listen object for a particular network ID cannot be created the network ID is ignored. If no listen objects are created `IceListenForWellKnownConnections` returns failure.

The return value of `IceListenForWellKnownConnections` is zero for failure and a positive value for success.

To close and free the listen objects, use `IceFreeListenObjs`

```
void IceFreeListenObjs( count,  *listen_objs);
```

count	The number of listen objects.
listen_objs	The listen objects.

To detect a new connection on a listen object, use `select` on the descriptor associated with the listen object.

To obtain the descriptor, use `IceGetListenConnectionNumber`

```
int IceGetListenConnectionNumber( *listen_objs);
```

listen_obj	The listen objects.

To obtain the network ID string associated with a listen object, use `IceGetListenConnectionString`

```
char IceGetListenConnectionString( listen_obj);
```

listen_obj	The listen objects.

A network ID has the following format:

tcp/<hostname>:<portnumber>	or
decnet/<hostname>::<objname>	or
local/<hostname>:<path>	

To compose a string containing a list of network IDs separated by commas (the format recognized by `IceOpenConnection` use `IceComposeNetworkIdList` `char` **`IceComposeNetworkIdList`**`(` *`count`*`,` *`*listen_objs`*`);`

count	The number of listen objects.
listen_objs	The listen objects.

Host Based Authentication for ICE Connections

If authentication fails when a client attempts to open an ICE connection and the initiating client has not required authentication, a host based authentication procedure may be invoked to provide a last chance for the client to connect. Each listen object has such a callback associated with it, and this callback is set using the `IceSetHostBasedAuthProc` function.

`void` **`IceSetHostBasedAuthProc`**`(` *`listen_obj`*`,` *`host_based_auth_proc`*`);`

IceListenObj	The listen object.
host_based_auth_proc	The host based authentication procedure.

By default, each listen object has no host based authentication procedure associated with it. Passing NULL for host_based_auth_proc turns off host based authentication if it was previously set.

`Bool` **`HostBasedAuthProc`**`(` *`*host_name`*`);`

host_name	The host name of the client that tried to open an ICE connection.

The host_name argument is a string in the form *protocol*/ *hostname*, where *protocol* is one of {tcp, decnet, local}.

If `IceHostBasedAuthProc` returns `True` access will be granted, even though the original authentication failed. Note that authentication can effectively be disabled by registering an `IceHostBasedAuthProc` which always returns `True`

Host based authentication is also allowed at `ProtocolSetup` time. The callback is specified in the `IceRegisterForProtocolReply` function (see *Protocol Registration*).

Accepting ICE Connections

After a connection attempt is detected on a listen object returned by `IceListenForConnections` you should call `IceAcceptConnection` This returns a new opaque ICE connection object.

`IceConn` **`IceAcceptConnection`**`(` *`listen_obj`*`,` *`*status_ret`*`);`

listen_obj	The listen object on which a new connection was detected.
status_ret	Return status information.

The status_ret argument is set to one of the following values:

- `IceAcceptSuccess` - the accept operation succeeded, and the function returns a new connection object.
- `IceAcceptFailure` - the accept operation failed, and the function returns NULL.
- `IceAcceptBadMalloc` - a memory allocation failed, and the function returns NULL.

In general, to detect new connections, you should call `select` on the file descriptors associated with the listen objects. When a new connection is detected, the `IceAcceptConnection` function should be called. `IceAcceptConnection` may return a new ICE connection that is in a pending state. This is because before the connection can become valid, authentication may be necessary. Because the ICE library cannot block and wait for the connection to become valid (infinite blocking can occur if the connecting client does not act properly), the application must wait for the connection status to become valid.

The following pseudo-code demonstrates how connections are accepted:

```
new_ice_conn = IceAcceptConnection (listen_obj, &accept_status);
if (accept_status != IceAcceptSuccess)
{
     close the file descriptor and return
}

status = IceConnectionStatus (new_ice_conn);
time_start = time_now;

while (status == IceConnectPending)
{
     select() on {new_ice_conn, all open connections}

     for (each ice_conn in the list of open connections)
          if (data ready on ice_conn)
          {
               status = IceProcessMessages (ice_conn, NULL, NULL);
               if (status == IceProcessMessagesIOError)
                    IceCloseConnection(ice_conn);
          }
     if data ready on new_ice_conn
     {
          /*
          * IceProcessMessages is called until the connection
          * is non-pending.  Doing so handles the connection
          * setup request and any authentication requirements.
          */

          IceProcessMessages ( new_ice_conn, NULL, NULL);
          status = IceConnectionStatus (new_ice_conn);
     }
     else
     {
          if (time_now - time_start > MAX_WAIT_TIME)
               status = IceConnectRejected;
     }
```

```
}

if (status == IceConnectAccepted)
{
     Add new_ice_conn to the list of open connections
}
else
{
     IceCloseConnection
     new_ice_conn
}
```

After `IceAcceptConnection` is called and the connection has been validated, the client is ready to receive a `ProtocolSetup` (provided that `IceRegisterForProtocolReply` was called) or send a `ProtocolSetup` (provided that `IceRegisterForProtocolSetup` was called).

