[MS-PSOM]:
PSOM Shared Object Messaging Protocol Specification

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1 Introduction

This document specifies the PSOM Shared Object Messaging Protocol, used to exchange messages between the client and server. A message typically represents a method invocation of a remote object, with a sequence of understood parameters.

This protocol can be divided into three areas:

- **Connection:** Establish and negotiate interfaces between a client and a server.
- **Distributed object primitives:** Detail the format in which messages are sent and received.
- **Application-specific calls:** Explain the sequence of messages required to perform an operation.

1.1 Glossary

The following terms are defined in [MS-GLOS]:

ASCII
authentication
big-endian
certificate
Coordinated Universal Time (UTC)
decryption
encryption
fully qualified domain name (FQDN)
Hypertext Transfer Protocol (HTTP)
Hypertext Transfer Protocol over Secure Sockets Layer (HTTPS)
network byte order
remote procedure call (RPC)
server
Transmission Control Protocol (TCP)
UTF-8
X.509

The following terms are defined in [MS-OFCGLOS]:

Advanced Encryption Standard (AES)
cookie
Dynamic Hypertext Markup Language (DHTML)
hash
hash code
keepalive message
notification
proxy
SHA-1
TCP/IP
token
Transport Layer Security (TLS)
URI (Uniform Resource Identifier)
URL (Uniform Resource Locator)
Web server
XML fragment

The following terms are specific to this document:

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distributed object: A collection of interfaces that enable a protocol client and a protocol server (2) to exchange messages with each other, and to use those messages to connect or disconnect from distributed objects and to call remote methods that have a predefined set of parameters. Each instance of a distributed object has a unique identifier, which ensures that messages are routed to the correct object.

PSOM channel: A packet, datagram, octet stream connection, or sequence of logical connections that exists between endpoints (5) that are not unique. The channel defines a unique identity for each endpoint (5) and helps secure communications between them. It uses a root distributed object to enable both logical connections between child distributed objects and the exchange of messages between peers. A single PSOM connection can contain multiple PSOM channels.

root distributed object: The top-level distributed object to which a protocol client or protocol server (2) connects immediately after a channel is created. After a connection is established with a root distributed object, all other distributed objects on the same channel are connected.

MAY, SHOULD, MUST, SHOULD NOT, MUST NOT: These terms (in all caps) are used as described in [RFC2119]. All statements of optional behavior use either MAY, SHOULD, or SHOULD NOT.

1.2 References

1.2.1 Normative References

We conduct frequent surveys of the normative references to assure their continued availability. If you have any issue with finding a normative reference, please contact dochelp@microsoft.com. We will assist you in finding the relevant information. Please check the archive site, http://msdn2.microsoft.com/en-us/library/E4BD6494-06AD-4aed-9823-445E921C9624, as an additional source.

[ECMA-376] Ecma International, "Standard ECMA-376 Office Open XML File Formats", December 2006, http://www.ecma-international.org/publications/standards/Ecma-376.htm

[FIPS197] National Institute of Standards and Technology, "Federal Information Processing Standards Publication 197: Advanced Encryption Standard (AES)", November 2001, http://csrc.nist.gov/publications/fips/fips197/fips-197.pdf

[IEEE754] Institute of Electrical and Electronics Engineers, "Standard for Binary Floating-Point Arithmetic", IEEE 754-1985, October 1985, http://ieeexplore.ieee.org/servlet/opac?punumber=2355

[ISO/IEC-29500:2008] International Organization for Standardization, "Information technology -- Document description and processing languages -- Office Open XML File Formats -- Parts 1-4", Publicly Available Standards, http://standards.iso.org/ittf/PubliclyAvailableStandards/index.html

[MS-CONFBAS] Microsoft Corporation, "Centralized Conference Control Protocol: Basic Architecture and Signaling Specification", June 2008.

[RFC2119] Bradner, S., "Key words for use in RFCs to Indicate Requirement Levels", BCP 14, RFC 2119, March 1997, http://www.ietf.org/rfc/rfc2119.txt

[RFC2616] Fielding, R., Gettys, J., Mogul, J., et al., "Hypertext Transfer Protocol -- HTTP/1.1", RFC 2616, June 1999, http://www.ietf.org/rfc/rfc2616.txt

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1.2.2 Informative References

[MS-GLOS] Microsoft Corporation, "Windows Protocols Master Glossary", March 2007.

[MS-OFCGLOS] Microsoft Corporation, "Microsoft Office Master Glossary", June 2008.

1.3 Protocol Overview (Synopsis)

This protocol is designed to facilitate communications for data collaboration and web conferencing applications. The two roles understood by this protocol are client and **server (2)**. This protocol could be used symmetrically across both roles. However, a small number of messages and actions are performed by a specific role, but must be understood by both. A server (2) can be connected to multiple clients at a time, but clients do not have a direct way to exchanging messages, unless the server (2) decides to communicate them. A server (2) differentiates between different clients based on their transport connection.

This protocol provides for a set of strongly-typed interfaces to be defined for both a server (2) and client. These interfaces can be called remotely, as this protocol takes care of all parameter marshaling, and method invocation. This protocol also provides a way to create an object hierarchy. These interfaces are allowed to connect and disconnect a child object, known as a **distributed object**. A distributed object is composed of the following parts:

- The client-side distributed object peer.
- Server-side distributed object peer components.

A concrete instantiation of a distributed object is allowed to send and receive messages to and from its peer when it is connected. There can be multiple instances of a distributed object at any time; it is analogous to a class definition and instance relationship. Each distributed object instance has a unique identifier that allows PSOM operations, as described in section 2.2.2, to be routed to them. This is known as a "**proxy** id."

Distributed objects can exist without the distributed object that created it, and are allowed to exchange messages with its peer. Components on each individual client are allowed to communicate, and all components on the server (2) can communicate amongst each other directly. This allows the creation of an object model where clients and the server (2) can exchange messages, and the server (2) can record the state of the conference and broadcast any changes to other connected clients via the distributed objects.

Once a client and server (2) connection has been authenticated, distributed objects are logically connected so that they can exchange messages. Some distributed objects are connected when a user creates content; others always exist in a given conference and have specific responsibilities. The connected distributed objects are allowed to exchange messages, which are defined by server (2) and client interfaces for each distributed object. An example interface could be the existence of an **sBroadcast** message on the server (2) and a **cReceiveBroadcast** on each client interface. When multiple clients connect to the server (2) and logically connect the distributed object with this set of messages, a client could send an **sBroadcast** message to the server's distributed object peer. When the server (2) receives this message with a payload of data to broadcast, it could then call **cReceiveBroadcast** with that data on all clients' distributed object for that given peer. This enables the construction of a distributed object model where clients and the server (2) can exchange messages amongst each other.

An interface is composed of a set of methods, which are also referred to as messages, and each method is allowed to have any number of parameters. The supported parameters include:

- String.

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- 16/32/64-bit integers.
- Floating point values, byte.
- References to other connected distributed objects.
- Arrays of basic parameter types and arrays of arrays.

For the full list of supported parameters, see section 2.2.

On the network, all byte orders are **big-endian**, unless otherwise indicated.

At a high level, messages sent as part of this protocol can be split into two parts:

- **Kernel:** Handle connection, versioning, **keepalive messages**, and preparation to connect the application distributed objects.
- **Application distributed object:** Allows for Web conferencing components to exchange messages to perform user-related activities, such as sharing a document.

This abstraction extends into the way channels are used. A channel extended by this abstraction is a **PSOM channel**. PSOM channels are always created by the client and have unique integer identifiers. PSOM channel 0, which is the initial PSOM channel, is created implicitly after connection. A PSOM channel provides a way for distributed objects to route messages to each other. Each PSOM channel has a **root distributed object** that provides a way to connect child distributed objects and exchange messages between peers. The following types of messages help route information:

- **Record messages**: Deal with PSOM channel management and routing of inside messages to the appropriate PSOM channel.
- **PSOM operation messages**: Enclosed in a record message. Contain the proxy **Id** to route distributed object method invocation and connection operations.

The other PSOM channel used is PSOM channel 2, where all application distributed object messages are exchanged, as shown in the following diagram.

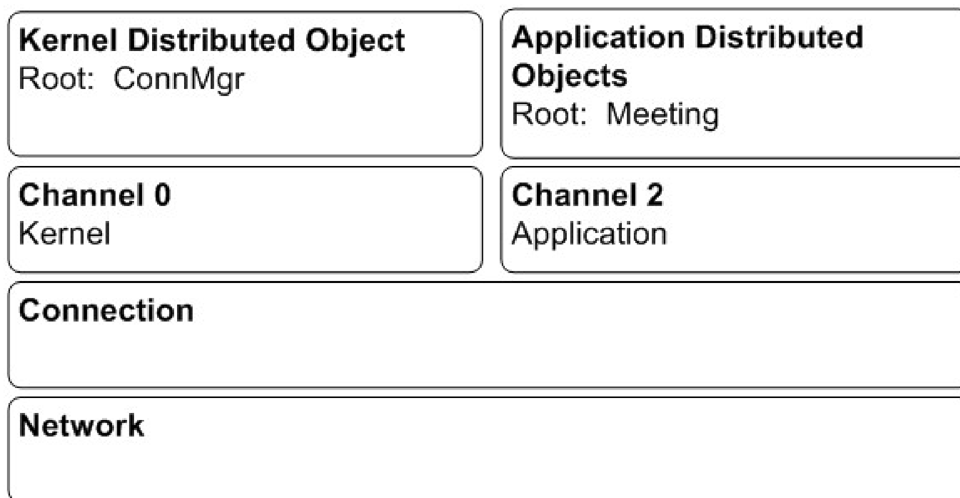

Figure 1: Overview of kernel and application channels

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The protocol does not specify any explicitly-defined acknowledgement components. If an application-level distributed object chooses to add this functionality, it is outside the scope of the kernel/message protocol. Generally, low-level failures are indicated by a server (2) or client sending a special termination message and disconnecting. In some cases, either may disconnect in response to a protocol violation.

As previously stated, there can be multiple instances of a distributed object. The following figure shows a sample distributed object structure on PSOM channel 2. The root distributed object has only one instance, and two child objects of the same type. Each child can only exchange messages with the corresponding child peer.

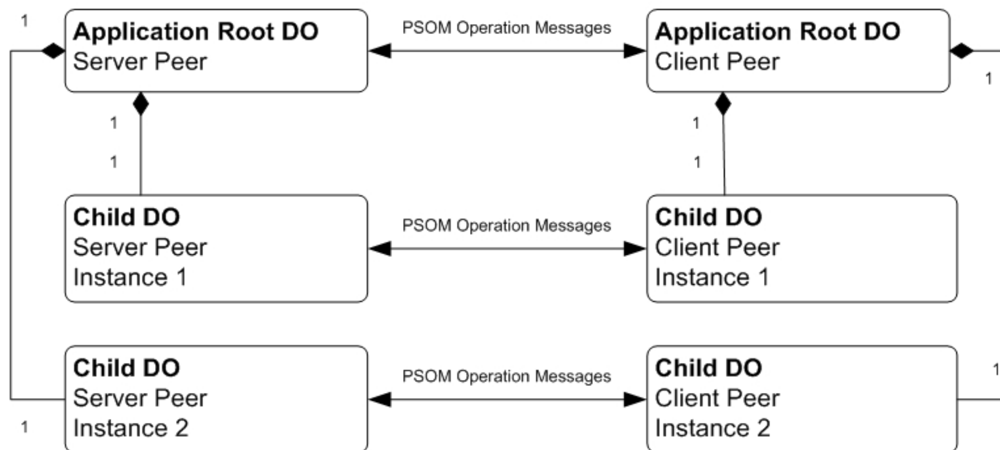

Figure 2: Sample Application distributed object connection

1.3.1 General Data Flow

Connections are always initiated by a client. The transport, as long as it is agreed on by client and server (2) components implicitly, can be any reliable transport. In general, **Transport Layer Security (TLS)** is the required transport. Once the connection is initiated and **encryption** negotiated, the client sends **authentication (2)** information. If the server (2) determines that the client is valid, it responds with an authentication (2) acknowledgement; otherwise it terminates the connection.

Once authentication (2) has completed, a capability and versioning sequence occurs. Because there is only one version of the protocol at present, this is nothing more than validating that both entities have the same object sets. This will be extended in the future to provide for different client and server (2) versioning. In this sequence, the client sends a **hash code** that is understood by both sides. This hash code is the sum of the client interface and the server (2) interface hash codes. Once completed, the server (2) does the same, except it communicates for each distributed object. Because there should be no versioning conflicts here, the server (2) and client continue from this point. Any disconnects as a result of versioning conflicts occur when a connect PSOM operation message is received. If the server (2) or client receives an unexpected hash code, such as when a different value is received than was expected, it sends a break or close message immediately and terminates the connection.

The definition of messages depends on the interface definition, which is summarized in a hash code that changes if the interface changes. This allows the client and server (2) to ensure that they understand the order of bytes in a PSOM operation message. Therefore, once versioning has completed, the server (2) and client can assume that the corresponding role has the same interface definitions.

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The client then sends a record message to create PSOM channel 2 for the root distributed object. At that point, the root distributed object is responsible for connecting child distributed objects and sending any other messages that are needed for the conference session. Once the connection is completed, server (2) and client distributed objects exchange messages based on the actions users take in a Web conference. When a user disconnects, PSOM channel record messages are exchanged to shut down the appropriate peers, and the client and server (2) terminate the connection, as shown in the following diagram.

