Inter-Client Exchange (ICE) Protocol

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ABSTRACT

There are numerous possible protocols that can be used for communication among clients. They have many similarities and common needs, including authentication, version negotiation, data typing, and connection management. The *Inter-Client Exchange* (ICE) protocol is intended to provide a framework for building such protocols. Using ICE reduces the complexity of designing new protocols and allows the sharing of many aspects of the implementation.

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1. Purpose and Goals

In discussing a variety of protocols — existing, under development, and hypothetical — it was noted that they have many elements in common. Most protocols need mechanisms for authentication, for version negotiation, and for setting up and taking down connections. There are also cases where the same two parties need to talk to each other using multiple protocols. For example, an embedding relationship between two parties is likely to require the simultaneous use of session management, data transfer, focus negotiation, and command notification protocols. While these are logically separate protocols, it is desirable for them to share as many pieces of implementation as possible.

The *Inter-Client Exchange* (ICE) protocol provides a generic framework for building protocols on top of reliable, byte-stream transport connections. It provides basic mechanisms for setting up and shutting down connections, for performing authentication, for negotiating versions, and for reporting errors. The protocols running within an ICE connection are referred to here as *subprotocols.* ICE provides facilities for each subprotocol to do its own version negotiation, authentication, and error reporting. In addition, if two parties are communicating using several different subprotocols, ICE will allow them to share the same transport layer connection.

2. Overview of the protocol

Through some mechanism outside ICE, two parties make themselves known to each other and agree that they would like to communicate using an ICE subprotocol. ICE assumes that this negotation includes some notion by which the parties will decide which is the "originating" party and which is the "answering" party. The negotiation will also need to provide the originating party with a name or address of the answering party. Examples of mechanisms by which parties can make themselves known to each other are the X selection mechanism, environment variables, and shared files.

The originating party first determines whether there is an existing ICE connection between the two parties. If there is, it can re-use the existing connection and move directly to the setup of the subprotocol. If no ICE connection exists, the originating party will open a transport connection to the answering party and will start ICE connection setup.

The ICE connection setup dialog consists of three major parts: byte order exchange, authentication, and connection information exchange. The first message in each direction is a **ByteOrder** message telling which byte order will be used by the sending party in messages that it sends. After that, the originating party sends a **ConnectionSetup** message giving information about itself (vendor name and release number) and giving a list of ICE version numbers it is capable of supporting and a list of authentication schemes it is willing to accept. Authentication is optional. If no authentication is required, the answering party responds with a **ConnectionReply** message giving information about itself, and the connection setup is complete.

If the connection setup is to be authenticated, the answering party will respond with an **AuthenticationRequired** message instead of a **ConnectionReply** message. The parties then exchange **AuthenticationReply** and **AuthenticationNextPhase** messages until authentication is complete, at which time the answering party finally sends its **ConnectionReply** message.

Once an ICE connection is established (or an existing connection reused), the originating party starts subprotocol negotiation by sending a **ProtocolSetup** message. This message gives the name of the subprotocol that the parties have agreed to use, along with the ICE major opcode that the originating party has assigned to that subprotocol. Authentication can also occur for the subprotocol, independently of authentication for the connection. Subprotocol authentication is optional. If there is no subprotocol authentication, the answering party responds with a **ProtocolReply** message, giving the ICE major opcode that it has assigned for the subprotocol.

Subprotocols are authenticated independently of each other, because they may have differing security requirements. If there is authentication for this particular subprotocol, it takes place before the answering party emits the **ProtocolReply** message, and it uses the **AuthenticationRequired**, **AuthenticationReply**, and **AuthenticationNextPhase** messages, just as for the connection authentication. Only when subprotocol authentication is complete does the answering party send its **ProtocolReply** message.

When a subprotocol has been set up and authenticated, the two parties can communicate using messages defined by the subprotocol. Each message has two opcodes: a major opcode and a minor opcode. Each party will send messages using the major opcode it has assigned in its **ProtocolSetup** or **ProtocolReply** message. These opcodes will, in general, not be the same. For a particular subprotocol, each party will need to keep track of two major opcodes: the major opcode it uses when it sends messages, and the major opcode it expects to see in messages it receives. The minor opcode values and semantics are defined by each individual subprotocol.