Closing ICE Connections

To close an ICE connection created with `IceOpenConnection` or `IceAcceptConnection` use `IceCloseConnection`

`IceCloseStatus` **`IceCloseConnection`**`(` *`ice_conn`*`);`

ice_conn The ICE connection to close.

To actually close an ICE connection, the following conditions must be met:

- The *open reference count* must have reached zero on this ICE connection. When `IceOpenConnection` is called, it tries to use a previously opened ICE connection. If it is able to use an existing connection, it increments the open reference count on the connection by one. So, to close an ICE connection, each call to `IceOpenConnection` must be matched with a call to `IceCloseConnection` The connection can be closed only on the last call to `IceCloseConnection`
- The *active protocol count* must have reached zero. Each time a `ProtocolSetup` succeeds on the connection, the active protocol count is incremented by one. When the client no longer expects to use the protocol on the connection, the `IceProtocolShutdown` function should be called, which decrements the active protocol count by one (see *Protocol Setup and Shutdown*).
- If shutdown negotiation is enabled on the connection, the client on the other side of the ICE connection must agree to have the connection closed.

  `IceCloseConnection` returns one of the following values:

- `IceClosedNow` - the ICE connection was closed at this time. The watch procedures were invoked and the connection was freed.
- `IceClosedASAP` - an IO error had occurred on the connection, but `IceCloseConnection` is being called within a nested `IceProcessMessages` The watch procedures have been invoked at this time, but the connection will be freed as soon as possible (when the nesting level reaches zero and `IceProcessMessages` returns a status of `IceProcessMessagesConnectionClosed`

- `IceConnectionInUse` - the connection was not closed at this time, because it is being used by other active protocols.
- `IceStartedShutdownNegotiation` - the connection was not closed at this time and shutdown negotiation started with the client on the other side of the ICE connection. When the connection is actually closed, `IceProcessMessages` will return a status of `IceProcessMessagesConnectionClosed`

When it is known that the client on the other side of the ICE connection has terminated the connection without initiating shutdown negotiation, the `IceSetShutdownNegotiation` function should be called to turn off shutdown negotiation. This will prevent `IceCloseConnection` from writing to a broken connection.

`void` **`IceSetShutdownNegotiation`**`(` *`ice_conn`*`,` *`negotiate`*`);`

ice_conn	A valid ICE connection object.
negotiate	If `False` shutdown negotiating will be turned off.

To check the shutdown negotiation status of an ICE connection, use `IceCheckShutdownNegotiation`

`Bool` **`IceCheckShutdownNegotiation`**`(` *`ice_conn`*`);`

ice_conn	A valid ICE connection object.

`IceCheckShutdownNegotiation` returns `True` if shutdown negotiation will take place on the connection; otherwise, it returns `False` Negotiation is on by default for a connection. It can only be changed with the `IceSetShutdownNegotiation` function.

Connection Watch Procedures

To add a watch procedure that will be called each time ICElib opens a new connection via `IceOpenConnection` or `IceAcceptConnection` or closes a connection via `IceCloseConnection` use `IceAddConnectionWatch`

`Status` **`IceAddConnectionWatch`**`(` *`watch_proc`*`,` *`client_data`*`);`

watch_proc	The watch procedure to invoke when ICElib opens or closes a connection.
client_data	This pointer will be passed to the watch procedure.

The return value of `IceAddConnectionWatch` is zero for failure, and a positive value for success.

Note that several calls to `IceOpenConnection` might share the same ICE connection. In such a case, the watch procedure is only invoked when the connection is first created (after authentication succeeds). Similarly, because connections might be shared, the watch procedure is called only if `IceCloseConnection` actually closes the connection (right before the IceConn is freed).

The watch procedures are very useful for applications that need to add a file descriptor to a select mask when a new connection is created and remove the file descriptor when the connection is destroyed. Because connections are shared, knowing when to add and remove the file descriptor from the select mask would be difficult without the watch procedures.

Multiple watch procedures may be registered with the ICE library. No assumptions should be made about their order of invocation.

If one or more ICE connections were already created by the ICE library at the time the watch procedure is registered, the watch procedure will instantly be invoked for each of these ICE connections (with the opening argument set to `True`

The watch procedure is of type `IceWatchProc`

`void` **`WatchProc`**`(` *`ice_conn`*`,` *`client_data`*`,` *`opening`*`,` *`*watch_data`*`);`

ice_conn	The opened or closed ICE connection. Call `IceConnectionNumber` to get the file descriptor associated with this connection.
client_data	Client data specified in the call to `IceAddConnectionWatch`
opening	If `True` the connection is being opened. If `False` the connection is being closed.
watch_data	Can be used to save a pointer to client data.