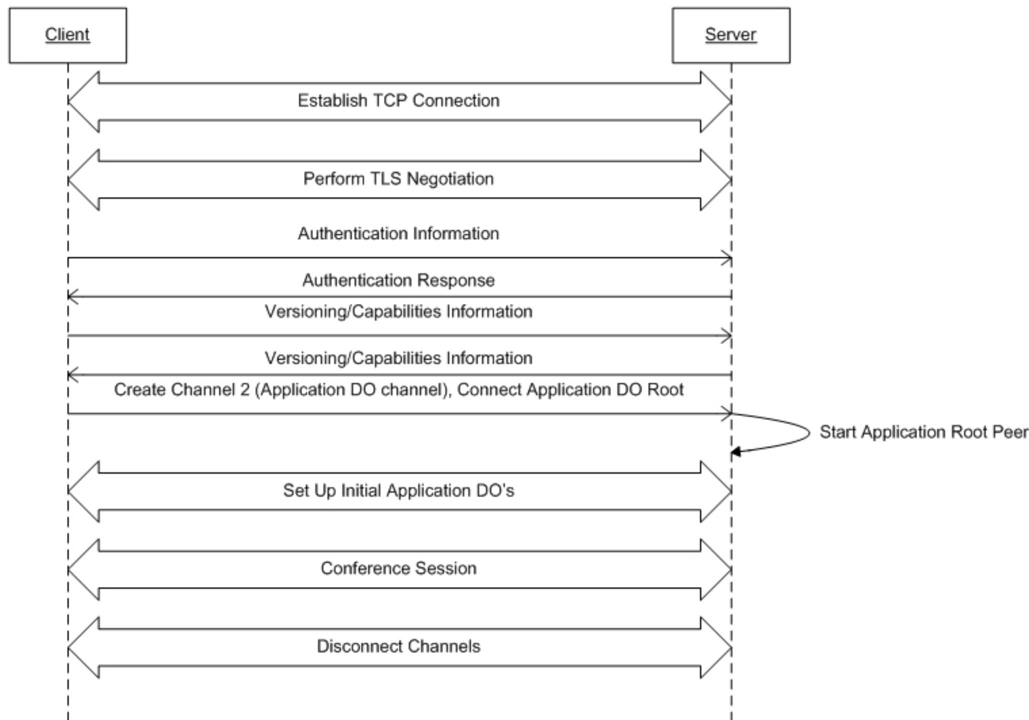

Figure 3: High-level protocol data flow

1.3.2 Message Flow

The understanding of a particular distributed object interface is critical in understanding both version negotiation and application communications. For details about distributed object interfaces, see section 3.1.4.1.2.

The message flow diagramed in this section has the following distributed objects defined:

- **ExampleDO**
- **ChildDO**

ChildDO is the child of **ExampleDO**. **ExampleDO** has a single method defined on the server (2) interface, which is named **HookUpChild**. This method can be called by any client and takes no parameters. **ChildDO** has two methods. The server (2) piece defines **ExampleServerMethod(string str)** and the client interface defines **ExampleClientMethod(string str)**. Both interfaces accept an argument of type string.

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The sequence of calls is as follows:

1. **Client::ExampleDO** calls **Server::ExampleDO**'s **HookUpChild()** method. This sample method causes the server (2) to hook up a child distributed object of type **Child** distributed object.

2. Server creates an object of type **ChildDO** to handle messages for that distributed object instance.

3. Server sends a special protocol message asking the **Client::ExampleDO** parent to create and allow the **ChildDO** instance to send and receive messages.

4. The client creates an instance of **ChildDO**.

5. When the **ChildDO** sample is initialized, it could call a server-side method on its peer, Server::ChildDO. It does so, and passes a string to be marshaled to the server (2). This protocol passes this message on.

6. When the server-side instance of **ChildDO** receives the **ExampleServerMethod(string)** call, it could call back with another method call, should the implementer choose.

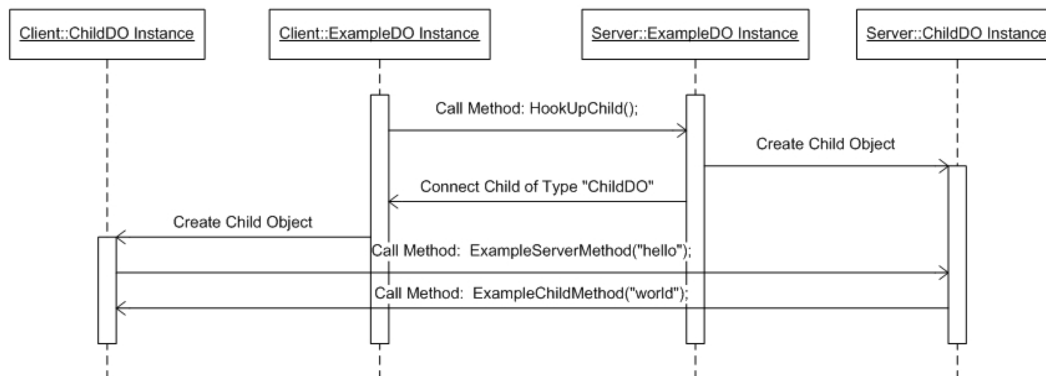

Figure 4: Example message flow between server and client distributed objects

1.3.3 Channels and Channel Distributed Object Roots

PSOM channels provide a way to divide kernel and application distributed objects easily. Every PSOM channel has a single root distributed object that is implicitly connected as soon as the PSOM channel is created. Messages exchanged by distributed object peers happen on the appropriate PSOM channel, as the peer and proxy identifiers used to route messages are unique on a per PSOM channel basis.

Only PSOM channels 0 and 2 are used by this protocol. Both are created by the client. PSOM channel 0 is used for all kernel communications. This PSOM channel is mainly used for exchanging distributed object version information. PSOM channel 2 is used for all application-related messages. These messages allow the Web conferencing application to define and carry out a Web conference. Both PSOM channels can be connected at the same time, as they provide a way to multiplex messages on a single connection.

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1.4 Relationship to Other Protocols

None.

1.5 Prerequisites/Preconditions

This protocol is used on top of a reliable transport such as **TCP/IP** with TLS encryption, as the protocol assumes that messages are not dropped and that the integrity of each message is maintained. TLS is required to connect directly to the server (2).

A proxy server (2) can be used to balance loads to the server (2). The only difference between the proxy and the server (2) is that an extra authentication (2) token is required upon connection. All other interactions are identical.

1.6 Applicability Statement

This protocol is used in Web conferencing scenarios, where a strongly-typed messaging infrastructure, with Web conferencing-related functionality, is required.

1.7 Versioning and Capability Negotiation

This protocol provides for versioning and capability negotiation in future releases, but currently no versioning negotiation is actively used. Exchange of interface versions and **hashes** happens before the application distributed objects are connected, so future implementations can make decisions about what methods are supported for each distributed object. However, because only one version exists, the initial version does not need to support calling into previous and future versions.

This document covers versioning issues in the following areas:

- **Supported transports:** This protocol can be implemented on top of **Transmission Control Protocol (TCP)** with TLS encryption as discussed in section 2.1.
- **Protocol versions:** Only one version of this protocol is currently supported.
- **Security and authentication methods:** This protocol is required to be used on top of TCP with TLS encryption.
- **Localization:** There is no localization-dependent protocol behavior. **Break** messages are to be treated as error codes, rather than strings that should be shown to a user.
- **Capability negotiation:** See previous discussion in this section.

1.8 Vendor-Extensible Fields

None.

1.9 Standards Assignments

None.

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2 Messages

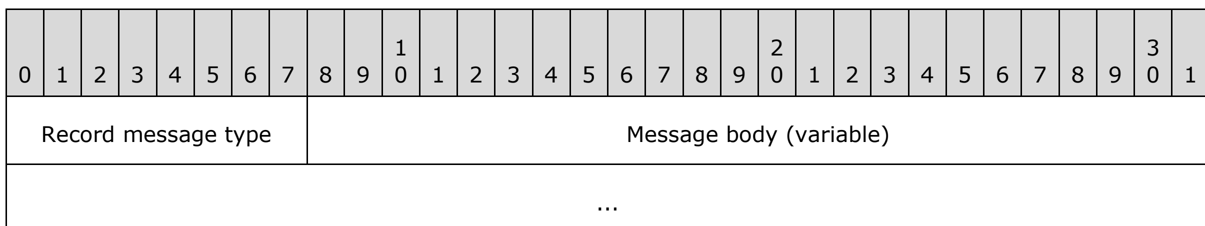
2.1 Transport

This protocol MUST be used over a TLS channel. The port and address are configurable, and are passed in from an external source, as described in section 3.2.3.1.

2.2 Message Syntax

2.2.1 Records

A record is designed to encapsulate a PSOM channel message, as defined in section 2.2.2. At a high level, protocol messages always contain a record, and optionally contain a PSOM channel message. Each record is encapsulated in a data structure that contains a message type and a body and has the following format.



Record message type (1 byte): The type of the record message.

Message body (variable): The message body length is determined both by type and embedded lengths for some types.

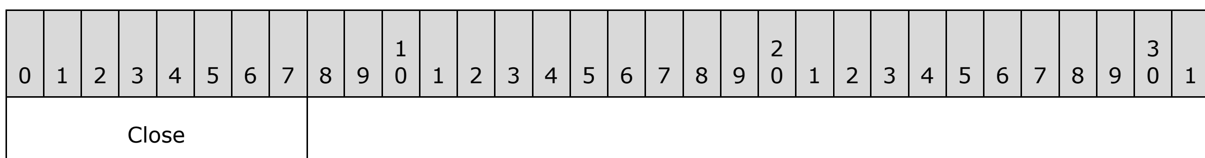
2.2.1.1 Record Types

The body lengths for all record types are unsigned, 32-bit, big-endian encoded integers.

2.2.1.1.1 Close Message

The **Close** message is represented by 0x00.

No data is contained in this message other than its type. This message closes the PSOM channel. This message MUST be sent during the disconnection phase, and results in all connected distributed objects transitioning into the disconnected state without sending messages. All other PSOM channels MUST be closed before the base PSOM channel, channel zero, is closed. This message has the following format.



Close (1 byte): Header; defined as 0x00.

2.2.1.1.2 SetChannel Message

The **SetChannel** message is represented by 0x04.

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SetChannel contains a 32-bit message body and indicates that all future records SHOULD be directed to the set channel, which is communicated as the 32-bit message body. The body is represented in network order, big-endian. For example, if the application channel is represented with a channel identifier of 2, this is represented as 0x00000002. This message has the following format.

<table>
<tr><td>0</td><td>1</td><td>2</td><td>3</td><td>4</td><td>5</td><td>6</td><td>7</td><td>8</td><td>9</td><td>1
0</td><td>1</td><td>2</td><td>3</td><td>4</td><td>5</td><td>6</td><td>7</td><td>8</td><td>9</td><td>2
0</td><td>1</td><td>2</td><td>3</td><td>4</td><td>5</td><td>6</td><td>7</td><td>8</td><td>9</td><td>3
0</td><td>1</td></tr>
<tr><td colspan="8">SetChannel</td><td colspan="24">ChannelId</td></tr>
<tr><td colspan="8">...</td></tr>
</table>

SetChannel (1 byte): Header for message type; defined as 0x04.

ChannelId (4 bytes): The representation of the channel identifier to be set. This PSOM channel is used for all following messages, with the exception of other **SetChannel** messages.

2.2.1.1.3 Break Message

The **Break** message is represented by 0x06.

A **Break** message results in the same actions as a **Close** Message, except that it contains a reason string. This string is not a PSOM-encoded string or a string provided as an argument to a method. It is an **ASCII** encoding of a reason code, which is typically an English representation of a reason that can be used for debugging purposes. The length of the string precedes the byte representation of the characters. This message has the following format.

<table>
<tr><td>0</td><td>1</td><td>2</td><td>3</td><td>4</td><td>5</td><td>6</td><td>7</td><td>8</td><td>9</td><td>1
0</td><td>1</td><td>2</td><td>3</td><td>4</td><td>5</td><td>6</td><td>7</td><td>8</td><td>9</td><td>2
0</td><td>1</td><td>2</td><td>3</td><td>4</td><td>5</td><td>6</td><td>7</td><td>8</td><td>9</td><td>3
0</td><td>1</td></tr>
<tr><td colspan="8">BreakChannel</td><td colspan="24">ReasonLength</td></tr>
<tr><td colspan="8">...</td><td colspan="24">ReasonString (variable)</td></tr>
<tr><td colspan="32">...</td></tr>
</table>

BreakChannel (1 byte): Header for the message type; defined as 0x06.

ReasonLength (4 bytes): The unsigned length of the following reason string.

ReasonString (variable): The ASCII byte representation of the reason code string. Each byte represents a single character.

For example, a **Break** message with the reason string "bye" is represented as follows:

```
0x06; 0x00000003; 0x62; 0x79; 0x65;
```

2.2.1.1.4 RpcMessage Message

The **RpcMessage** message is represented by 0x16.

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This message represents a message to a PSOM channel for a PSOM operation, as described in the following section. The message body length varies, and depends on the contents of the message. The first 4 bytes following the message type MUST be the big-endian encoding of the body length in bytes. The body of the message is described in section 2.2.2. This message has the following format.

<table>
<tr><th>0</th><th>1</th><th>2</th><th>3</th><th>4</th><th>5</th><th>6</th><th>7</th><th>8</th><th>9</th><th>1
0</th><th>1</th><th>2</th><th>3</th><th>4</th><th>5</th><th>6</th><th>7</th><th>8</th><th>9</th><th>2
0</th><th>1</th><th>2</th><th>3</th><th>4</th><th>5</th><th>6</th><th>7</th><th>8</th><th>9</th><th>3
0</th><th>1</th></tr>
<tr><td colspan="8">RpcMessage</td><td colspan="24">BodyLength</td></tr>
<tr><td colspan="8">...</td><td colspan="24">Body (variable)</td></tr>
<tr><td colspan="32">...</td></tr>
</table>

RpcMessage (1 byte): Header for the message type; defined as 0x16.