Each subprotocol will have one or more messages whose semantics are that the subprotocol is to be shut down. Whether this is done unilaterally or is performed through negotiation is defined by each subprotocol. Once a subprotocol is shut down, its major opcodes are removed from use; no further messages on this subprotocol should be sent until the opcode is reestablished with **ProtocolSetup**.

ICE has a facility to negotiate the closing of the connection when there are no longer any active subprotocols. When either party decides that no subprotocols are active, it can send a **WantToClose** message. If the other party agrees to close the connection, it can simply do so. If the other party wants to keep the connection open, it can indicate its desire by replying with a **NoClose** message.

It should be noted that the party that initiates the connection isn't necessarily the same as the one that initiates setting up a subprotocol. For example, suppose party A connects to party B. Party A will issue the **ConnectionSetup** message and party B will respond with a **ConnectionReply** message. (The authentication steps are omitted here for brevity.) Typically, party A will also issue the **ProtocolSetup** message and expect a **ProtocolReply** from party B. Once the connection is established, however, either party may initiate the negotiation of a subprotocol. Continuing this example, party B may decide that it needs to set up a subprotocol for communication with party A. Party B would issue the **ProtocolSetup** message and expect a **ProtocolReply** from party A.

3. Data Types

ICE messages contain several types of data. Byte order is negotiated in the initial connection messages; in general data is sent in the sender's byte order and the receiver is required to swap it appropriately. In order to support 64-bit machines, ICE messages are padded to multiples of 8 bytes. All messages are designed so that fields are "naturally" aligned on 16-, 32-, and 64-bit boundaries. The following formula gives the number of bytes necessary to pad E bytes to the next multiple of b:

$$\text{pad}(E, b) = (b - (E \bmod b)) \bmod b$$

3.1. Primitive Types

Type Name	Description
CARD8	8-bit unsigned integer
CARD16	16-bit unsigned integer
CARD32	32-bit unsigned integer
BOOL	**False** or **True**
LPCE	A character from the X Portable Character Set in Latin Portable Character Encoding

3.2. Complex Types

Type Name	Type
VERSION	[Major, minor: CARD16]
STRING	LISTofLPCE

LISTof<type> denotes a counted collection of <type>. The exact encoding varies depending on the context; see the encoding section.

4. Message Format

All ICE messages include the following information:

Field Type	Description
CARD8	protocol major opcode
CARD8	protocol minor opcode
CARD32	length of remaining data in 8-byte units

The fields are as follows:

Protocol major opcode
: This specifies what subprotocol the message is intended for. Major opcode 0 is reserved for ICE control messages. The major opcodes of other subprotocols are dynamically assigned and exchanged at protocol negotiation time.

Protocol minor opcode
: This specifies what protocol-specific operation is to be performed. Minor opcode 0 is reserved for Errors; other values are protocol-specific.

Length of data in 8-byte units
: This specifies the length of the information following the first 8 bytes. Each message-type has a different format, and will need to be separately length-checked against this value. As every data item has either an explicit length, or an implicit length, this can be easily accomplished. Messages that have too little or too much data indicate a serious protocol failure, and should result in a **BadLength** error.

5. Overall Protocol Description

Every message sent in a given direction has an implicit sequence number, starting with 1. Sequence numbers are global to the connection; independent sequence numbers are *not* maintained for each protocol.

Messages of a given major-opcode (i.e., of a given protocol) must be responded to (if a response is called for) in order by the receiving party. Messages from different protocols can be responded to in arbitrary order.

Minor opcode 0 in every protocol is for reporting errors. At most one error is generated per request. If more than one error condition is encountered in processing a request, the choice of which error is returned is implementation-dependent.

Error

offending-minor-opcode:
CARD8

severity:
{ **CanContinue**, **FatalToProtocol**, **FatalToConnection** }

sequence-number:
CARD32

class:
CARD16

value(s):
<dependent on major/minor opcode and class>

This message is sent to report an error in response to a message from any protocol. The **Error** message exists in all protocol major-opcode spaces; it is minor-opcode zero in every protocol. The minor opcode of the message that caused the error is reported, as well as the sequence number of that message. The severity indicates the sender's behavior following the identification of the error. **CanContinue** indicates the sender is willing to accept additional messages for this protocol. **FatalToProcotol** indicates the sender is unwilling to accept further messages for this protocol but that messages for other protocols may be accepted. **FatalToConnection** indicates the sender is unwilling to accept any further messages for any protocols on the connection. The sender is required to conform to specified severity conditions for generic and ICE (major opcode 0) errors; see Sections 6.1 and 6.2. The class defines the generic class of error. Classes are specified separately for each protocol (numeric values can mean different things in different protocols). The error values, if any, and their types vary with the specific error class for the protocol.