If opening is `True` the client should set the *watch_data pointer to any data it may need to save until the connection is closed and the watch procedure is invoked again with opening set to `False`

To remove a watch procedure, use `IceRemoveConnectionWatch`

`void` **`IceRemoveConnectionWatch`**`(` *`watch_proc`*`,` *`client_data`*`);`

watch_proc	The watch procedure that was passed to `IceAddConnectionWatch`
client_data	The client_data pointer that was passed to `IceAddConnectionWatch`

Chapter 8. Protocol Setup and Shutdown

To activate a protocol on a given ICE connection, use `IceProtocolSetup`

`IceProtocolSetupStatus` **`IceProtocolSetup`**`(` *`ice_conn`*`,` *`my_opcode`*`,` *`client_data`*`,` *`must_authenticate`*`,` *`*major_version_ret`*`,` *`*minor_version_ret`*`,` *`**vendor_ret`*`,` *`**release_ret`*`,` *`error_length`*`,` *`*error_string_ret`*`);`

ice_conn	A valid ICE connection object.
my_opcode	The major opcode of the protocol to be set up, as returned by `IceRegisterForProtocolSetup`
client_data	The client data stored in this pointer will be passed to the `IcePoProcessMsgProc` callback.
must_authenticate	If `True` the other client may not bypass authentication.
major_version_ret	The major version of the protocol to be used is returned.
minor_version_ret	The minor version of the protocol to be used is returned.
vendor_ret	The vendor string specified by the protocol acceptor.
release_ret	The release string specified by the protocol acceptor.
error_length	Specifies the length of the error_string_ret argument passed in.
error_string_ret	Returns a null-terminated error message, if any. The error_string_ret argument points to user supplied memory. No more than error_length bytes are used.

The vendor_ret and release_ret strings should be freed with `free` when no longer needed.

`IceProtocolSetup` returns one of the following values:

- `IceProtocolSetupSuccess` - the major_version_ret, minor_version_ret, vendor_ret, release_ret are set.
- `IceProtocolSetupFailure` or `IceProtocolSetupIOError` - check error_string_ret for failure reason. The major_version_ret, minor_version_ret, vendor_ret, release_ret are not set.
- `IceProtocolAlreadyActive` - this protocol is already active on this connection. The major_version_ret, minor_version_ret, vendor_ret, release_ret are not set.

To notify the ICE library when a given protocol will no longer be used on an ICE connection, use `IceProtocolShutdown`

`Status` **`IceProtocolShutdown`**`(` *`ice_conn`*`,` *`major_opcode`*`);`

ice_conn	A valid ICE connection object.
major_opcode	The major opcode of the protocol to shut down.

The return value of `IceProtocolShutdown` is zero for failure and a positive value for success.

Failure will occur if the major opcode was never registered OR the protocol of the major opcode was never activated on the connection. By activated, we mean that a `ProtocolSetup` succeeded on the connection. Note that ICE does not define how each sub-protocol triggers a protocol shutdown.

Chapter 9. Processing Messages

To process incoming messages on an ICE connection, use `IceProcessMessages`

`IceProcessMessagesStatus` **`IceProcessMessages`**`(` *`ice_conn`*`,` *`*reply_wait`*`,` *`*reply_ready_ret`*`);`

ice_conn	A valid ICE connection object.
reply_wait	Indicates if a reply is being waited for.
reply_ready_ret	If set to `True` on return, a reply is ready.

`IceProcessMessages` is used in two ways:

- In the first, a client may generate a message and block by calling `IceProcessMessages` repeatedly until it gets its reply.
- In the second, a client calls `IceProcessMessages` with reply_wait set to NULL in response to `select` showing that there is data to read on the ICE connection. The ICE library may process zero or more complete messages. Note that messages that are not blocked for are always processed by invoking callbacks.

`IceReplyWaitInfo` contains the major/minor opcodes and sequence number of the message for which a reply is being awaited. It also contains a pointer to the reply message to be filled in (the protocol library should cast this `IcePointer` to the appropriate reply type). In most cases, the reply will have some fixed-size part, and the client waiting for the reply will have provided a pointer to a structure to hold this fixed-size data. If there is variable-length data, it would be expected that the `IcePoProcessMsgProc` callback will have to allocate additional memory and store pointer(s) to that memory in the fixed-size structure. If the entire data is variable length (for example, a single variable-length string), then the client waiting for the reply would probably just pass a pointer to fixed-size space to hold a pointer, and the `IcePoProcessMsgProc` callback would allocate the storage and store the pointer. It is the responsibility of the client receiving the reply to free up any memory allocated on its behalf.

```
typedef struct {
     unsigned long sequence_of_request;
     int major_opcode_of_request;
     int minor_opcode_of_request;
     IcePointer reply;
} IceReplyWaitInfo;
```

If reply_wait is not NULL and `IceProcessMessages` has a reply or error to return in response to this reply_wait (that is, no callback was generated), then the reply_ready_ret argument will be set to `True`

If reply_wait is NULL, then the caller may also pass NULL for reply_ready_ret and be guaranteed that no value will be stored in this pointer.

`IceProcessMessages` returns one of the following values:

- `IceProcessMessagesSuccess` - no error occurred.

- `IceProcessMessagesIOError` - an IO error occurred, and the caller must explicitly close the connection by calling `IceCloseConnection`
- `IceProcessMessagesConnectionClosed` - the ICE connection has been closed (closing of the connection was deferred because of shutdown negotiation, or because the `IceProcessMessages` nesting level was not zero). Do not attempt to access the ICE connection at this point, since it has been freed.