BodyLength (4 bytes): The unsigned length of the following body.

Body (variable): The payload of the PSOM operation message. This message is described in section 2.2.2.

2.2.1.1.5 RPCOpen Message

The **RPCOpen** message is represented by 0x37.

This is a PSOM channel open message and instructs the implementation to begin accepting messages for the specified PSOM channel. The record body MUST include the PSOM channel identifier, which is an unsigned 32-bit integer, and a special **ConnMgr** distributed object. **RpcMessage** MUST follow this identifier. For more information about the special **RpcMessage**, see the Connection section. This message MUST only be used to create the root distributed object PSOM channel, PSOM channel 2, and not the connection PSOM channel, PSOM channel 0. This message has the following format.

<table>
<tr><th>0</th><th>1</th><th>2</th><th>3</th><th>4</th><th>5</th><th>6</th><th>7</th><th>8</th><th>9</th><th>1
0</th><th>1</th><th>2</th><th>3</th><th>4</th><th>5</th><th>6</th><th>7</th><th>8</th><th>9</th><th>2
0</th><th>1</th><th>2</th><th>3</th><th>4</th><th>5</th><th>6</th><th>7</th><th>8</th><th>9</th><th>3
0</th><th>1</th></tr>
<tr><td colspan="8">RpcOpen</td><td colspan="24">ChannelId</td></tr>
<tr><td colspan="8">...</td><td colspan="24">RpcMsgBodyLen</td></tr>
<tr><td colspan="8">...</td><td colspan="24">RpcMessageBody</td></tr>
<tr><td colspan="32">...</td></tr>
</table>

RpcOpen header (1 byte): The header to denote the message type.

ChannelId (4 bytes): The unsigned integer value of the PSOM channel to open.

RpcMessageBodyLen (4 bytes): The unsigned integer value of the length of the message body.

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RpcMessageBody (variable): The contents of the message, intended to be treated as an **RpcMessage** body for a distributed object proxy object on the previous PSOM channel.

2.2.2 PSOM Operation Channel Messages (RpcMessage)

PSOM channel messages represent a PSOM operation, which is an action to take or method to call that involves a particular distributed object. PSOM channel messages are exchanged between the two peers of a distributed object, client and server (2), and represent one of the following operations:

- Connect child.
- Disconnect child.
- Call a method.

These operations are described in additional detail later in this document.

The term "RPC message" refers to a PSOM operation that requests a call of a given method on a distributed object interface.

Each PSOM operation is sent on a given PSOM channel. Any PSOM message sent after a **SetChannel** record are on that PSOM channel. The length of these messages on the network can be determined by the length header in the record frame.

Each connected distributed object instance is assigned a proxy identifier, which is a signed 32-bit integer, but represented as a GenericInt on the network. When a distributed object is first connected, it MUST be assigned a unique identifier that is understood by the server (2) and client.

When a distributed object is connected, the peer that is connecting the distributed object MUST assign any outgoing connect message a monotonically increasing integer, starting at 1, while the receiving distributed object MUST assign it a monotonically decreasing value starting at -1. When a server (2) sends a connect message for a particular distributed object, that peer MUST be assigned a proxy Id of $+n$, where n is any positive integer greater than zero. The receiving distributed object MUST assign the value $-n$ to the peer for its **ProxyId**. When a server (2) or client receives a connect request, it MUST assign the negative value of the **ProxyId**. For example, the first child distributed object of the **Meeting** distributed object, which is the PSOM channel root distributed object, which is connected by the server (2), receives a proxy Id of -1 on the client side, and a value of 1 on the server (2) side. Therefore, both the client and server (2) can uniquely refer to this instance when sending PSOM operation messages.

PSOM operation messages are always routed to an existing distributed object peer with a valid **ProxyId**. The receiving peer is the one whose **ProxyId** is the received value, negated. Therefore, any time a **ProxyId** is read from the network, it MUST be immediately negated, causing a negative to become positive and a positive to become negative, to determine which peer instance receives the message.

The root distributed object always has a **ProxyId** of zero.

In general, a PSOM operation frame is formatted as follows.

<table>
<tr><td>0</td><td>1</td><td>2</td><td>3</td><td>4</td><td>5</td><td>6</td><td>7</td><td>8</td><td>9</td><td>1
0</td><td>1</td><td>2</td><td>3</td><td>4</td><td>5</td><td>6</td><td>7</td><td>8</td><td>9</td><td>2
0</td><td>1</td><td>2</td><td>3</td><td>4</td><td>5</td><td>6</td><td>7</td><td>8</td><td>9</td><td>3
0</td><td>1</td></tr>
<tr><td colspan="8">OpenClose</td><td colspan="24">ProxyId (variable)</td></tr>
</table>

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...
Payload (variable)
...

OpenClose (1 byte): Either 0x84 (open) or 0x86 (close).

ProxyId (variable): Signed integer encoded as a **GenericInt**.

Payload (variable): The body for a **remote procedure call (RPC)** message, as defined in section 2.2.2.2. The length can be determined by the length of the current record body. **Payload** MUST be present if the **OpenClose** byte header is present.

2.2.2.1 Connect/Disconnect Child

These operations are symmetric, and provide the ability for a parent distributed object to connect and disconnect child distributed objects. Child objects are useful from a design perspective, and help segment functionality within objects. The only distributed object connected implicitly is the root distributed object of a PSOM channel, which is either the **Meeting** distributed object or the **ConnMgr** distributed object, depending on the PSOM channel. Any other distributed objects MUST be explicitly connected. Distributed object connect and disconnect messages can be sent by either the client or server (2).

Note that proxy Ids for connecting and identifying distributed objects are determined by negating any incoming value. When any given distributed object is connected, it has the value "+n", where *n* is greater than zero, on the initiating side, while the proxy has the value "–n" on the receiver's side. Therefore, to parse an incoming message, the incoming value MUST be negated and the resulting negated value is looked up in a local table with **proxyId** to distributed object mappings.

2.2.2.1.1 Connect (OP_CONNECT)

All connect requests include a **PartName** that is used to identify which child to connect. This part name is understood explicitly by both the server (2) and client components. The part name can be any string that is understood by both the client and server (2) distributed object peers. The string communicates what object should be connected and is eligible to receive messages. Once an **OP_CONNECT** message is sent, the peer MUST assume the corresponding peer is eligible to receive messages. Failure does not have to be indicated but, if it is, it can be done through disconnection or an RPC message to another distributed object by the application. This message is formatted as follows.

0	1	2	3	4	5	6	7	8	9	10	1	2	3	4	5	6	7	8	9	20	1	2	3	4	5	6	7	8	9	30	1
OP_CONNECT								ParentProxyId (variable)																							
...																															
PartName (variable)																															
...																															

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Hash (variable)
...

OP_CONNECT (1 byte): The constant header for a **Close** operation within the record frame.

ParentProxyId (variable): A 32-bit signed integer, encoded as a **GenericInt**. Represents the parent of the child distributed object to be connected.

PartName (variable): A PSOM-encoded string that details the name of the child to connect.

Hash(variable): A 64-bit signed integer encoded as a **GenericInt**. This represents the hash of the initiating peer's child distributed object. For example, if the client is sending the **OP_CONNECT** message, it includes the hash of the **ClientInterface** portion of the distributed object. If the server (2) is initiating the connection, it includes the **ServerInterface** hash for this parameter. The incoming hash MUST match the distributed object that is to be connected.

2.2.2.1.2 Disconnect (OP_CLOSE)

Disconnecting a distributed object means that a distributed object peer can no longer receive PSOM operation messages. A special header is sent, followed by the GenericInt encoding of the proxy Id to disconnect. Any child objects of a connected distributed object can still receive messages, and are therefore still connected, unless they are disconnected through disconnect PSOM operation messages sent to them. A disconnect message can be sent as a response to a received disconnect for a given proxy as an acknowledgment. This message is formatted as follows.

0	1	2	3	4	5	6	7	8	9	1 0	1	2	3	4	5	6	7	8	9	2 0	1	2	3	4	5	6	7	8	9	3 0	1
OP_CLOSE								ProxyId (variable)																							
...																															

OP_CLOSE (1 byte): The constant header for a **Close** operation within the record frame.

ProxyId (variable): A 32-bit signed integer, encoded as a GenericInt. Represents the distributed object peer to be closed.

2.2.2.2 RPC Message (Call Method) (OP_DATA)

)If the first byte is not 0x84 or 0x86, **OP_CONNECT** or **OP_CLOSE**, the PSOM operation refers to an RPC message. Because of the structure of the **GenericInt** encoding algorithm, 0x84 or 0x86 are never the first byte in a **GenericInt**, so this is a safe assumption.

The RPC message type indicates the message is meant to call a given interface method with a pre-defined set of parameters. The structure of an RPC message is as follows.

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0	1	2	3	4	5	6	7	8	9	1 0	1	2	3	4	5	6	7	8	9	2 0	1	2	3	4	5	6	7	8	9	3 0	1
ProxyId (variable)																															
...																															
MethodIdx								Payload (variable)																							
...																															

ProxyId (variable): The sending proxy's identifier. Encoded as a **GenericInt**.

MethodIdx (1 byte): A signed byte indicating the method to call. This is the computed **MethodIndex** that is derived from the base **MethodIndex** defined in the interface.

Payload (variable): The individual parameters required to call the method that corresponds to **MethodIdx**. If no parameters are expected, this can be omitted.

The ordering of **Payload** MUST match the ordering of parameters in the distributed object definition. For example, if a method is declared as follows:

```
Method(Int32 param1, String param2)
```

The encoded bytes in the parameters section are, in order:

param1: (variable): Encoded as a **GenericInt**.

param2: (variable): Encoded as a PSOM string type. This is a 2-byte length header followed by a specially encoded payload of byte representations of characters.

RPC messages do not require any response. The receiver MUST invert the sign of **ProxyId** to find the appropriate distributed object peer instance to handle the message.

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3 Protocol Details

3.1 Common Details

In general, the server (2) and client roles are symmetric. However, there are some actions that a server (2) cannot take. For more information about these restricted actions, see section 3.3.

3.1.1 Abstract Data Model

This section describes a conceptual model of possible data organization that an implementation maintains to participate in this protocol. The described organization is provided to facilitate the explanation of how the protocol behaves. This document does not mandate that implementations adhere to this model as long as their external behavior is consistent with that described in this document.

This protocol is a highly symmetric protocol at the connection/channel/RPC layer. The differences between the server (2) and client exist at a higher layer, where a set of message interfaces are defined. At the RPC layer, there is a set of objects. Each object in the set is a distributed object. Each distributed object has a server (2) and client component. Each component is able to exchange messages, disconnect from the other, or connect to another distributed object.

Each RPC message is a method on each server (2) and client interface. This method never returns a value, but it does take parameters. These parameters are listed in the following section.

3.1.1.1 PSOM types

This section contains a list of all of the supported PSOM types, which are used as part of the record message **RpcMessage** and distributed object method parameters. When some types, such as Int32, are listed in the following sections, those types only apply to the parameters in the interface definitions.

3.1.1.1.1 Arrays

Arrays are not a type. They modify other primitive PSOM types to create collections. Each array is encoded as the number of elements as a GenericInt, followed by each element in sequence. Because all elements are the same type, the length of the array can be determined based on the length of each type. It is possible to create an array of arrays. This is represented by treating each contained array as its own type. For example, an array of 2 arrays of type byte with 1 element each would look as follows:

```
[GenericInt(2)] [GenericInt(1)] [value of byte in array 0] [GenericInt(1)] [value of byte in
array 1]
```

3.1.1.1.2 Boolean

Encoded as 0x01 for **true**; 0x00 for **false**.

3.1.1.1.3 Byte

An unsigned byte. This type is encoded exactly as represented over the network.

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3.1.1.1.4 Distributed Object Reference

A distributed object reference is a reference to a distributed object peer. If the object is null, it is encoded as a single byte, 0x8C. To refer to a non-null distributed object, this is encoded as a GenericInt containing the value of a proxy identifier.

3.1.1.1.5 GenericInt

GenericInt is a specially formatted value used to represent any signed integer that is 64 bytes or less. The encoding algorithm results in a variable size based on the original value. For algorithm details, see section 6. Note that interface details can reference **Int32** and **Int64**. These SHOULD be encoded as **GenericInt**.

A **GenericInt** is never a directly referenced type; instead, it is an encoding for **Int32**, **Int64**, **UInt32**, **UInt64** types. They are all encoded the same way, but the given integer types determine the appropriate bounds and sign for the number.

3.1.1.1.6 Int32

A 32-bit signed integer encoded as a **GenericInt**.

3.1.1.1.7 Int64

A 64-bit signed integer encoded as a **GenericInt**.

3.1.1.1.8 String

String represents a specially-encoded string of a **UTF-8** string.

For algorithm details, see section 6.

3.1.1.1.9 Double

A double-precision (64-bit) floating point number, big-endian encoded with the bytes in the sequence specified in [IEEE754] section 3.

3.1.2 Timers

There is a **ping** method called with no parameters used as a keepalive message sent every 30 seconds by both the client and the server (2) on the **ConnMgr** distributed object. For the **ConnMgr** definitions, see section 3.1.3.1. Once the timer has expired, a new one is set at the same interval period.