6. ICE Control Subprotocol — Major Opcode 0

Each of the ICE control opcodes is described below. Most of the messages have additional information included beyond the description above. The additional information is appended to the message header and the length field is computed accordingly.

In the following message descriptions, "Expected errors" indicates errors that may occur in the normal course of events. Other errors (in particular **BadMajor**, **BadMinor**, **BadState**, **BadLength**, **BadValue**, **ProtocolDuplicate**, and **MajorOpcodeDuplicate**) might occur, but generally indicate a serious implementation failure on the part of the errant peer.

ByteOrder

byte-order:
{ **MSBfirst**, **LSBfirst** }

Both parties must send this message before sending any other, including errors. This message specifies the byte order that will be used on subsequent messages sent by this party.

Note: If the receiver detects an error in this message, it must be sure to send its own **ByteOrder** message before sending the **Error**.

ConnectionSetup

versions:
LISTofVERSION

must-authenticate:
BOOL

authentication-protocol-names:
LISTofSTRING

vendor:
STRING

release:
STRING

Responses:
ConnectionReply, **AuthenticationRequired**. (See note)

Expected errors:
NoVersion, **SetupFailed**, **NoAuthentication**, **AuthenticationRejected**, **AuthenticationFailed**.

The party that initiates the connection (the one that does the "connect()") must send this message as the second message (after **ByteOrder**) on startup.

Versions gives a list, in decreasing order of preference, of the protocol versions this party is capable of speaking. This document specifies major version 1, minor version 0.

If must-authenticate is **True**, the initiating party demands authentication; the accepting party *must* pick an authentication scheme and use it. In this case, the only valid response is **AuthenticationRequired**.

If must-authenticate is **False**, the accepting party may choose an authentication mechanism, use a host-address-based authentication scheme, or skip authentication. When must-authenticate is **False**, **ConnectionReply** and **AuthenticationRequired** are both valid responses. If a host-address-based authentication scheme is used, **AuthenticationRejected** and **AuthenticationFailed** errors are possible.

Authentication-protocol-names specifies a (possibly null, if must-authenticate is **False**) list of authentication protocols the party is willing to perform. If must-authenticate is **True**, presumably the party will offer only authentication mechanisms allowing mutual authentication.

Vendor gives the name of the vendor of this ICE implementation.

Release gives the release identifier of this ICE implementation.

AuthenticationRequired

authentication-protocol-index:
CARD8

data:
<specific to authentication protocol>

Response:
AuthenticationReply.

Expected errors:
AuthenticationRejected, **AuthenticationFailed**.

This message is sent in response to a **ConnectionSetup** or **ProtocolSetup** message to specify that authentication is to be done and what authentication mechanism is to be used.

The authentication protocol is specified by a 0-based index into the list of names given in the **ConnectionSetup** or **ProtocolSetup**. Any protocol-specific data that might be required is also sent.

AuthenticationReply

data:
<specific to authentication protocol>

Responses:
AuthenticationNextPhase, **ConnectionReply**, **ProtocolReply**.

Expected errors:
AuthenticationRejected, **AuthenticationFailed**, **SetupFailed**.

This message is sent in response to an **AuthenticationRequired** or **AuthenticationNextPhase** message, to supply authentication data as defined by the authentication protocol being used.

Note that this message is sent by the party that initiated the current negotiation — the party that sent the **ConnectionSetup** or **ProtocolSetup** message.

AuthenticationNextPhase indicates that more is to be done to complete the authentication. If the authentication is complete, **ConnectionReply** is appropriate if the current authentication handshake is the result of a **ConnectionSetup**, and a **ProtocolReply** is appropriate if it is the result of a **ProtocolSetup**.