Chapter 10. Ping

To send a "Ping" message to the client on the other side of the ICE connection, use `IcePing`

`Status` **`IcePing`**`(` *`ice_conn`*`,` *`ping_reply_proc`*`,` *`client_data`*`);`

ice_conn	A valid ICE connection object.
ping_reply_proc	The callback to invoke when the Ping reply arrives.
client_data	This pointer will be passed to the `IcePingReplyProc` callback.

`IcePing` returns zero for failure and a positive value for success.

When `IceProcessMessages` processes the Ping reply, it will invoke the `IcePingReplyProc` callback.

`void` **`PingReplyProc`**`(` *`ice_conn`*`,` *`client_data`*`);`

ice_conn	A valid ICE connection object.
client_data	The client data specified in the call to `IcePing`

Chapter 11. Using ICElib Informational Functions

`IceConnectStatus` **`IceConnectionStatus`**`(` *`ice_conn`*`);`

`IceConnectionStatus` returns the status of an ICE connection. The possible return values are:

- `IceConnectPending` - the connection is not valid yet (that is, authentication is taking place). This is only relevant to connections created by `IceAcceptConnection`
- `IceConnectAccepted` - the connection has been accepted. This is only relevant to connections created by `IceAcceptConnection`
- `IceConnectRejected` - the connection had been rejected (that is, authentication failed). This is only relevant to connections created by `IceAcceptConnection`
- `IceConnectIOError` - an IO error has occurred on the connection.

`char` **`*IceVendor`**`(` *`ice_conn`*`);`

`IceVendor` returns the ICE library vendor identification for the other side of the connection. The string should be freed with a call to `free` when no longer needed.

`char` **`*IceRelease`**`(` *`ice_conn`*`);`

`IceRelease` returns the release identification of the ICE library on the other side of the connection. The string should be freed with a call to `free` when no longer needed.

`int` **`IceProtocolVersion`**`(` *`ice_conn`*`);`

`IceProtocolVersion` returns the major version of the ICE protocol on this connection.

`int` **`IceProtocolRevision`**`(` *`ice_conn`*`);`

`IceProtocolRevision` returns the minor version of the ICE protocol on this connection.

`int` **`IceConnectionNumber`**`(` *`ice_conn`*`);`

`IceConnectionNumber` returns the file descriptor of this ICE connection.

`char` **`*IceConnectionString`**`(` *`ice_conn`*`);`

`IceConnectionString` returns the network ID of the client that accepted this connection. The string should be freed with a call to `free` when no longer needed.

`unsigned long` **`IceLastSentSequenceNumber`**`(` *`ice_conn`*`);`

`IceLastSentSequenceNumber` returns the sequence number of the last message sent on this ICE connection.

`unsigned long` **`IceLastReceivedSequenceNumber`**`(` *`ice_conn`*`);`

`IceLastReceivedSequenceNumber` returns the sequence number of the last message received on this ICE connection.

`Bool` **`IceSwapping`**`(` *`ice_conn`*`);`

`IceSwapping` returns `True` if byte swapping is necessary when reading messages on the ICE connection.

`IcePointer` **`IceGetContext`**`(` *`ice_conn`*`);`

`IceGetContext` returns the context associated with a connection created by `IceOpenConnection`

Chapter 12. ICE Messages

All ICE messages have a standard 8-byte header. The ICElib macros that read and write messages rely on the following naming convention for message headers:

```
CARD8 major_opcode;
CARD8 minor_opcode;
CARD8 data[2];
CARD32 length B32;
```

The 3rd and 4th bytes of the message header can be used as needed. The length field is specified in units of 8 bytes.

Sending ICE Messages

The ICE library maintains an output buffer used for generating messages. Protocol libraries layered on top of ICE may choose to batch messages together and flush the output buffer at appropriate times.

If an IO error has occurred on an ICE connection, all write operations will be ignored. For further information, see *Error Handling*.

To get the size of the ICE output buffer, use `IceGetOutBufSize`

`int` **`IceGetOutBufSize`**`(` *`ice_conn`*`);`

ice_conn	A valid ICE connection object.

To flush the ICE output buffer, use `IceFlush`

`int` **`IceFlush`**`(` *`ice_conn`*`);`

ice_conn	A valid ICE connection object.

Note that the output buffer may be implicitly flushed if there is insufficient space to generate a message.

The following macros can be used to generate ICE messages:

`IceGetHeader``(` *`ice_conn`*`,` *`major_opcode`*`,` *`minor_opcode`*`,` *`header_size`*`,` *`*pmsg`*`);`

ice_conn	A valid ICE connection object.
major_opcode	The major opcode of the message.
minor_opcode	The minor opcode of the message.
header_size	The size of the message header (in bytes).
<C_data_type>	The actual C data type of the message header.
pmsg	The message header pointer. After this macro is called, the library can store data in the message header.

`IceGetHeader` is used to set up a message header on an ICE connection. It sets the major and minor opcodes of the message, and initializes the message's length to the length of the header. If additional variable length data follows, the message's length field should be updated.