3.1.3 Initialization

When this protocol is initialized, it MUST begin connecting to a server (2) or client or wait for incoming connections from a server (2). The protocol has no state at this point, and no distributed objects are connected. At a high level, connection is established, and is followed by authentication (2), versioning, and then the root distributed object connection. For more information about these steps, see section 3.2 and section 3.3.

3.1.3.1 ConnMgr Distributed Object

The **ConnMgr** distributed object is defined in its corresponding client and server (2) sections. This distributed object is responsible for exchanging versioning information about supported distributed

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objects between the client and server (2). At this point, there are no additional versioning requirements because there is only one version.

3.1.4 Higher-Layer Triggered Events

The higher-layer objects consist of a set of distributed objects that represent a conference. The root distributed object is the **Meeting** distributed object. It is the first distributed object connected on that PSOM channel. The following sections describe how distributed objects are connected, and the description of all possible methods on each interface. Unexpected calls, dictated by business logic, can result in other distributed object calls in the reverse direction, or result in a **Break** or **Close** message being sent.

3.1.4.1 Distributed Objects

All interface parameters are encoded as PSOM arguments as specified in section 3.1.1.1.

3.1.4.1.1 Distributed Object Interface Definition

The understanding of particular distributed object interfaces is critical in understanding both version negotiation and application communications. This section describes a way of representing client and server (2) distributed object interfaces.

```
[Name="ProtocolName", Version=1]
DOInterface DOName
{
    [Hash=1234567890123456L]
    ServerInterface
    {
        SampleServerMethod1(Int64 parameter1, Int32 parameter2);
    }

    [Hash=-6543210987654321L]
    ClientInterface
    {
        SampleClientMethod1();
    }

    Children
    {
        (DOChildName1, DOChildType1)
        (DOChildName2, DOChildType2)
    }
}
```

Attributes are denoted by square brackets ([or]) and are intended to add information to the object that follows them. Each **DOInterface** entry has a **ServerInterface**, **ClientInterface**, and **Children** as sub-components. For detail about the PSOM operation methods that can be called by the opposite peer, see section 3.2.4.1 and section 3.3.4.1. The ordering is important. The first method in each interface type is assigned a method index of 1, and each subsequent method declaration is given a monotonically increasing integer value. This value is used as a reference in certain PSOM operation messages.

In some cases, the child objects might be represented differently. For example, the name might be used to indicate alternative usage. If this is the case, **DOChildNameN** is referenced appropriately in the text that describes the child elements. In general, **DOChildNameN** refers to a specific single

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child that has the distributed object type **DOChildType**. **DOChildNameN** is the text of the string sent as part of the **OP_CONNECT** message.

3.1.4.1.1.1 DOInterface Attributes

Name (string): The string representation of the protocol name. Used to identify which **DOInterface** is referenced.

Version (integer): An integer value greater than zero. See section 3.1.4.1.3 for details.

3.1.4.1.1.2 Server/Client Interface Attributes

Hash (64-bit signed integer): A pre-defined value used to ensure interfaces are the same. This is provided for future extensions to use in testing for conflicts.

3.1.4.1.1.3 Method Declarations

Each method declaration MUST be in the following format:

```
MethodName(ParameterType1, parameterName1, …);
```

Method ordering is important, as discussed previously, because it reflects the byte identifier used on the wire. The **ParameterType** MUST be a PSOM supported type, as defined in section 3.1.1.1. For example, "Int32" represents a signed, 32-bit integer that is encoded as a **GenericInt** on the wire.

Note that because messages do not have return values, the previous method definitions do not specify them.

3.1.4.1.1.4 Children

Children is not exclusive. Other names can be sent without declaring them. For example, to connect to a specific instance of an object, a connection message can be sent with a custom string such as "objectInstance123." This attribute details child objects for the reader. The previous interface definition includes a distributed object with two well-defined child objects with a given name and type. Because distributed object connection routines allow any string to be sent on the wire, this section details any variants that can be sent as part of the **OP_CONNECT** message.

3.1.4.1.2 Sample Distributed Object

This section illustrates a sample distributed object to help the reader understand the format for these distributed objects. Server (2) and client method descriptions can be found in section 3.3 and section 3.2.

3.1.4.1.2.1 Interface

The following is a sample interface definition for a distributed object.

```
[Name="ProtocolName", Version=1]
DOInterface DOName
{
    [Hash=1234567890123456]
    ServerInterface
    {
        sSampleServerMethod1(Int64 parameter1, Int32 parameter2);
```


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```
        }

        [Hash=-6543210987654321]
        ClientInterface
        {
            cSampleClientMethod1();
        }

        Children
        {
            (DOChildName1, DOChildType1)
            (DOChildName2, DOChildType2)
        }
    }
```

The bracketed fields indicate the names that are used as part of the name in the **Connect** messages, and the hashes are exchanged during connection and versioning. The order of the messages indicates their base **MethodIndex**, which is also defined by the alphabetic order, compared ordinally, relative to other methods on that interface. The computed **MethodIndex**, which is sent via the network, can be determined by the logic in section 3.1.4.1.3.

Children is defined as the set of distributed objects that the **DOName** distributed object is able to send RPC connect messages for. The directionality of those connect messages is typically limited to one way, either server (2) to client or client to server (2), but that is defined further for each distributed object.

3.1.4.1.2.2 Sample Server Method

<< The description of a method goes here. The server (2) is able to receive a message with this name >>

parameter1 (Int64): << Description of parameter >>

parameter2 (Int32): << Description of parameter >>

3.1.4.1.2.3 Sample Client Method

See section 3.1.4.1.2.2. This section contains descriptions for messages the client can receive.

3.1.4.1.2.4 Children

Anything that comes in a **Connect** message is detailed under **Children**. Because the **OP_CONNECT** message is sent with a string for the name of the distributed object or a string value to connect, each half of the distributed object MUST be aware of the distributed objects it is allowed to connect. This section describes the direction for this **OP_CONNECT** message. Either client can send an **OP_DISCONNECT** message to its peer at any time.

3.1.4.1.3 Versioning

There is a basic versioning level supported for future releases. Currently, there is only one version of client and server (2) supported, which might not be version 1, and each distributed object has a version on the client and the server (2). In some cases, clients might send multiple versions via the **addProtocol** message; only the version that matches the values in the DOInterface tables SHOULD be respected. As described previously, each distributed object method has a base **MethodIndex**

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determined by its order in the interface definition. This base **MethodIndex** is used to calculate the computed **MethodIndex** that is sent as part of an RPC message for Server to Client messages.

The server (2) and client, when referring to a given method, must compute the computed **MethodIndex** when sending any RPC messages to the client by doing the following:

[computed **MethodIndex**] = [base **MethodIndex**] + ([version] << 16) // << is the left shift operator

For example, the **MethodIndex** the server (2) sends to the client for a distributed object with base **MethodIndex** set to "1" and version set to "1" is:

1 + (1 << 16) = 65537

For base **MethodIndex** set to "1" and version set to "2", it is:

1 + (2 << 16) = 131073

The version is described in the **DOInterface** definitions. When the client sends RPC Messages to the server (2), it should always use the base **MethodIndex**, regardless of the version. This is only for the current version. Once multiple versions are supported, this will change. When the server (2) is sending to the client, it MUST compute the computed **MethodIndex** with the appropriate version. Unlike server to client messages, when client sends RPC messages to the client, it MUST use version set to "1" to determine the computed **MethodIndex**.

3.1.4.1.4 ContentManager

ContentManager is a distributed object that maintains a collection of **Content** distributed objects that are currently present in the **Meeting**. It provides methods for deleting **Content** distributed objects. It notifies the client of **Content** distributed objects that have been added through **UploadManager** or removed. It also provides support for reserving the title for a content before adding it to ensure uniqueness of all content titles within a **Meeting**. Additionally, it allows for a user to become the active presenter and to give up the active presenter baton and gives **notifications** when the active presenter changes.

The following table lists the **TitleReservationStatus** values. For more information, see section 3.3.4.1.3.1.

Value	Numeric value	Description
ReservedForCreation	1	The requested title was reserved successfully.
ReservedForUpgrade	2	The requested title was reserved for upgrade successfully.
FailedReservedForCreation	3	The requested title could not be reserved because it is already reserved by someone else for upgrade.
FailedReservedForUpgrade	4	The requested title could not be reserved because it is already reserved by someone else for upgrade.
FailedExternalIdLockedForCreate	5	The requested external ID could not be reserved because it is already reserved by someone else for creation.

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Value	Numeric value	Description
FailedExternalIdLockedForUpgrade	6	The requested external ID could not be reserved because it is already reserved by someone else for upgrade.
FailedReservationMaxExceeded	7	The user has exceeded the maximum number of allowed reservations.
FailedCookieInUse	8	The supplied **cookie** is already in use for an existing reservation.
FailedNotAuthorized	9	The user does not have the proper credentials to complete the operation.
FailedInvalidExtension	10	The extension of the provided title is not allowed for upload.
FailedInvalidTitle	11	The provided title was not in a valid format. Reasons for this error include that the character length is longer than a chosen value, or contains characters that are not supported. This is used for the server (2) to enforce well-named restrictions on the title if it is used as a file name.

3.1.4.1.4.1 Interface

```
[Name="Microsoft.Rtc.Server.DataMCU.Meeting.ContentManager", Version=2]
DOInterface ContentManager
{
    [Hash=3800622354142801969]
    ServerInterface
    {
        void sDeleteContent(Int64 contentId);

        void sPresent();

        void sReleaseTitle(Int32 cookie);

        void sReserveTitle(String title, Int32 cookie);

        void sReserveTitle(String title, Int32 cookie, String externalId);

        void sStopPresenting();
    }

    [Hash=-8255121175073997388]
    ClientInterface
    {
        void cContentAdded(Int64 contentId, String type);

        void cContentCreated(Int64 contentId, Int32 cookie);

        void cContentCreationFailed(Int32 cookie, Int32 reason);

        void cContentRemoved(Int64 contentId);
```


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```
        void cReserveTitleCompleted(Int32 /* TitleReservationStatus */ status, Int32 cookie, 
Int64 contentId, Int64 owningUserId);

        void cSetActiveContent(Int64 activeContentId);

        void cSetActivePresenter(Int64 activePresenterId);
        void cTitleReleased(Int32 cookie);

    }

    Children
    {
        (UploadManager, Microsoft.Rtc.Server.DataMCU.Meeting.UploadManager)
        ("content.X", Microsoft.Rtc.Server.DataMCU.Meeting.Content)
    }
}
```

3.1.4.1.4.2 Children

The **UploadManager** distributed object is connected by the server (2) and is a required distributed object.

The **Content** distributed objects are hooked up by the client by sending an **rpcConnect**. The part name used for the **rpcConnect** is a string concatenation of the string "content." and the content ID in base-10 format, with no leading zeros. As an example, if a client is attempting to hook up the content with the ID of "2", the string passed in **rpcConnect** is "content.2".

3.1.4.1.5 Content

Content is a distributed object that handles generic content methods, such as presenting a content, renaming one, setting a content's visibility in the **Meeting**, or being told properties about the content. The content-specific methods and properties, such as the number of slides in a PowerPoint presentation, or which slide to navigate to, is handled by the **extendedContent** child object.

The following table lists the **SetTitleStatus** values and descriptions.

Value	Numeric value	Description
Success	1	The operation completed successfully.
FailedTitleExists	2	Another content has this title.
FailedReservedForCreation	3	The requested title is currently reserved.
UserNotAuthorized	4	The user is not allowed to modify the title.
FailedInvalidExtension	5	The extension is not on the approved list.
FailedInvalidTitle	6	The provided title was not in a valid format.

The following table lists the **ContentVisibility** values and descriptions.

Value	Numeric value	Description
MeetingOrganizer	1	Only the meeting organizer can see this content.

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Value	Numeric value	Description
Presenters	2	Only presenters can see this content.
Everyone	3	Everyone can see this content.