AuthenticationNextPhase

data:
<specific to authentication protocol>

Response:
AuthenticationReply.

Expected errors:
AuthenticationRejected, **AuthenticationFailed**.

This message is sent in response to an **AuthenticationReply** message, to supply authentication data as defined by the authentication protocol being used.

ConnectionReply

version-index:
CARD8

vendor:
STRING

release:
STRING

This message is sent in response to a **ConnectionSetup** or **AuthenticationReply** message to indicate that the authentication handshake is complete.

Version-index gives a 0-based index into the list of versions offered in the **ConnectionSetup** message; it specifies the version of the ICE protocol that both parties should speak for the duration of the connection.

Vendor gives the name of the vendor of this ICE implementation.

Release gives the release identifier of this ICE implementation.

ProtocolSetup

protocol-name:
STRING

major-opcode:
CARD8

versions:
LISTofVERSION

vendor:
STRING

release:
STRING

must-authenticate:
BOOL

authentication-protocol-names:
LISTofSTRING

Responses:
AuthenticationRequired, **ProtocolReply**.

Expected errors:
UnknownProtocol, **NoVersion**, **SetupFailed**, **NoAuthentication**, **AuthenticationRejected**, **AuthenticationFailed**.

This message is used to initiate negotiation of a protocol and establish any authentication specific to it.

Protocol-name gives the name of the protocol the party wishes to speak.

Major-opcode gives the opcode that the party will use in messages it sends.

Versions gives a list of version numbers, in decreasing order of preference, that the party is willing to speak.

Vendor and release are identification strings with semantics defined by the specific protocol being negotiated.

If must-authenticate is **True**, the initiating party demands authentication; the accepting party *must* pick an authentication scheme and use it. In this case, the only valid response is **AuthenticationRequired**.

If must-authenticate is **False**, the accepting party may choose an authentication mechanism, use a host-address-based authentication scheme, or skip authentication. When must-authenticate is **False**, **ProtocolReply** and **AuthenticationRequired** are both valid responses. If a host-address-based authentication scheme is used, **AuthenticationRejected** and **AuthenticationFailed** errors are possible.

Authentication-protocol-names specifies a (possibly null, if must-authenticate is **False**) list of authentication protocols the party is willing to perform. If must-authenticate is **True**, presumably the party will offer only authentication mechanisms allowing mutual authentication.

ProtocolReply

major-opcode:
CARD8

version-index:
CARD8

vendor:
STRING

release:
STRING

This message is sent in response to a **ProtocolSetup** or **AuthenticationReply** message to indicate that the

authentication handshake is complete.

Major-opcode gives the opcode that this party will use in messages that it sends.

Version-index gives a 0-based index into the list of versions offered in the **ProtocolSetup** message; it specifies the version of the protocol that both parties should speak for the duration of the connection.

Vendor and release are identification strings with semantics defined by the specific protocol being negotiated.

Ping

Response:

PingReply.

This message is used to test if the connection is still functioning.

PingReply

This message is sent in response to a **Ping** message, indicating that the connection is still functioning.

WantToClose

Responses:

WantToClose, **NoClose**, **ProtocolSetup**.

This message is used to initiate a possible close of the connection. The sending party has noticed that, as a result of mechanisms specific to each protocol, there are no active protocols left. There are four possible scenarios arising from this request:

(1) The receiving side noticed too, and has already sent a **WantToClose**. On receiving a **WantToClose** while already attempting to shut down, each party should simply close the connection.

(2) The receiving side hasn't noticed, but agrees. It closes the connection.

(3) The receiving side has a **ProtocolSetup** "in flight," in which case it is to ignore **WantToClose** and the party sending **WantToClose** is to abandon the shutdown attempt when it receives the **ProtocolSetup**.

(4) The receiving side wants the connection kept open for some reason not specified by the ICE protocol, in which case it sends **NoClose**.

See the state transition diagram for additional information.

NoClose

This message is sent in response to a **WantToClose** message to indicate that the responding party does not want the connection closed at this time. The receiving party should not close the connection. Either party may again initiate **WantToClose** at some future time.