IceGetHeaderExtra(*ice_conn*, *major_opcode*, *minor_opcode*, *header_size*, *extra*, **pmsg*, **pdata*);

ice_conn	A valid ICE connection object.
major_opcode	The major opcode of the message.
minor_opcode	The minor opcode of the message.
header_size	The size of the message header (in bytes).
extra	The size of the extra data beyond the header (in 8-byte units).
<C_data_type>	The actual C data type of the message header.
pmsg	The message header pointer. After this macro is called, the library can store data in the message header.
pdata	Returns a pointer to the ICE output buffer that points immediately after the message header. The variable length data should be stored here. If there was not enough room in the ICE output buffer, pdata is set to NULL.

`IceGetHeaderExtra` is used to generate a message with a fixed (and relatively small) amount of variable length data. The complete message must fit in the ICE output buffer.

IceSimpleMessage(*ice_conn*, *major_opcode*, *minor_opcode*);

ice_conn	A valid ICE connection object.
major_opcode	The major opcode of the message.
minor_opcode	The minor opcode of the message.

`IceSimpleMessage` is used to generate a message that is identical in size to the ICE header message, and has no additional data.

IceErrorHeader(*ice_conn*, *offending_major_opcode*, *offending_minor_opcode*, *offending_sequence_num*, *severity*, *error_class*, *data_length*);

ice_conn	A valid ICE connection object.
offending_major_opcode	The major opcode of the protocol in which an error was detected.
offending_minor_opcode	The minor opcode of the protocol in which an error was detected.
offending_sequence_num	The sequence number of the message that caused the error.

severity	`IceCanContinue` `IceFatalToProtocol` or `IceFatalToConnection`
error_class	The error class.
data_length	Length of data (in 8-byte units) to be written after the header.

`IceErrorHeader` sets up an error message header.

Note that the two clients connected by ICE may be using different major opcodes for a given protocol. The offending_major_opcode passed to this macro is the major opcode of the protocol for the client sending the error message.

Generic errors, which are common to all protocols, have classes in the range 0x8000..0xFFFF. See the *Inter-Client Exchange Protocol* standard for more details.

IceBadMinor	0x8000
IceBadState	0x8001
IceBadLength	0x8002
IceBadValue	0x8003

Per-protocol errors have classes in the range 0x0000-0x7fff.

To write data to an ICE connection, use the `IceWriteData` macro. If the data fits into the ICE output buffer, it is copied there. Otherwise, the ICE output buffer is flushed and the data is directly sent.

This macro is used in conjunction with `IceGetHeader` and `IceErrorHeader`

`IceWriteData``(` *`ice_conn`*`,` *`bytes`*`,` *`*data`*`);`

ice_conn	A valid ICE connection object.
bytes	The number of bytes to write.
data	The data to write.

To write data as 16-bit quantities, use `IceWriteData16`

`IceWriteData16``(` *`ice_conn`*`,` *`bytes`*`,` *`*data`*`);`

ice_conn	A valid ICE connection object.
bytes	The number of bytes to write.
data	The data to write.

To write data as 32-bit quantities, use `IceWriteData32`

`IceWriteData32``(` *`ice_conn`*`,` *`bytes`*`,` *`*data`*`);`

ice_conn	A valid ICE connection object.
bytes	The number of bytes to write.
data	The data to write.

To write data as 32-bit quantities, use `IceWriteData32`

To bypass copying data to the ICE output buffer, use `IceSendData` to directly send data over the network connection. If necessary, the ICE output buffer is first flushed.

IceSendData(*ice_conn*, *bytes*, **data*);

ice_conn	A valid ICE connection object.
bytes	The number of bytes to send.
data	The data to send.

To force 32-bit or 64-bit alignment, use `IceWritePad` A maximum of 7 pad bytes can be specified.

IceWritePad(*ice_conn*, *bytes*, **data*);

ice_conn	A valid ICE connection object.
bytes	The number of bytes to write.
data	The number of pad bytes to write.

Reading ICE Messages

The ICE library maintains an input buffer used for reading messages. If the ICE library chooses to perform nonblocking reads (this is implementation-dependent), then for every read operation that it makes, zero or more complete messages may be read into the input buffer. As a result, for all of the macros described in this section that read messages, an actual read operation will occur on the connection only if the data is not already present in the input buffer.

To get the size of the ICE input buffer, use `IceGetInBufSize`

int **IceGetInBufSize**(*ice_conn*);

ice_conn	A valid ICE connection object.

When reading messages, care must be taken to check for IO errors. If any IO error occurs in reading any part of a message, the message should be thrown out. After using any of the macros described below for reading messages, the `IceValidIO` macro can be used to check if an IO error occurred on the connection. After an IO error has occurred on an ICE connection, all read operations will be ignored. For further information, see *Error Handling*.

Bool **IceValidIO**(*ice_conn*);

ice_conn	A valid ICE connection object.

The following macros can be used to read ICE messages.

IceReadSimpleMessage(*ice_conn*, **pmsg*);

ice_conn	A valid ICE connection object.
<C_data_type>	The actual C data type of the message header.

pmsg	This pointer is set to the message header.

`IceReadSimpleMessage` is used for messages that are identical in size to the 8-byte ICE header, but use the spare 2 bytes in the header to encode additional data. Note that the ICE library always reads in these first 8 bytes, so it can obtain the major opcode of the message. `IceReadSimpleMessage` simply returns a pointer to these 8 bytes; it does not actually read any data into the input buffer.