3.1.4.1.5.1 Interface

```
[Name=" Microsoft.Rtc.Server.DataMCU.Meeting.Content", Version=1]
DOInterface Content
{
    [Hash= -6470662138903778586L]
    ServerInterface
    {
        void sForceSync ();

        void sMakeHighestPresentationOrder ();

        void sPresent ();

        void sSetTitle (string title);

        void sSetVisibility (ContentVisibility visibility);

        void sStopPresenting ();
    }

    [Hash= 1113513223610002283L]
    ClientInterface
    {
        void cConnectCompleted ();

        void cForceSync ();

        void cSetCreationTime (string creationTime);

        void cSetLastUsedTime (string lastUsedTime);

        void cSetNativeFileInfo (string filename, byte[] key, byte[] iv, byte[] hash, long
fileSize);

        void cSetOwerId (Int64 id);

        void cSetPresentInfo (bool isPresented, Int64 presenterId);

        void cSetPresentationOrder (Int64 presentationOrder);

        void cSetTitle(string title);

        void cSetTitleComplete(Int32 /* SetTitleStatus */ status, string title);

        void cSetVisibility (Int32 /* ContentVisibility */ visibility);
    }

    Children
    {
        ("extendedContent", content-specific-DO)
    }
```


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```
}
```

3.1.4.1.5.2 Children

The **Content** distributed object has one client-hooked-up child distributed object, called the **extendedContent** distributed object. This is the implementation of the content's specific features, such as PowerPoint. To connect the **extendedContent** distributed object, the client sends an **rpcConnect** with the string "extendedContent".

3.1.4.1.6 Meeting

Meeting is the root distributed object for all the application distributed objects. It consists of the **ContentManager**, which keeps track of all content in the **Meeting**, and the **ContentUserManager**, which keeps track of all relevant users in a **Meeting**. It also communicates the **URL (Uniform Resource Locator)** base for the **Meeting**.

3.1.4.1.6.1 Interface

```
[Name=" Microsoft.Rtc.Server.DataMCU.Meeting.Meeting", Version=2]
DOInterface Meeting
{
    [Hash=7811924786664530844]
    ServerInterface
    {
         sSetInfo(String info);
    }

    [Hash=2106930589629680263]
    ClientInterface
    {
        cSetInfo(String info);

        cSetUrlBase(String urlBase);

        cMeetingReady();

        cSetServerTime(String serverTime);
    }

    Children
    {
        (ContentManager, Microsoft.Rtc.Server.DataMCU.Meeting.ContentManager)
        (ContentUserManager, Microsoft.Rtc.Server.DataMCU.Meeting.ContentUserManager)
    }
}
```

3.1.4.1.6.2 Children

The **ContentManager** and **ContentUserManager** MUST be connected as **Children** distributed objects of the **Meeting** before **cMeetingReady** is called.

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3.1.4.1.7 ContentUserManager

The **ContentUserManager** is a one-way notification mechanism to tell each client which **URI (Uniform Resource Identifier)** and display name maps to a given user ID. This way, the URI and display name can be sent once, and each content and annotation can just use an ID to indicate ownership or that an action happened.

3.1.4.1.7.1 Interface

```
[Name=" Microsoft.Rtc.Server.DataMCU.Meeting.ContentUserManager", Version=1]
DOInterface Meeting
{
    [Hash=3286152179062983692]
    ServerInterface
    {
    }

    [Hash=5320330165687787020]
    ClientInterface
    {
        cUsersAdded(Int64[] ids, String[] uris, String[] displayNames);

        cUsersRemoved(Int64[] ids);
    }
}
```

3.1.4.1.8 UploadManager

The **UploadManager** distributed object is responsible for uploading OC Package files to the server (2). See section 3.3.4.2 for details related to the OC Package. The OC Package is a single file for the purposes of uploading. The upload traffic is through the PSOM channel rather than **Hypertext Transfer Protocol (HTTP)** for the download.

3.1.4.1.8.1 Interface

```
[Name=" Microsoft.Rtc.Server.DataMCU.Meeting.UploadManager", Version=1]
DOInterface UploadManager
{
    [Hash=4004400404121921234]
    ServerInterface
    {
        void sRequestUploadBlob(Int64 length, Int32 cookie);

        void sUploadFinished(Int32 cookie, Boolean cancel);
    }

    [Hash=-8511879503649873756]
    ClientInterface
    {
        void cAcceptUpload(Int32 cookie, DistributedObject stream);

        void cRejectUpload(Int32 cookie, Int32 reason);

        void cSetAvailableSpace(Int64 size);

        void cUploadFinished(Int32 cookie, Int32 reason);
```


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```
    }

    Children
    {
        (Streams, IDOCollection)
        (ActiveStream, DOUploadStream)
    }
}
```

3.1.4.1.8.2 Children

UploadManager has two **Children**. Each MUST be connected by the server (2) sending a **Connect** message to the client that has requested an upload to start.

3.1.4.1.8.2.1 Streams

The **UploadManager** distributed object maintains a child distributed object named **Streams**, which is a **DOCollection** that holds all of the current on-going **UploadStream** distributed objects. There can be more than one **UploadStream** distributed objects that is uploading data to the **DataMCU**, but only one at a time can do the upload.

3.1.4.1.8.2.2 ActiveStream

ActiveStream is the **UploadStream** distributed object that is currently uploading data to the server (2).

3.1.4.1.9 UploadStream

The **UploadStream** distributed object is responsible for uploading content package files to the server (2). Note that the names **UploadStream** and **IRCStream** are used interchangeably.

3.1.4.1.9.1 Interface

```
Name="Microsoft.Rtc.Server.DataMCU.Meeting.Parts.IRCStream", Version=1]
DOInterface UploadStream
{
    [Hash=-6716385024907738156]
    ServerInterface
    {
        void sDisconnect();

        void sWrite(byte[] data, Int32 packetNum);
    }

    [Hash=5963839780483567246]
    ClientInterface
    {
        void cDisconnect();

        void cWriteComplete(Int32 nBytes);
    }
}
```


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3.1.4.1.10 NativeFileOnlyContent

The **NativeFileOnlyContent** distributed object is a content distributed object that is used to share a file with meeting attendees. A presenter uploads a file and creates a **NativeFileOnlyContent** distributed object, and the attendees can choose to download the file. The **NativeFileOnlyContent** distributed object is a wrapper of a basic content type, and does not require other specific content operations.

There is a one-to-one mapping between **NativeFileOnlyContent** and **Content**. If **Content's** type is **NativeFileOnly**, a **NativeFileOnlyContent** instance, or proxy, MUST be created.

3.1.4.1.10.1 Interface

```
[Name="Microsoft.Rtc.Server.DataMCU.Meeting.NativeFileOnlyContent", Version=1]
DOInterface NativeFileOnlyContent
{
    [Hash=6421877628186475469]
    ServerInterface
    {
        /* No methods exist */
    }

    [Hash=5585496037459248534]
    ClientInterface
    {
        void cConnectCompleted();
    }
}
```

3.1.4.1.11 PptContent

The **PptContent** distributed object represents an instance of PowerPoint content shared in the session. This distributed object allows the server (2) to signal content resource location, content source encryption information, and changes to the navigation state of the content made by other clients.

The **ResourceFormat** enumeration represents the different resources that can be associated with a **PptContent**. The following table lists the values of the **ResourceFormat** enumeration.

Value	Numeric value
None	0
PartialPpt	1
FullPpt	2
NativeFile	3
PartialDhtml_Deprecated	4
FullDhtml_Deprecated	5
PartialJpeg	6
FullJpeg	7

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Value	Numeric value
PreviewThumbnail	8
SlideThumbnails	9
Notes	10
Dhtml	11

The **ResourceErrorCode** enumeration enumerates the reasons that a resource is not available. The following table lists the values of the **ResourceErrorCode** enumeration.

Value	Numeric value
ClientConversionFailed	1
ClientUploadFailed	2
ClientDependentResourceFailed	3
UploaderClientDisconnected	100
UploaderClientDemoted	101
UnsupportedResourceFormat	102

PptLocation: The following **Location** schema is used as the location argument for the methods **sSetLocation** and **cSetLocation**.

```
<xs:schema
  version="1.0"
  targetNamespace="http://schemas.microsoft.com/2008/08/datamcu-content"
  xmlns:tns="http://schemas.microsoft.com/2008/08/datamcu-content"
  xmlns:xs="http://www.w3.org/2001/XMLSchema"
  xmlns:ms="urn:microsoft-cpp-xml-serializer"

  elementFormDefault="qualified"
  attributeFormDefault="unqualified"
  >

  <xs:annotation>
    <xs:documentation>Schema for PowerPoint Content Location.</xs:documentation>
  </xs:annotation>

  <xs:element name="PptLocation" type="tns:pptloc_type"
ms:className="CXmlPptContentLocationRoot" />

  <!-- Complex type for PptLocation -->
  <xs:complexType name="pptloc_type" ms:className="CXmlPptContentLocation" >
    <xs:sequence>
       <xs:element name="SlideNumber"   type="xs:nonNegativeInteger"
ms:PropertyName="SlideNumber"/>
       <xs:element name="Click"         type="xs:nonNegativeInteger"  ms:PropertyName="Click"
/>

      <xs:any namespace="##other" processContents="lax" minOccurs="0"
maxOccurs="unbounded"></xs:any>
```


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```
    </xs:sequence>
    <xs:anyAttribute namespace="##other" processContents="lax"/>
  </xs:complexType>

</xs:schema>
```

SlideNumber: MUST be greater than or equal to zero and less than the slide count of the **PptContent**.

Click: SHOULD be greater than or equal to zero and less than or equal to the number of clicks in the slide referenced by **SlideNumber**.

3.1.4.1.11.1 Interface

```
[Name=" Microsoft.Rtc.Server.DataMCU.Meeting.PptContent", Version=2]
DOInterface PptContent
{
    [Hash=5075721282249770644]
    ServerInterface
    {
        void sSetLocation(String location);

        void sSetResourceErrorCode(
            Int32 beginSlide,
            Int32 endSlide,
            Int32 format,
            Int32 code);
    }

    [Hash=-3775280164302319261]
    ClientInterface
    {
        void cConnectCompleted();

        void cErrorAddingResource(
            Int32 resourceId,
            Int32 errorCode);

        void cSetFullPptFileInfo(
            String url,
            Byte[] key,
            Byte[] iv,
            Byte[] hash);

        void cSetLocation(String location);

        void cSetNotesInfo(
            String url,
            Int32[] slideNumbers,
            Byte[] key,
            Byte[] iv,
            Byte[] hash);

        void cSetPartialPptFileInfo(
            String url,
            Int32[] slideNumbers,
            Byte[] key,
```


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```
            Byte[] iv,
            Byte[] hash);

        void cSetPreviewThumbnailFileInfo(
            String url,
            Byte[] key,
            Byte[] iv,
            Byte[] hash);

        void cSetResourceErrorCode(
            Int32 beginSlide,
            Int32 endSlide,
            Int32 format,
            Int32 code);

        void cSetSlideCount(Int32 slideCount);

        void cSetSlideDhtmlResourceInfo(
            String resourceOriginalFileName,
            String url,
            Byte[] key,
            Byte[] iv,
            Byte[] hash);

        void cSetSlideDhtmlMarkupInfo(
            Int32 slideNumber,
            Int32 clickCount,
            String markupUrl,
            String[] resourceOriginalFileNames,
            Byte[] key,
            Byte[] iv,
            Byte[] hash);

        void cSetSlideJpegInfo(
            Int32 slideNumber,
            String url,
            Byte[] key,
            Byte[] iv,
            Byte[] hash);

        void cSetThumbnailFileInfo(
            String[] files,
            String url,
            Byte[] key,
            Byte[] iv,
            Byte[] hash);

    }

    Children
    {
        (annotationContainer, AnnotationContainer)
    }

}
```


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3.1.4.1.11.2 Children

The **AnnotationContainer** child distributed object is responsible for managing the annotations of the **PptContent**. Connection to this child is initiated by the server (2).

3.1.4.1.12 AnnotationContainer

The **AnnotationContainer** distributed object is responsible for communicating operations involving **Annotations**. These operations include adding and removing annotations, and changing annotation properties. Any component that needs **Annotation** functionality SHOULD include this distributed object as a child.

AnnotationConstraint: Used in some distributed object messages. These represent various constraints on annotations referenced in server/client message sections. The following table lists the values for **AnnotationConstraint**.

Value	Numeric value
MaxNumDrawingAnnotations	1
MaxNumTextAnnotations	2
MaxNumImageAnnotations	3
MaxNumStampAnnotations	4
MaxDrawingPathDataLength	5
MaxDrawingStrokeThickness	6
MaxTextLength	7
MaxTextFontSize	8
MaxImageFileSize	9
MaxImageWidth	10
MaxImageHeight	11

3.1.4.1.12.1 Interface

```
[Name="Microsoft.Rtc.Server.DataMCU.Meeting.AnnotationContainer", Version=1]
DOInterface AnnotationContainer
{
    [Hash=-5714708003270970775]
    ServerInterface
    {
        sAddAnnotation(Int32 type, String[][] properties);

        sChangeProperties(Int32 id, Int32 gen, String[][] properties);

        sChangePropertyForGroup(Int32[] ids, Int32[] gens, String property, String value);

        sChangePropertyForGroup(Int32[] ids, Int32[] gens, String property, String[] values);

        sChangeText(Int32 id, Int32 gen, Int32 textVersion, Int32[] begins, Int32[] ends,
String[] characters);
```


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```
        sClearAnnotations();

        sRemoveAnnotation(Int32 id);

        sRemoveAnnotations(Int32[] ids, Int32 cookie);

        sSetTelepointer(String anchor, Boolean visible);
    }

    [Hash=2571074477103256610]
    ClientInterface
    {
        cAddAnnotationBatch(Int32[] ids, Int32[] gens, Int32[] types, Int64[] ownerIds, 
Int64[] modifierIds, Int32[] propertyCounts, String[] properties, String[] values);

        cChangePropertiesBatch(Int32[] ids, Int32[] gens, Int64[] modifierIds, Int32[] 
propertyCounts, String[] properties, String[] values);

        cChangeTextBatch(Int32[] ids, Int32[] gens, Int64[] modifierIds, Int32[] 
textVersions, Int32[] deltaCounts, Int32[] begins, Int32[] ends, String[] characters);

        cClearAnnotations(Int64 removerId);

        cErrorAddAnnotation(Int32 type, String[][] properties, String errorCode);

        cErrorChangeProperties(Int32 id, Int32 gen, Int64 modifierId, String[][] properties, 
String errorCode);

        cErrorChangePropertyForGroup(Int32[] ids, Int32[] gens, Int64[] modifierIds, String 
property, String[] values, String errorCode);

        cErrorChangeText(Int32 id, Int32 gen, Int64 modifierId, String errorCode);

        cErrorClearAnnotations(String errorCode);

        cErrorRemoveAnnotation(Int32 id, String errorCode);

        cErrorRemoveAnnotations(Int32[] ids, String errorCode, Int32 cookie);

        cErrorSetTelepointer(String errorCode);

        cRemoveAnnotation(Int32 id, Int64 removerId);

        cRemoveAnnotations(Int32[] ids, Int64 removerId, Int32 cookie);

        cSetAnnotationConstraints(Int32[] constraints, Int32[] values);

        cSetImageFileInfo(Int32 id, String url, Byte[] key, Byte[] iv, Byte[] hash);

        cSetTelepointer(String anchor, Int64 ownerId, Boolean visible);
    }

    Children
    {
    }
}
```


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3.1.4.1.12.2 Children

This distributed object MUST NOT contain any child distributed objects.

3.1.4.1.13 WhiteboardContent

The **WhiteboardContent** distributed object is responsible for operations on whiteboard content. It represents an instance of a **Whiteboard** shared in the content session. Currently, there is only one operation. This distributed object is also a parent for the **AnnotationContainer** distributed object, which is responsible for the annotation functionality on the **Whiteboard**.

3.1.4.1.13.1 Interface