6.1. Generic Error Classes

These errors should be used by all protocols, as applicable. For ICE (major opcode 0), **FatalToProtocol** should be interpreted as **FatalToConnection.**

BadMinor

offending-minor-opcode:
<any>

severity:
FatalToProtocol or **CanContinue** (protocol's discretion)

values:
(none)

Received a message with an unknown minor opcode.

BadState

offending-minor-opcode:
<any>

severity:
FatalToProtocol or **CanContinue** (protocol's discretion)

values:
(none)

Received a message with a valid minor opcode which is not appropriate for the current state of the protocol.

BadLength

offending-minor-opcode:
<any>

severity:
FatalToProtocol or **CanContinue** (protocol's discretion)

values:
(none)

Received a message with a bad length. The length of the message is longer or shorter than required to contain the data.

BadValue

offending-minor-opcode:
<any>

severity:
CanContinue

values:
CARD32 Byte offset to offending value in offending message
CARD32 Length of offending value
<varies> Offending value

Received a message with a bad value specified.

6.2. ICE Error Classes

These errors are all major opcode 0 errors.

BadMajor

offending-minor-opcode:
<any>

severity:
CanContinue

values:
CARD8 Opcode

The opcode given is not one that has been registered.

NoAuthentication

offending-minor-opcode:
ConnectionSetup, **ProtocolSetup**

severity:
ConnectionSetup → **FatalToConnection**
ProtocolSetup → **FatalToProtocol**

values:
(none)

None of the authentication protocols offered are available.

NoVersion

offending-minor-opcode:
ConnectionSetup, **ProtocolSetup**

severity:
ConnectionSetup → **FatalToConnection**
ProtocolSetup → **FatalToProtocol**

values:
(none)

None of the protocol versions offered are available.

SetupFailed

offending-minor-opcode:
ConnectionSetup, **ProtocolSetup**, **AuthenticationReply**

severity:
ConnectionSetup → **FatalToConnection**
ProtocolSetup → **FatalToProtocol**
AuthenticationReply → **FatalToConnection** if authenticating a connection, otherwise **FatalToProtocol**

values:
STRING reason

The sending side is unable to accept the new connection or new protocol for a reason other than authentication failure. Typically this error will be a result of inability to allocate additional resources on the sending side. The reason field will give a human-interpretable message providing further detail on the type of failure.

AuthenticationRejected

offending-minor-opcode:
AuthenticationReply, **AuthenticationRequired**, **AuthenticationNextPhase**

severity:
FatalToProtocol

values:
STRING reason

Authentication rejected. The peer has failed to properly authenticate itself. The reason field will give a human-interpretable message providing further detail.

AuthenticationFailed

offending-minor-opcode:
AuthenticationReply, **AuthenticationRequired**, **AuthenticationNextPhase**

severity:
FatalToProtocol

values:
STRING reason

Authentication failed. **AuthenticationFailed** does not imply that the authentication was rejected, as **AuthenticationRejected** does. Instead it means that the sender was unable to complete the authentication for some other reason. (For instance, it may have been unable to contact an authentication server.) The reason field will give a human-interpretable message providing further detail.

ProtocolDuplicate

offending-minor-opcode:
ProtocolSetup

severity:
FatalToProtocol (but see note)

values:
STRING protocol name

The protocol name was already registered. This is fatal to the "new" protocol being set up by **ProtocolSetup**, but it does not affect the existing registration.

MajorOpcodeDuplicate

offending-minor-opcode:
ProtocolSetup

severity:
FatalToProtocol (but see note)

values:
CARD8 opcode

The major opcode specified was already registered. This is fatal to the "new" protocol being set up by **ProtocolSetup**, but it does not affect the existing registration.

UnknownProtocol

offending-minor-opcode:
ProtocolSetup

severity:
FatalToProtocol

values:
STRING protocol name

The protocol specified is not supported.

7. State Diagrams

Here are the state diagrams for the party that initiates the connection:

`start`:
connect to other end, send **ByteOrder**, **ConnectionSetup** → `conn_wait`

`conn_wait`:
receive **ConnectionReply** → `stasis`
receive **AuthenticationRequired** → `conn_auth1`
receive **Error** → `quit`
receive <other>, send **Error** → `quit`

`conn_auth1`:
if good auth data, send **AuthenticationReply** → `conn_auth2`
if bad auth data, send **Error** → `quit`

`conn_auth2:`
receive **ConnectionReply** → `stasis`
receive **AuthenticationNextPhase** → `conn_auth1`
receive **Error** → `quit`
receive <other>, send **Error** → `quit`

Here are top-level state transitions for the party that accepts connections.