For a message with variable length data, there are two ways of reading the message. One method involves reading the complete message in one pass using `IceReadCompleteMessage` The second method involves reading the message header (note that this may be larger than the 8-byte ICE header), then reading the variable length data in chunks (see `IceReadMessageHeader` and `IceReadData`

IceReadCompleteMessage(*ice_conn*, *header_size*, **pmsg*, **pdata*);

ice_conn	A valid ICE connection object.
header_size	The size of the message header (in bytes).
<C_data_type>	The actual C data type of the message header.
pmsg	This pointer is set to the message header.
pdata	This pointer is set to the variable length data of the message.

If the ICE input buffer has sufficient space, `IceReadCompleteMessage` will read the complete message into the ICE input buffer. Otherwise, a buffer will be allocated to hold the variable length data. After the call, the pdata argument should be checked against NULL to make sure that there was sufficient memory to allocate the buffer.

After calling `IceReadCompleteMessage` and processing the message, `IceDisposeCompleteMessage` should be called.

IceDisposeCompleteMessage(*ice_conn*, **pdata*);

ice_conn	A valid ICE connection object.
pdata	The pointer to the variable length data returned in `IceReadCompleteMessage`

If a buffer had to be allocated to hold the variable length data (because it did not fit in the ICE input buffer), it is freed here by ICElib.

IceReadMessageHeader(*ice_conn*, *header_size*, **pmsg*);

ice_conn	A valid ICE connection object.
header_size	The size of the message header (in bytes).
<C_data_type>	The actual C data type of the message header.
pmsg	This pointer is set to the message header.

`IceReadMessageHeader` reads just the message header. The rest of the data should be read with the `IceReadData` family of macros. This method of reading a message should be used when the variable length data must be read in chunks.

To read data directly into a user supplied buffer, use `IceReadData`

`IceReadData``(` *`ice_conn`*`,` *`bytes`*`,` *`*pdata`*`);`

ice_conn	A valid ICE connection object.
bytes	The number of bytes to read.
pdata	The data is read into this user supplied buffer.

To read data as 16-bit quantities, use `IceReadData16`

`IceReadData16``(` *`ice_conn`*`,` *`swap`*`,` *`bytes`*`,` *`*pdata`*`);`

ice_conn	A valid ICE connection object.
swap	If `True`, the values will be byte swapped.
bytes	The number of bytes to read.
pdata	The data is read into this user supplied buffer.

To read data as 32-bit quantities, use `IceReadData32`

`IceReadData32``(` *`ice_conn`*`,` *`swap`*`,` *`bytes`*`,` *`*pdata`*`);`

ice_conn	A valid ICE connection object.
swap	If `True`, the values will be byte swapped.
bytes	The number of bytes to read.
pdata	The data is read into this user supplied buffer.

To force 32-bit or 64-bit alignment, use `IceReadPad` A maximum of 7 pad bytes can be specified.

`IceReadPad``(` *`ice_conn`*`,` *`bytes`*`);`

ice_conn	A valid ICE connection object.
bytes	The number of pad bytes.

Chapter 13. Error Handling

There are two default error handlers in ICElib:

- One to handle typically fatal conditions (for example, a connection dying because a machine crashed)
- One to handle ICE-specific protocol errors

These error handlers can be changed to user-supplied routines if you prefer your own error handling and can be changed as often as you like.

To set the ICE error handler, use `IceSetErrorHandler`

`IceSetErrorHandler``(` *`ice_conn`*`,` *`bytes`*`);`

handler	The ICE error handler. You should pass NULL to restore the default handler.

`IceSetErrorHandler` returns the previous error handler.

The ICE error handler is invoked when an unexpected ICE protocol error (major opcode 0) is encountered. The action of the default handler is to print an explanatory message to `stderr` and if the severity is fatal, call `exit` with a nonzero value. If exiting is undesirable, the application should register its own error handler.

Note that errors in other protocol domains should be handled by their respective libraries (these libraries should have their own error handlers).

An ICE error handler has the type of `IceErrorHandler`

`void` **`IceErrorHandler`**`(` *`ice_conn`*`,` *`swap`*`,` *`offending_minor_opcode`*`,` *`offending_sequence_num`*`,` *`error_class`*`,` *`severity`*`,` *`values`*`);`

handler	The ICE connection object.
swap	A flag that indicates if the values need byte swapping.
offending_minor_opcode	The ICE minor opcode of the offending message.
offending_sequence_num	The sequence number of the offending message.
error_class	The error class of the offending message.
severity	`IceCanContinue` `IceFatalToProtocol` or `IceFatalToConnection`
values	Any additional error values specific to the minor opcode and class.

The following error classes are defined at the ICE level:

```
IceBadMinor
IceBadState
IceBadLength
```

```
IceBadValue
IceBadMajor
IceNoAuth
IceNoVersion
IceSetupFailed
IceAuthRejected
IceAuthFailed
IceProtocolDuplicate
IceMajorOpcodeDuplicate
IceUnknownProtocol
```

For further information, see the *Inter-Client Exchange Protocol* standard.