```
[Name="Microsoft.Rtc.Server.DataMCU.Meeting.WhiteboardContent", Version=1]
DOInterface WhiteboardContent
{
    [Hash=4720625287907297465]
    ServerInterface
    {
    }

    [Hash=5909677840878629841]
    ClientInterface
    {
        cConnectCompleted();
    }

    Children
    {
        (annotationContainer, AnnotationContainer)
    }
}
```

3.1.4.1.13.2 Children

The **WhiteboardContent** distributed object has one child distributed object, the **AnnotationContainer** distributed object. The **AnnotationContainer** distributed object encapsulates the annotation functionality for whiteboard content. The server (2) MUST initiate the connect operation for the child distributed object, supplying the distributed object name "annotationContainer". Exactly one **AnnotationContainer** child distributed object MUST be connected.

3.1.4.1.14 PollContent

The **PollContent** distributed object is responsible for operations on poll content. It represents an instance of a real-time collaborative poll, or survey, with a single question and a list of up to 7 multiple choice answers. The creator includes initial poll information, both question and choices, during the package upload. Clients are allowed to vote for any given choice, where the values zero ("0") to "6" represent a given choice. A value of "-1" corresponds to no vote. When a given client votes, the sum of the votes for a given choice are tabulated and sent out to all clients that are allowed to view poll results.

The **open** state represents whether or not users can vote. The **results** state allows the client to show or hide results.

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3.1.4.1.14.1 Interface

```
[Name="Microsoft.Rtc.Server.DataMCU.Meeting.PollContent", Version=1]
DOInterface PollContent
{
    [Hash=7882912516919930871]
    ServerInterface
    {
        sClearVotes();

        sModify(String question, String[] choices, Boolean rememberPastUsers, String 
customizationXml);

        sSetOpenState(Boolean open);

        sSetResultsState(Boolean visibleToAll);

        sVote(Int32 choice);
    }

    [Hash=-1572291151947590318]
    ClientInterface
    {
        cConnectCompleted();

        cSetLocalVote(Int32 choice);

          cSetOpenState(Boolean open);

        cSetQuestion(String question, String[] choices, Boolean rememberPastUsers, String 
customizationXml);

        cSetResults(Int32[] results);

        cSetResultsState(Boolean visibleToAll);
    }

    Children
    {
    }
}
```

3.1.4.1.14.1.1 Children

PollContent has no child objects.

3.1.5 Message Processing Events and Sequencing Rules

Each message MUST be processed in the order received. If an unrecognized message is ever received, the connection MUST be terminated immediately.

3.1.6 Timer Events

When the ping timer expires, a **ping** message is sent with no data on PSOM channel 0. This serves as a keepalive message on the transport.

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3.1.7 Other Local Events

When a connection is lost, no recovery action is taken. To reconnect, a full connect sequence MUST be repeated. All timers SHOULD be reset, and the state SHOULD mirror that of the starting state prior to connection.

3.2 Client Details

The client and server (2) have the life-cycle stages shown in the following diagram.

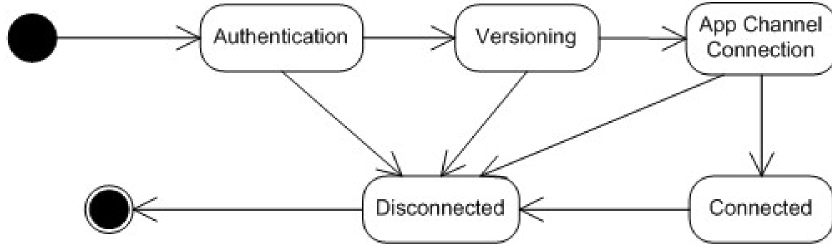

Figure 5: Client and server life-cycle stages

Each state requires mutual operations by both the client and the server (2) to get to the next state. If there is a critical failure, the connection can be terminated.

3.2.1 Abstract Data Model

This section describes a conceptual model of possible data organization that an implementation maintains to participate in this protocol. The described organization is provided to facilitate the explanation of how the protocol behaves. This document does not mandate that implementations adhere to this model as long as their external behavior is consistent with that described in this document.

The abstract data model for the client is covered in section 3.1.1 because this protocol is a symmetric protocol at the lower layer. At a higher layer, the client has a set of interfaces and objects that are created. Generally, the server (2) sends RPC connect messages, except in the case of the content-related distributed objects. These objects are generally connected by the client sending the connect message.

3.2.2 Timers

There is a **ping** method called with no parameters used as a keepalive message sent every 30 seconds by the client on the **ConnMgr** distributed object. For the **ConnMgr** definitions, see section 3.2.3.1.3.1.4. Once the timer has expired, a new one is set at the same interval period.

3.2.3 Initialization

When this protocol is initialized, it MUST begin connecting to a client or server (2) or wait for incoming connections from a server (2). The protocol has no state at this point, and no distributed objects are connected. At a high level, connection is established, and is followed by authentication (2), versioning, and then the root distributed object connection.

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3.2.3.1 Connections

This section describes the steps required for a client to connect and successfully negotiate a connection with a server (2). Connection entails the following main components:

- Authentication (2)
- Interface versioning
- Root distributed object PSOM channel negotiation

3.2.3.1.1 Authentication

Authentication (2) involves two steps:

1. Obtain the **AuthenticationToken**, a string used to identify users to the **DataMCU**. This step is done via a different PSOM channel than the next step.
2. PSOM connection join.

3.2.3.1.1.1 Obtain the Authentication Token

For references to details such as **sAuthId** and **pwrpc.modes**, see [MS-CONFBAS] section 2.2.3.15. This reference describes the **AddUser** request and response mechanism where these values are obtained.

The client needs the **sAuthId** from the **AddUser** response from the server (2) to authenticate. Additionally, if a proxy server (2) is used to allow for load balancing of the server (2), the client needs the **proxyHeader** field from the **AddUser** response.

If the **pwrpc.modes** field is "tls", only **sAuthId** is needed. If it is "fwdtls", both **sAuthId** and **proxyHeader** MUST be sent to the server (2) as follows.

To determine the **FQDN** to connect to, if **pwrpc.modes** is "tls", the client MUST establish a TLS connection to the server (2) and port given in **pwrpc.pwsURI**. This MUST be in the form *"[fqdn]*:*[port]*", where *[fqdn]* is the appropriate FQDN of the server (2), and *[port]* is the open port that will accept connections. If **pwrpc.modes** is "fwdtls", the client MUST attempt to establish a connection to a proxy with a given FQDN and port at proxy[*i*].FQDN and proxy[*i*].Port where *i* is an integer that starts from 0 and goes to N. The client MUST try to connect to a random value of *i*, and if that fails, attempt to connect to another possible FQDN and port.

In establishing a connection, if **alternativeName** is present in the **AddUser** and **pwrpc.modes** is "tls", **alternativeName** MUST be used in place of the **X.509 certificate (2)** subject to validate the FQDN to complete the TLS negotiation. Once the connection has been established through TLS, authentication (2) begins.

Authorization is only sent by the client and validated by the server (2). The server (2) MUST immediately terminate any client connection that does provide this information correctly.

Immediately after establishing a connection over the appropriate transport to the server (2), if applicable, the client MUST send the length of **proxyHeader** in **network byte order**. It MUST follow that with the value it has for **proxyHeader**.

Regardless of whether a proxy is present, the client MUST then send the following in network byte order:

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```
[0x70 77 32 00][0x 00 00 00 00] [length of sAuthId in bytes][sAuthId].
```

See section 3.2.3.1.1.2 for additional details.

To complete authentication of a valid **sAuthId** and **proxyHeader**, the server (2) MUST respond with `[0x 70 77 32 00]`. Once this sequence is completed, the versioning stage begins.

3.2.3.1.1.2 PSOM Connection Join

Once a transport connection has been established, the client MUST place a special signature on the wire, followed by the **AuthenticationVersion**. Then it MUST place an encoded version of the **AuthenticationToken**, which was obtained in section 3.3.3.1.1, on the wire. At this point, the client can continue to send data. This has the following format.

0	1	2	3	4	5	6	7	8	9	1 0	1	2	3	4	5	6	7	8	9	2 0	1	2	3	4	5	6	7	8	9	3 0	1
Signature																															
AuthenticationVersion																															
AuthenticationTokenLen																															
AuthenticationToken (variable)																															
...																															

Signature (4 bytes): Defined as 0x70773200. This field is constant.

AuthenticationVersion (4 bytes): Defined as 0x00000000. This field is constant.

AuthenticationTokenLen (4 bytes): The length of the following **AuthenticationToken**, in bytes.

AuthenticationToken (variable): The byte representation of each character in the **AuthenticationToken** string.

3.2.3.1.2 Interface Versioning

After authentication (2) has completed, the client MUST exchange hashes of each supported distributed object version with the server (2). Because the root PSOM channel, channel 0, is set up implicitly, a special distributed object is used to exchange versioning information messages. This distributed object is referred to as **ConnMgr** and handles exchanging the supported list of distributed objects, which are to be connected on PSOM channel 2 at a later time. If at any time version hashes do not match, the client MUST terminate the connection immediately. A **break** message can be sent prior to closing the connection.

Prior to interface versioning, the client MUST send a **setChannel** record message to the server (2), and set the channelId to 0x00000000. After that, it is free to send any RPC messages to its **ConnMgr** peer on the server (2), as the root distributed object is implicitly connected.

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At a high level, **ConnMgr** negotiation has the client send the following RPC messages to the server (2):

- A **version** message.
- An **addProtocol** message for each supported protocol on the client.
- A **doneProtocols** message.

The payload of **version** should be the distributed object hash for **ConnMgr's** client interface. An **addProtocol** call MUST be made for each supported distributed object on the client-side. Each **addProtocol** call MUST contain the **DOInterface** name attribute, the set of supported versions, which is also declared in the **DOInterface** definition, and each version's corresponding client hash code. Once **doneProtocols** is sent, **version**, **addProtocol**, and **doneProtocols** MUST NOT be sent by the client again.

Once the client has received **doneProtocols** from the server (2), the versioning phase is complete. At this point in time, the connection is established, and the client has validated that it has compatible protocol versions with the server (2).

The **log** method MUST NOT be called by the client.

3.2.3.1.3 ConnMgr Distributed Object Interface Definition

```
[Name="Microsoft.Rtc.Server.DataMCU.Meeting.Pod.ConnMgr", Version=1]
DOInterface ConnMgr
{
    [Hash=8322047979521208965L]
    ClientInterface
    {
        version(Int64 stubHash);

        addProtocol(String name, Int32[] versions, Int64[] hashes);

        doneProtocols();

        ping();
    }

    Children
    {
    }
}
```

3.2.3.1.3.1 ConnMgr Client Methods

The usage of these methods is required to complete connection.

3.2.3.1.3.1.1 version

Allows the server (2) to send its **ConnMgr** hash code to the client.

stubHash (Int64): The hash code of the **ConnMgr ServerInterface**.

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3.2.3.1.3.1.2 addProtocol

Allows the server (2) to communicate the name, versions, and hashes for a given distributed object interface. The current implementation SHOULD only use arrays with one element. Some implementations MAY send multiple versions/hashes. Only the corresponding version/hash from the DOInterface is required. It MUST never be called after **doneProtocols** is sent.

name (String): The name of the **DOInterface**, from the attribute **Name**.

versions (Int32[]): A list of versions. Only one element with the value 1 is supported.

hashes (Int64[]): A list of summed hashes for the corresponding client and server (2) interface versions, or client interface hash value plus server (2) interface hash value. Only one value MUST be sent.

3.2.3.1.3.1.3 doneProtocols

The **doneProtocols** method is called once all **addProtocol** calls are completed. This call signals that the client is done sending protocol versions with **addProtocol**.

3.2.3.1.3.1.4 ping

The **ping** method is used as a keep-alive mechanism. It is a no-op. For more information about this method, see section 3.2.2.

3.2.3.1.4 Root Distributed Object Channel Negotiation

After versioning has completed, the client MUST initiate creation of PSOM channel 2. This PSOM channel is used to send all application messages, unlike PSOM channel 0 that is exclusively used for protocol level negotiations and messages. Any message sent on PSOM channel 2 has to do with application logic.

To do this, the client MUST send an **rpcOpenMessage** with a 32-bit integer payload of 0x00000002. Per the messaging section, this message MUST be followed by an RPC message. This message references the **ConnMgr** proxy, because the current PSOM channel is still 0, and SHOULD call the **lookup** method. The values of **Name** and **protocol** are ignored, but MUST be valid PSOM string payloads. **ProxyHash** is the hash of the application root distributed object client interface. At this point, the message MUST be sent.

Once the **lookup** message is sent, it MUST be followed by a **setChannel** record. The payload of this record is a 32-bit big-endian unsigned integer with the value 0x00000002. At this point, the root distributed object PSOM channel has been negotiated successfully. Any following messages are sent on PSOM channel 2, unless another **setChannel** message is sent to modify this. For more information about the root distributed object connection and connection of the subsequent application distributed objects, see section 3.1.4.1.