`listener`:
accept connection → `init_wait`

`init_wait`:
receive **ByteOrder**, **ConnectionSetup** → `auth_ask`
receive <other>, send **Error** → `quit`

`auth_ask`:
send **ByteOrder**, **ConnectionReply** → `stasis`
send **AuthenticationRequired** → `auth_wait`
send **Error** → `quit`

`auth_wait`:
receive **AuthenticationReply** → `auth_check`
receive <other>, send **Error** → `quit`

`auth_check`:
if no more auth needed, send **ConnectionReply** → `stasis`
if good auth data, send **AuthenticationNextPhase** → `auth_wait`
if bad auth data, send **Error** → `quit`

Here are the top-level state transitions for all parties after the initial connection establishment subprotocol.

Note: this is not quite the truth for branches out from stasis, in that multiple conversations can be interleaved on the connection.

`stasis`:
send **ProtocolSetup** → `proto_wait`
receive **ProtocolSetup** → `proto_reply`
send **Ping** → `ping_wait`
receive **Ping**, send **PingReply** → `stasis`
receive **WantToClose** → `shutdown_attempt`
receive <other>, send **Error** → `stasis`
all protocols shut down, send **WantToClose** → `close_wait`

`proto_wait`:
receive **ProtocolReply** → `stasis`
receive **AuthenticationRequired** → `give_auth1`
receive **Error**, give up on this protocol → `stasis`
receive **WantToClose** → `proto_wait`

`give_auth1`:
if good auth data, send **AuthenticationReply** → `give_auth2`
if bad auth data, send **Error**, give up on this protocol → `stasis`
receive **WantToClose** → `give_auth1`

`give_auth2`:
receive **ProtocolReply** → `stasis`
receive **AuthenticationNextPhase** → `give_auth1`
receive **Error**, give up on this protocol → `stasis`
receive **WantToClose** → `give_auth2`

`proto_reply`:
send **ProtocolReply** → `stasis`
send **AuthenticationRequired** → `take_auth1`
send **Error**, give up on this protocol → `stasis`

`take_auth1`:
receive **AuthenticationReply** → `take_auth2`
receive **Error**, give up on this protocol → `stasis`

`take_auth2`:
if good auth data → `take_auth3`
if bad auth data, send **Error**, give up on this protocol → `stasis`

`take_auth3`:
if no more auth needed, send **ProtocolReply** → `stasis`
if good auth data, send **AuthenticationNextPhase** → `take_auth1`
if bad auth data, send **Error**, give up on this protocol → `stasis`

`ping_wait`:
receive **PingReply** → `stasis`

`quit`:
→ close connection

Here are the state transitions for shutting down the connection:

`shutdown_attempt`:
if want to stay alive anyway, send **NoClose** → `stasis`
else → `quit`

`close_wait`:
receive **ProtocolSetup** → `proto_reply`
receive **NoClose** → `stasis`
receive **WantToClose** → `quit`
connection close → `quit`

8. Protocol Encoding

In the encodings below, the first column is the number of bytes occupied. The second column is either the type (if the value is variable) or the actual value. The third column is the description of the value (e.g., the parameter name). Receivers must ignore bytes that are designated as unused or pad bytes.

This document describes major version 1, minor version 0 of the ICE protocol.

LISTof<type> indicates some number of repetitions of <type>, with no additional padding. The number of repetitions must be specified elsewhere in the message.