To handle fatal I/O errors, use `IceSetIOErrorHandler`

`IceIOErrorHandler` **`IceSetIOErrorHandler`**`(` *`handler`*`);`

handler	The I/O error handler. You should pass NULL to restore the default handler.

`IceSetIOErrorHandler` returns the previous IO error handler.

An ICE I/O error handler has the type of `IceIOErrorHandler`

`void` **`IceIOErrorHandler`**`(` *`ice_conn`*`);`

ice_conn	The ICE connection object.

There are two ways of handling IO errors in ICElib:

- In the first, the IO error handler does whatever is necessary to respond to the IO error and then returns, but it does not call `IceCloseConnection` The ICE connection is given a "bad IO" status, and all future reads and writes to the connection are ignored. The next time `IceProcessMessages` is called it will return a status of `IceProcessMessagesIOError` At that time, the application should call `IceCloseConnection`
- In the second, the IO error handler does call `IceCloseConnection` and then uses the `longjmp` call to get back to the application's main event loop. The `setjmp` and `longjmp` calls may not work properly on all platforms, and special care must be taken to avoid memory leaks. Therefore, this second model is less desirable.

Before the application I/O error handler is invoked, protocol libraries that were interested in being notified of I/O errors will have their `IceIOErrorProc` handlers invoked. This handler is set up in the protocol registration functions (see `IceRegisterForProtocolSetup` and `IceRegisterForProtocolReply` and could be used to clean up state specific to the protocol.

`void` **`IceIOErrorProc`**`(` *`ice_conn`*`);`

ice_conn	The ICE connection object.

Note that every `IceIOErrorProc` callback must return. This is required because each active protocol must be notified of the broken connection, and the application IO error handler must be invoked afterwards.

Chapter 14. Multi-Threading Support

To declare that multiple threads in an application will be using the ICE library, use `IceInitThreads`

Status IceInitThreads()

The `IceInitThreads` function must be the first ICElib function a multi-threaded program calls. It must complete before any other ICElib call is made. `IceInitThreads` returns a nonzero status if and only if it was able to initialize the threads package successfully. It is safe to call `IceInitThreads` more than once, although the threads package will only be initialized once.

Protocol libraries layered on top of ICElib will have to lock critical sections of code that access an ICE connection (for example, when generating messages). Two calls, which are generally implemented as macros, are provided:

```
void IceLockConn( ice_conn);
```

```
void IceUnlockConn( ice_conn);
```

ice_conn	The ICE connection object.

To keep an ICE connection locked across several ICElib calls, applications use `IceAppLockConn` and `IceAppUnlockConn`

```
void IceAppLockConn( ice_conn);
```

ice_conn	The ICE connection object.

The `IceAppLockConn` function completely locks out other threads using the connection until `IceAppUnlockConn` is called. Other threads attempting to use ICElib calls on the connection will block. If the program has not previously called `IceInitThreads` `IceAppLockConn` has no effect.

```
void IceAppUnlockConn( ice_conn);
```

ice_conn	The ICE connection object.

The `IceAppUnlockConn` function allows other threads to complete ICElib calls on the connection that were blocked by a previous call to `IceAppLockConn` from this thread. If the program has not previously called `IceInitThreads` `IceAppUnlockConn` has no effect.

Chapter 15. Miscellaneous Functions

To allocate scratch space (for example, when generating messages with variable data), use `IceAllocScratch` Each ICE connection has one scratch space associated with it. The scratch space starts off as empty and grows as needed. The contents of the scratch space is not guaranteed to be preserved after any ICElib function is called.

`char` **`*IceAllocScratch`**`(` *`ice_conn`*`,` *`size`*`);`

ice_conn	The ICE connection object.
size	The number of bytes required.

Note that the memory returned by `IceAllocScratch` should not be freed by the caller. The ICE library will free the memory when the ICE connection is closed.

Chapter 16. Acknowledgements

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Appendix A. Authentication Utility Functions

As discussed in this document, the means by which authentication data is obtained by the ICE library (for `ConnectionSetup` messages or `ProtocolSetup` messages) is implementation-dependent. [1]

This appendix describes some utility functions that manipulate an ICE authority file. The authority file can be used to pass authentication data between clients.

The basic operations on the .ICEauthority file are:

- Get file name
- Lock
- Unlock
- Read entry
- Write entry
- Search for entry

These are fairly low-level operations, and it is expected that a program, like "iceauth", would exist to add, remove, and display entries in the file.

In order to use these utility functions, the <X11/ICE/ICEutil.h> header file must be included.

An entry in the .ICEauthority file is defined by the following data structure:

```
typedef struct {
     char *protocol_name;
     unsigned short protocol_data_length;
     char *protocol_data;
     char *network_id;
     char *auth_name;
     unsigned short auth_data_length;
     char *auth_data;
} IceAuthFileEntry;
```

The protocol_name member is either "ICE" for connection setup authentication or the subprotocol name, such as "XSMP". For each entry, protocol specific data can be specified in the protocol_data member. This can be used to search for old entries that need to be removed from the file.