3.2.4 Higher-Layer Triggered Events

This section details application PSOM channel events. Any application PSOM channel actions are typically driven by user action.

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3.2.4.1 Distributed Objects

This section details all **Application** distributed objects and their client side methods. Once the connection and versioning phase is complete, the root distributed object, **Meeting**, is connected. This contains all valid server (2) to client RPC calls.

3.2.4.1.1 Meeting

The client component of the **Meeting** distributed object is the root distributed object for the application distributed objects. Its sole responsibility is to receive distributed object **connect** messages and the messages in the following subsections.

3.2.4.1.1.1 Methods

The methods for the **Meeting** distributed object are as follows:

cSetInfo: This method can be called by the server (2). If a client receives this, it should ignore it.

info (String): Not defined.

cSetUrlBase: This method communicates information about the base URL for all downloadable files. It MUST be called by the server (2) before **cMeetingReady** is called.

urlBase (String): The base URL used to for all downloadable files. This MUST be a valid URL path.

cMeetingReady: This method signals that all **Meeting** distributed object state has been communicated. Logically, the **Meeting** distributed object has nothing else to do once this is called.

cSetServerTime: This method communicates the current time on the server (2) in **Coordinated Universal Time (UTC)**. The format MUST be: *yyyy'-'MM'-'dd'T'HH':'mm':'ss*. It MUST be called by the server (2) before **cMeetingReady** is called.

serverTime (String): The current time in **UTC** on the server (2) when this message is sent.

3.2.4.1.2 ContentUserManager

3.2.4.1.2.1 Methods

cUsersAdded: This method is called to tell the user about new user mappings. An **id**, **uri**, and **displayName** are grouped together. If the arrays each contain two elements, the first element of each array is the first user entry, and the second element of each array is the second user entry.

ids (Int64[]): Array of server-generated user ID for this mapping.

uris (string []): Array of URIs.

displayNames (string[]): Array of **displayNames**.

cUsersRemoved: This method indicates that a user mapping is no longer valid.

ids (Int64[]): Array of server-generated user IDs that are no longer valid.

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3.2.4.1.3 ContentManager

The server (2) MUST call **cContentAdded** or **cContentRemoved** to inform clients when a content is available or no longer available to that client. Additionally, when a client has requested a new content and it is created, the server (2) MUST call **cContentCreated** to let the client know that the content was created.

Prior to creating any content, the title MUST be reserved by the client. This enforces title uniqueness among all content.

The active presenter for the meeting is managed through the Content Manager. This is managed via **sPresent** and **sStopPresenting** and communicated to the clients via **cSetActivePresenter**.

3.2.4.1.3.1 Methods

The methods for the **ContentManager** distributed object are as follows:

cContentAdded: This method informs the client that a new content has been made available to it.

contentId (Int64): A server-generated integer that uniquely identifies the content for this meeting.

type (String): The type of the content object. This MUST be one of the following: "Content.Ppt", "Content.Whiteboard", "Content.NativeFileOnly", "Content.Poll". These correspond to the content's implementation distributed object.

cContentCreated: This method is called only on the client that originated the content creation request. It indicates to the creating client that a new content has been successfully created. This gives the new content ID and the cookie that was sent during the creation request so that the client can map the request to the **Content** distributed object.

contentId (Int64): A server-generated integer that uniquely identifies the content for this **Meeting**.

cookie (Int32): A client-generated integer that the client put in the content creation request via the **UploadManager**.

cContentCreationFailed: This method has been deprecated.

cookie (Int32): Deprecated.

reason (Int32): Deprecated.

cContentRemoved: This method informs a client that the content is no longer available to it.

contentId (Int64): A server-generated integer that uniquely identifies the content for this meeting.

cReserveTitleCompleted: This method informs the client about the success or failure of an attempt to reserve a title.

status (Int32 - TitleReservationStatus): Result of the attempt to reserve a title.

cookie (Int32): A client-generated integer that clients use to track the reservation request.

contentId (Int64): The **contentId** associated with the reservation request. For a creation reservation, this is zero (0). For an upgrade reservation, this is the content Id of the content

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to be upgraded. Otherwise, this contains the content ID of the content that already owns the reservation.

owningUserId (Int64): The **ContentUser** Id associated with the client that owns the reservation.

cSetActiveContent: This method informs the client what the active content is for the **Meeting**. This can be zero (0) to indicate there is no active content.

activeContentId (Int64): A server-generated integer that represents the **Content** Id of the content that is the actively presented content.

cSetActivePresenter: This method informs the client who the current active presenter is for the **Meeting**. This can be zero (0) to indicate there is no active presenter.

activePresenterId (Int64): A server-generated integer that represents the **ContentUser** Id of the user who is the active presenter.

cTitleReleased: This method informs the client that the reservation has been released. This can be because of a client request or other conditions, such as a demotion that prevents the client's use of title reservations.

cookie (Int32): The client-generated integer that was sent as part of the **sReserveTitle** request.

3.2.4.1.4 UploadManager

To upload an OC package, the client MUST initiate the upload by sending an **sRequestUpload** message to the server (2).

The server (2) can accept or deny the upload. If the server (2) accepts the upload, the client can proceed with the upload using the upload stream distributed object provided by the server (2) when the upload is accepted. When the upload is complete, the client MUST call the **sUploadFinished** method to notify the server (2) that it has sent all the data.

The following table lists the **UploadFinishReason** response codes.

Response code	Numeric value	Description
Ok	0	Success.
UserCancel	1	The user cancelled the upload.
MaxPackageSizeExceeded	2	The size of the package was too large as determined by the server (2).
CapacityExceeded	3	There is not enough space on the server (2) to complete the operation.
UnknownFailure	4	Unknown failure.
AlreadyUploading	5	The client is already uploading with that cookie.
VerifyFailed	6	There was an error verifying the package on the server (2).
VirusScanTimeout	7	The virus scanning engine took an excessive amount of time.

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Response code	Numeric value	Description
NotUploading	8	The cookie provided was invalid.
TooManyUploads	9	The client has attempted to initiate too many uploads at once.
ArchiveFailed	10	There was a failure archiving important information.
TooManyContents	11	There are more than a predefined number of Content objects in the conference.
TooManySlides	12	A given PowerPoint content upload contained more than a predefined number of slides.

3.2.4.1.4.1 Methods

cAcceptUpload: This method is called by the server (2) to notify the client that the server (2) is ready, and the client can proceed with the upload for the content that corresponds to the specified cookie. The client can proceed to upload the package when it receives the call.

cookie (Int32): The unique cookie value that corresponds to the content.

stream (DistributedObject): The **UploadStream** distributed object that the client uses to upload the content package.

cRejectUpload: This method is called by the server (2) to the client to notify that the content upload request with the specific cookie is rejected and any further calls with the given cookie MUST NOT be made. After the client has called **sRequestUpload** to the server (2), the server (2) MUST respond with **cRejectUpload** or **cAcceptUpload**.

cookie(int32): The unique cookie value that corresponds to the content.

reason (Int32): A reason code for rejecting the upload. See the preceding table for the response codes.

cUploadFinished: This method is called by the server (2) to the upload client to notify it that the server (2) has finished processing the content upload that corresponds to the specific cookie. The function is called in both success and failure cases.

cookie (Int32): The unique cookie value that corresponds to the content.

reason (Int32): The reason that the upload finished. In failure cases, the parameter specifies the reason of the failure.

cSetAvailableSpace: This method is called by the server (2) to notify the client that the storage space is available on the server (2). It is currently deprecated.

size (Int64): Specifies the number of bytes available on the server (2).

3.2.4.1.5 UploadStream

The **UploadStream** distributed object client uploads an OCP package to the server (2). The client MUST call the **sWrite** method to send a data chunk of the OCP package to the server (2). It MUST provide the byte array data, and a sequence number that denotes the data sent this time. The

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sequence number MUST be an incrementing number. The server (2) can disconnect the client by the **cDisconnect** call.

3.2.4.1.5.1 Methods

cDisconnect: This method is called by the server (2) to disconnect the upload stream distributed object.

cWriteComplete: This method is called by the server (2) to notify the client that a previously uploaded data chunk is received.

nBytes (Int32): The number of bytes for the uploaded data chunk.

3.2.4.1.6 Content

3.2.4.1.6.1 Methods

The methods for the **Content** distributed object are as follows:

cConnectCompleted: This method is called when the server (2) has finished setting up the initial state for the content. It does this by calling various other client-side calls to set initial properties.

cForceSync: This method is not used.

cSetCreationTime: This method tells the client what time the content was created on the server (2).

creationTime (string): The time the content was created, in UTC time in string format.

cSetLastUsedTime: This method tells the client the time when the content was last used or presented on the server (2).

lastUsedtime (string): The time the content was last used, in UTC time in string format.

cSetNativeFileInfo: If the content has a "native file", such as the original PowerPoint document, attached to it, this method is used to communicate the file name, **decryption** keys, hash, and file size.

fileName (string): Name of the native file.

key (byte[]): Byte array containing the decryption key.

iv (byte[]): Byte array containing the second part of the decryption key.

hash (byte[]): Byte array containing the hash for this file.

fileSize (Int64): The size of the file.

cSetOwnerId: This method informs the client of the **ContentUser** Id of the owner, or the person who created and uploaded this content.

id (Int64): The server-generated integer of the **ContentUser** Id.

cSetPresentInfo: This method informs the client who the current active presenter is for this content, if any, and the current presented state. ContentManager’s **cSetActiveContent** MUST be sent in addition to this because it is more accurate.

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presented (Boolean): Whether or not this content is in a presented state.

presenterId (Int64): A server-generated integer that represents the **ContentUser** Id of the user who is the active presenter of this content.

cSetPresentationOrder: This method informs the client what the current order is for showing content. The highest number is the most recently presented content.

presentationOrder (Int64): Presentation order. Zero if the content is not presented.

cSetTitle: This method informs the client what the title of the content is.

title (string): Title of the content.

cSetTitleComplete: This method informs the client about the success or failure of an **sSetTitle** call.

status (Int32 - SetTitleStatus): Status, either success or failure, of the **sSetTitle** call.

title (string): Title that was requested for the content.

cSetVisibility: This method informs the client what the current visibility of this content is.

visibility (Int32 - ContentVisibility): Value representing the visibility.

3.2.4.1.7 NativeFileOnlyContent

NativeFileOnlyContent's client interface is only called once the associated **Content** distributed object is logically connected.

3.2.4.1.7.1 Methods

cConnectCompleted: This method allows the server (2) to communicate that the logical content distributed object connection is completed and that **cSetNativeFileInfo** has been called previously. This method MUST be called once per client after all other **Content** distributed object calls are completed.

3.2.4.1.8 AnnotationContainer

cSetAnnotationConstraints MUST be called on the client indicating all the constraints that are going to be imposed on the server (2). After this, **cAddAnnotationBatch** MUST be called on the client with all of the pre-existing annotations.

3.2.4.1.8.1 Methods

cAddAnnotationBatch: This method is used by the server (2) to send a batch of added annotations to the client.

ids (Int32 []): Ids of the annotations added.

gens (Int32 []): Current generation numbers for the annotations.

types (Int32 []): Types of the annotations added.

ownerIds (Int64 []): Ids of the owners of the annotations.

modifierIds (Int64[]): Ids of the last modifiers of the annotations.

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propertyCounts (Int32 []) : Count of properties per annotation.

properties (String []): Property names for the annotations. This array can be larger than the other arrays. The **propertyCounts** MUST be used to figure out how many property names belong to each annotation.

values (String []): Property values for the annotations. This array can be larger than the other arrays. The **propertyCounts** MUST be used to figure out how many property values belong to each annotation.

cChangePropertiesBatch: This method is used by the server (2) to send a batch of changed properties to the client.

ids (Int32 []): Ids of the annotations changed.

gens (Int32 []): Current generation numbers for the annotations.

modifierIds (Int64 []): Ids of the modifiers of the annotations.

propertyCounts (Int32 []): Count of properties per annotation.

properties (String []): Property names for the annotations. This array can be larger than the other arrays. The **propertyCounts** MUST be used to figure out how many property names belong to each annotation.

values (String []): Property values for the annotations. This array can be larger than the other arrays. The **propertyCounts** MUST be used to figure out how many property values belong to each annotation.

cChangeTextBatch: This method is used by the server (2) to send a batch of text changes to the client. This method MUST only be called for text annotations.

ids (Int32 []): Ids of the text annotations that have changed.

gens (Int32 []): Current generation numbers for the annotations.

modifierIds (Int64 []): Ids of the modifiers of the annotations.

textVersions (Int32 []): Current text versions for the annotations.

deltaCounts (Int 32[]): Count of deltas per annotation.

begins (Int 32[]): Beginning positions of the text deltas. This array can be larger than the other arrays. The **deltaCounts** MUST be used to figure out how many deltas belong to each annotation.

ends (Int 32[]): Ending positions of the text deltas. This array can be larger than the other arrays. The **deltaCounts** MUST be used to figure out how many deltas belong to each annotation.

characters (String []): Characters in the text deltas. An empty string indicates that the delta is for a deleted sequence in the text. This array can be larger than the other arrays. The **deltaCounts** MUST be used to figure out how many deltas belong to each annotation.

cClearAnnotations: This method is used by the server (2) to indicate to the client that all the annotations have been cleared.

removerId (Int64): Id of the remover.