8.1. Primitive Types

Type Name	Length (bytes)	Description
CARD8	1	8-bit unsigned integer
CARD16	2	16-bit unsigned integer
CARD32	4	32-bit unsigned integer
LPCE	1	A character from the X Portable Character Set in Latin Portable Character Encoding

8.2. Enumerations

Type Name	Value	Description
BOOL	0	**False**
	1	**True**

8.3. Compound Types

Type Name	Length (bytes)	Type	Description
VERSION			
	2	CARD16	Major version number
	2	CARD16	Minor version number
STRING			
	2	CARD16	length of string in bytes
	n	LISTofLPCE	string
	p		unused, p = pad(n+2, 4)

8.4. ICE Minor opcodes

Message Name	Encoding
Error	0
ByteOrder	1
ConnectionSetup	2
AuthenticationRequired	3
AuthenticationReply	4
AuthenticationNextPhase	5
ConnectionReply	6
ProtocolSetup	7
ProtocolReply	8
Ping	9
PingReply	10
WantToClose	11
NoClose	12

8.5. Message Encoding

Error

1	CARD8	major-opcode
1	0	Error
2	CARD16	class
4	(n+p)/8+1	length
1	CARD8	offending-minor-opcode
1		severity:
	0	CanContinue
	1	FatalToProtocol
	2	FatalToConnection
2		unused
4	CARD32	sequence number of erroneous message
n	<varies>	value(s)
p		pad, p = pad(n,8)

ByteOrder

1	0	ICE
1	1	ByteOrder
1		byte-order:
	0	LSBfirst
	1	MSBfirst
1		unused
4	0	length

ConnectionSetup

1	0	ICE
1	2	ConnectionSetup
1	CARD8	Number of versions offered
1	CARD8	Number of authentication protocol names offered
4	(i+j+k+m+p)/8+1	length
1	BOOL	must-authenticate
7		unused
i	STRING	vendor
j	STRING	release
k	LISTofSTRING	authentication-protocol-names
m	LISTofVERSION	version-list
p		unused, p = pad(i+j+k+m,8)

AuthenticationRequired

1	0	ICE
1	3	AuthenticationRequired
1	CARD8	authentication-protocol-index
1		unused
4	(n+p)/8+1	length
2	n	length of authentication data
6		unused
n	<varies>	data
p		unused, p = pad(n,8)

AuthenticationReply

1	0	ICE
1	4	AuthenticationReply
2		unused
4	(n+p)/8+1	length
2	n	length of authentication data
6		unused
n	<varies>	data
p		unused, p = pad(n,8)

AuthenticationNextPhase

1	0	ICE
1	5	AuthenticationNextPhase
2		unused
4	(n+p)/8+1	length
2	n	length of authentication data
6		unused
n	<varies>	data
p		unused, p = pad(n,8)

ConnectionReply

1	0	ICE
1	6	ConnectionReply
1	CARD8	version-index
1		unused
4	(i+j+p)/8	length
i	STRING	vendor
j	STRING	release
p		unused, p = pad(i+j,8)

ProtocolSetup

1	0	ICE
1	7	ProtocolSetup
1	CARD8	major-opcode
1	BOOL	must-authenticate
4	(i+j+k+m+n+p)/8+1	length
1	CARD8	Number of versions offered
1	CARD8	Number of authentication protocol names offered
6		unused
i	STRING	protocol-name
j	STRING	vendor
k	STRING	release
m	LISTofSTRING	authentication-protocol-names
n	LISTofVERSION	version-list
p		unused, p = pad(i+j+k+m+n,8)

ProtocolReply

1	0	ICE
1	8	ProtocolReply
1	CARD8	version-index
1	CARD8	major-opcode
4	(i+j+p)/8	length
i	STRING	vendor
j	STRING	release
p		unused, p = pad(i+j, 8)

Ping

1	0	ICE
1	9	Ping
2	0	unused
4	0	length

PingReply

1	0	ICE
1	10	PingReply
2	0	unused
4	0	length

WantToClose

1	0	ICE
1	11	WantToClose
2	0	unused
4	0	length

NoClose

1	0	ICE
1	12	NoClose
2	0	unused
4	0	length

8.6. Error Class Encoding

Generic errors have classes in the range 0x8000–0xFFFF, and subprotocol-specific errors are in the range 0x0000–0x7FFF.

8.6.1. Generic Error Class Encoding

Class	Encoding
BadMinor	0x8000
BadState	0x8001
BadLength	0x8002
BadValue	0x8003

8.6.2. ICE-specific Error Class Encoding

Class	Encoding
BadMajor	0
NoAuthentication	1
NoVersion	2
SetupFailed	3
AuthenticationRejected	4
AuthenticationFailed	5
ProtocolDuplicate	6
MajorOpcodeDuplicate	7
UnknownProtocol	8

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