The network_id member is the network ID of the client accepting authentication (for example, the network ID of a session manager). A network ID has the following form:

---

[1] The X Consortium's ICElib implementation assumes the presence of an ICE authority file.

tcp/<hostname>:<portnumber> or

decnet/<hostname>::<objname> or

local/<hostname>:<path>

The auth_name member is the name of the authentication method. The auth_data member is the actual authentication data, and the auth_data_length member is the number of bytes in the data.

To obtain the default authorization file name, use `IceAuthFileName`

char *IceAuthFileName()

If the ICEAUTHORITY environment variable if set, this value is returned. Otherwise, the default authorization file name is $HOME/.ICEauthority. This name is statically allocated and should not be freed.

To synchronously update the authorization file, the file must be locked with a call to `IceLockAuthFile` This function takes advantage of the fact that the `link` system call will fail if the name of the new link already exists.

`int` **`IceLockAuthFile`**`(` *`*file_name`*`,` *`retries`*`,` *`timeout`*`,` *`dead`*`);`

file_name	The authorization file to lock.
retries	The number of retries.
timeout	The number of seconds before each retry.
dead	If a lock already exists that is the specified dead seconds old, it is broken. A value of zero is used to unconditionally break an old lock.

One of three values is returned:

- `IceAuthLockSuccess` - the lock succeeded.
- `IceAuthLockError` - a system error occurred, and `errno` may prove useful.
- `IceAuthLockTimeout` - the specified number of retries failed.

To unlock an authorization file, use `IceUnlockAuthFile`

`int` **`IceUnlockAuthFile`**`(` *`*file_name`*`);`

file_name	The authorization file to unlock.

To read the next entry in an authorization file, use `IceReadAuthFileEntry`

`IceAuthFileEntry` **`*IceReadAuthFileEntry`**`(` *`*auth_file`*`);`

auth_file	The authorization file.

Note that it is the responsibility of the application to open the file for reading before calling this function. If an error is encountered, or there are no more entries to read, NULL is returned.

Entries should be free with a call to `IceFreeAuthFileEntry`

To write an entry in an authorization file, use `IceWriteAuthFileEntry`

`Status` **`IceWriteAuthFileEntry`**`(` *`*auth_file`*`,` *`*entry`*`);`

auth_file	The authorization file.
entry	The entry to write.

Note that it is the responsibility of the application to open the file for writing before calling this function. The function returns a nonzero status if the operation was successful.

To search the default authorization file for an entry that matches a given protocol_name/network_id/auth_name tuple, use `IceGetAuthFileEntry`

`IceAuthFileEntry` **`*IceGetAuthFileEntry`**`(`*`protocol_name`*`,` *`network_id`*`,` *`auth_name`*`);`

auth_file	The name of the protocol to search on.
network_id	The network ID to search on.
auth_name	The authentication method to search on.

If `IceGetAuthFileEntry` fails to find such an entry, NULL is returned.

To free an entry returned by `IceReadAuthFileEntry` or `IceGetAuthFileEntry` use `IceFreeAuthFileEntry`

`void` **`IceFreeAuthFileEntry`**`(` *`*entry`*`);`

entry	The entry to free.

Appendix B. MIT-MAGIC-COOKIE-1 Authentication

The X Consortium's ICElib implementation supports a simple MIT-MAGIC-COOKIE-1 authentication scheme using the authority file utilities described in Appendix A.

In this model, an application, such as a session manager, obtains a magic cookie by calling `IceGenerateMagicCookie` and then stores it in the user's local .ICEauthority file so that local clients can connect. In order to allow remote clients to connect, some remote execution mechanism should be used to store the magic cookie in the user's .ICEauthority file on a remote machine.

In addition to storing the magic cookie in the .ICEauthority file, the application needs to call the `IceSetPaAuthData` function in order to store the magic cookie in memory. When it comes time for the MIT-MAGIC-COOKIE-1 authentication procedure to accept or reject the connection, it will compare the magic cookie presented by the requestor to the magic cookie in memory.

`char` **`*IceGenerateMagicCookie`**`(` *`length`*`);`

length	The desired length of the magic cookie.

The magic cookie returned will be null-terminated. If memory can not be allocated for the magic cookie, the function will return NULL. Otherwise, the magic cookie should be freed with a call to `free`

To store the authentication data in memory, use `IceSetPaAuthData` Currently, this function is only used for MIT-MAGIC-COOKIE-1 authentication, but it may be used for additional authentication methods in the future.

`void` **`IceSetPaAuthData`**`(` *`num_entries`*`,` *`*entries`*`);`

num_entries	The number of authentication data entries.
entries	The list of authentication data entries.

Each entry has associated with it a protocol name (for example, "ICE" for ICE connection setup authentication, "XSMP" for session management authentication), a network ID for the "accepting" client, an authentication name (for example, MIT-MAGIC-COOKIE-1), and authentication data. The ICE library will merge these entries with previously set entries, based on the (protocol_name, network_id, auth_name) tuple.

```
typedef struct {
 char *protocol_name;
 char *network_id;
 char *auth_name;
 unsigned short auth_data_length;
 char *auth_data;
} IceAuthDataEntry;
```