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cErrorAddAnnotation: This method is used by the server (2) to indicate an error in adding an annotation. This method MUST only be called on the client that requested the add operation. The server (2) MUST NOT send the "Telepointer" type or a non-supported type in the type parameter.

type (Int32): Type of annotation.

The following table lists the values of **type.**

Value	Numeric value
Drawing	0
Text	1
Image	2
Telepointer	3

properties (String [][]): Initial set of properties and values for the annotation that were sent to the server (2).

errorCode (String): Error code from the server (2).

cErrorChangeProperties: This method is used by the server (2) to indicate an error in changing properties for an annotation. The current values on the server (2) MUST be sent back to the client. This method MUST only be called on the client that requested the property changes.

id (Int32): Id of the annotation.

gen (Int32): Current generation number of the annotation.

modifierId (Int64): Id of the last modifier.

properties (String [][]): Current values of properties that were sent to the server (2).

errorCode (String): Error code from the server (2).

cErrorChangePropertyForGroup: This method is used by the server (2) to indicate an error in changing a property for a group of annotations. The current values on the server (2) for the property MUST be sent back to the client. This method MUST only be called on the client that requested the property changes.

ids (Int32 []): Identifiers of the annotations.

gens (Int32 []): Current generation numbers for the annotations.

modifierIds (Int64): Id of the last modifier.

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property (String): The property that could not be changed.

values (String []): Current values on the server (2) for the property for the group of annotations.

errorCode (String): Error code from the server (2).

cErrorChangeText: This method is used by the server (2) to indicate an error in changing the text property of a text annotation. This method MUST only be called on the client that requested the text change.

id (Int32): Identifier of the text annotation.

gen (Int32): Current generation number of the annotation.

modifierId (Int64): Identifier of the last modifier.

errorCode (String): Error code from the server (2).

cErrorClearAnnotations: This method is used by the server (2) to indicate an error in clearing all the annotations to the client. This method MUST only be called on the client that requested the clear operation.

errorCode (String): Error code from the server (2).

cErrorRemoveAnnotation: This method is used by the server (2) to indicate an error in removing the annotation to the client. This method MUST only be called on the client that requested the remove operation.

id (Int32): Identifier of the annotation.

errorCode (String): Error code from the server (2).

cErrorRemoveAnnotations: This method is used by the server (2) to indicate an error in removing a group of annotations to the client. This method MUST only be called on the client that requested the remove operation.

ids (Int32 []): Identifiers of the annotations.

errorCode (String): Error code from the server (2).

cookie (Int32): Cookie that was passed to the server (2) with the remove operation. This cookie is opaque to the server (2).

cErrorSetTelepointer: This method is used by the server (2) to indicate an error in updating a **Telepointer** to the client. This method MUST only be called on the client that requested the **Telepointer** update.

errorCode (String): Error code from the server (2).

cRemoveAnnotation: This method is used by the server (2) to indicate to the client that an annotation was removed.

id (Int32): Identifier of the annotation that was removed.

removerId (Int64): Identifier of the remover.

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cRemoveAnnotations: This method is used by the server (2) to indicate to the client that a group of annotations were removed.

ids (Int32 []): Identifiers of the annotations that were removed.

removerId (Int64): Identifier of the remover.

cookie (Int32): Cookie that was passed to the server (2) with the remove operation. This cookie is opaque to the server (2).

cSetAnnotationConstraints: This method is used by the server (2) to send the constraints that are going to be imposed on the server (2).

Constraints (Int32 []): The constraints defined in the enumeration **AnnotationContainerConstants.Constraint**.

Values (Int32 []): The values of the constraints.

cSetImageFileInfo: This method is used by the server (2) to set the image file information for an image annotation. The image annotation MUST exist on the client. This method MUST be called exactly once per client for each image annotation.

id (Int32): The identifier of the annotation.

url (String): URL of the image file resource. The image file pointed to by this URL MUST be AES256 encrypted, and can be decrypted by the key and initialization vector parameters.

key (Byte []): The AES256 key of the encrypted file pointed to by **url**.

iv (Byte []): The initialization vector for **key**.

hash (Byte []): The **SHA-1** hash of the file pointed to by **url**. The **hash** MUST be of the unencrypted file.

cSetTelepointer: This method is used by the server (2) to indicate to the client that a **Telepointer** was updated.

anchor (String): Anchor property that describes the location of the **Telepointer**.

ownerId (Int64): Identifier of the owner.

visible (Boolean): Visibility property that describes whether the **Telepointer** is visible.

3.2.4.1.9 WhiteboardContent

The **cConnectCompleted** method MUST be called exactly once per client.

3.2.4.1.9.1 Methods

cConnectCompleted: This method is used by the server (2) to indicate to the client that its child distributed object is done connecting. This method has no parameters. The child distributed object MUST be connected before this call. This method MUST be called once per client.

3.2.4.1.10 PptContent

The client-side **PptContent** distributed object receives slide count, location, and resource information from the server (2).

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3.2.4.1.10.1 Methods

The methods for the **PptContent** distributed object are as follows:

cConnectCompleted: This method allows the server (2) to communicate that the current location, all slide info, and the thumbnail info have been sent. The **cSetSlideCount** and **cSetLocation** methods SHOULD have been called previously. SHOULD be called once per client.

cSetSlideCount: This method allows the server (2) to communicate the number of slides in the **PptContent**.

slidecount (Int32): The number of slides in the **PptContent**.

cSetLocation: This method allows the server (2) to communicate a new location value for the **PptContent**. SHOULD be called on all clients in response to a successful **sSetLocation** call from a client.

location (String): New location information to be set for **PptContent**. MUST conform to **PptContentLocation** schema.

cSetPreviewThumbnailFileInfo: This method allows the server (2) to communicate to clients resource information for the preview thumbnail of the **PptContent**. This method SHOULD be called once per client.

url (String): URL of the preview thumbnail. The file that **url** points to MUST be AES256 encrypted and can be decrypted with **key** and **iv**.

key (Byte[]): The AES256 key of the file pointed to by **url**.

iv (Byte[]): The input vector of **key**.

hash (Byte[]): The SHA-1 hash of the file pointed to by **url**. The **hash** MUST be of the file in its unencrypted form.

cSetThumbnailFileInfo: This method allows the server (2) to communicate to clients the resource information for the slide thumbnails of the **PptContent**. This method SHOULD be called once per client, and only if there are thumbnail resources uploaded for the **PptContent**.

files (String[]): File names of the thumbnail files that are in the Open Package Convention file pointed to by **url**. File names MUST be in the order of the slide that they refer to.

url (String): URL of the Open Package Convention file containing all slide thumbnails for the **PptContent**. The file that **url** points to MUST be AES256 encrypted and can be decrypted with **key** and **iv**.

key (Byte[]): The AES256 key of the file pointed to by **url**.

iv (Byte[]): The input vector of **key**.

hash (Byte[]): The SHA-1 hash of the file pointed to by **url**. The hash MUST be of the file in its unencrypted form.

cSetPartialPptFileInfo: This method allows the server (2) to communicate to clients the resource information for the partial PowerPoint file. A partial PowerPoint file is a PowerPoint 97-2003 Presentation file that includes some or all of the slides in the presentation.

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url (String): URL of the Open Package Convention file containing the partial PowerPoint file. The file that **url** points to MUST be AES256 encrypted and can be decrypted with **key** and **iv**.

slideNumbers (Int32[]): The slide numbers that are contained in the partial PowerPoint file.

key (Byte[]): The AES256 key of the file pointed to by **url**.

iv (Byte[]): The input vector of **key**.

hash (Byte[]): The SHA-1 hash of the file pointed to by **url**. The hash MUST be of the file in its unencrypted form.

cSetNotesInfo: This method allows the server (2) to communicate to clients resource information for the slide notes of the **PptContent**.

slideNumbers (Int32[]): The slide numbers that are contained in the Open Package Convention file containing the notes.

url (String): URL of the Open Package Convention file that contains the slide notes. The file that **url** points to MUST be AES256 encrypted and can be decrypted with **key** and **iv**.

key (Byte[]): The AES256 key of the file pointed to by **url**.

iv (Byte[]): The input vector of **key**.

hash (Byte[]): The SHA-1 hash of the file pointed to by **url**. The hash MUST be of the file in its unencrypted form.

cSetSlideDhtmlResourceInfo: This method allows the server (2) to communicate to clients the resource information for the **Dynamic Hypertext Markup Language (DHTML)** resource for a slide. These resources can be shared between markup resources.

resourceOriginalFileName (String): Unique name corresponding to a shared asset/resource. This can be referred to by one or more **cSetSlideDHtmlMarkupInfo** calls.

url (String): URL for the Open Package Convention file that contains the DHTML resource for the resource. The file that **url** points to MUST be AES256 encrypted and can be decrypted with **key** and **iv**.

key (Byte[]): The AES256 key of the file pointed to by **url**.

iv (Byte[]): The input vector of **key**.

hash (Byte[]): The SHA-1 hash of the file pointed to by **url**. The hash MUST be of the file in its unencrypted form.

cSetSlideDhtmlMarkupInfo: This method allows the server (2) to communicate to clients the resource information for the DHTML resource for a slide.

slideNumber (Int32): Slide number that resources in **url** are for.

clickCount (Int32): The number of animations on the slide.

markupUrl (String): URL for the Open Package Convention file that contains the DHTML resources for the slide. The file that **url** points to MUST be AES256 encrypted and can be decrypted with **key** and **iv**.

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resourceOriginalFileNames (String[]): Array of **DhtmlResources** that are associated with this slide. Each entry MUST correspond to a corresponding call from **cSetSlideDhtmlResourceInfo's resourceOriginalFileName** parameter.

key (Byte[]): The AES256 key of the file pointed to by **url**.

iv (Byte[]): The input vector of **key**.

hash (Byte[]): The SHA-1 hash of the file pointed to by **url**. The hash MUST be of the file in its unencrypted form.

cSetFullPptFileInfo: This method allows the server (2) to communicate to clients the resource information for the PowerPoint 97-2003 format file of the presentation containing all slides of the **PptContent**. SHOULD be called once per client and only if the resource is available.

url (String): URL of the Open Package Convention file containing the PowerPoint 97-2003 format file that has all slides of the **PptContent**. The file that **url** points to MUST be AES256 encrypted and can be decrypted with **key** and **iv**.

key (Byte[]): The AES256 key of the file pointed to by **url**.

iv (Byte[]): The input vector of **key**.

hash (Byte[]): The SHA-1 hash of the file pointed to by **url**. The hash MUST be of the file in its unencrypted form.

cErrorAddingResource: This method allows the server (2) to communicate to the uploading client that there was a server-side failure while adding a resource. SHOULD be called on the client that attempted to upload the particular resource.

resourceId (Int32): Resource identifier of the resource for which the error occurred.

errorCode (Int32): Error code for the failure. MUST be one of the values specified in the **ResourceErrorCode** type in section 3.1.

cSetResourceErrorCode: This method allows the server (2) to communicate to clients that there was an error with adding a particular resource and that the resource will not be available.

beginSlide (Int32): The beginning index, inclusive, of the slide range for the error. MUST be greater than or equal to zero, less than the number of slides for the **PptContent**, and less than or equal to **endSlide**.

endSlide (Int32): The ending index, inclusive, of the slide range for the error. MUST be greater than or equal to zero, less than the number of slides for the **PptContent**, and greater than or equal to **beginSlide**.

format (Int32): The format of the resource generating the error. MUST be one of the values specified in the **ResourceFormat** enumeration.

errorCode (Int32): Error code for the failure. MUST be one of the values specified in the **ResourceErrorCode** enumeration.

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3.2.4.1.11 PollContent

The **PollContent** client distributed object is able to receive state, the local user's vote, and the aggregate sum of responses for the choices. Both the client and server (2) can choose to enforce maximum length limits on any strings or arrays.

3.2.4.1.11.1 Methods

The methods for the **PollContent** distributed object are as follows:

cSetQuestion: This method allows the server (2) to communicate the sum of the votes for a given choice. If the results are not visible to the client, this MUST be an array of all zeros.

question (String): The text of the question.

choices (String[]): An array with length greater than 1 and less than or equal to 7. Each element represents the text of a given choice. The ordinal positions of each array element are held consistent across all other calls. For example, position zero corresponds to position zero in the results array in **cSetResults**.

rememberPastUsers (Boolean): This is provided for future extensibility. MUST be "true".

customizationXml (String): This is provided for future extensibility. MUST be an empty string.

cSetResults: This method allows the server (2) to communicate the sum of the votes for a given choice. If the results are not visible to the client, this MUST be an array of all zeros.

results (Int32[]): Array of integer vote sums. The length MUST be either the maximum allowed number of choices, which is 7, or the number of choices used in **cSetQuestion**. If the results are not visible to a given client, this MUST be an array of all zeros; otherwise it MUST be non-negative sums of the number of users that voted for a given choice.

cSetOpenState: This method allows the server (2) to communicate whether or not clients can call **sVote**.

open (Boolean): When "true", all clients can call **sVote**. When "false", clients SHOULD NOT call **sVote**. If they do, the server (2) MUST respond with **cSetLocalVote** with the value of the client's vote that was set when **cSetOpenState**, which means that **open** equals "true".

cSetResultsState: This method allows the server (2) to communicate whether or not results should be shown to a certain subset of attendees.

results (Boolean): When "true", all clients can view the results. If "false", only presenters can view the results.

cSetLocalVote: This method communicates the client's local vote. This MUST be persisted by the server (2) if the client, as the same user, ever connects to this distributed object and had a past vote.

choice (Int32): The value of the user's vote. A value of "-1" represents the absence of a vote.

cConnectComplete: This method allows the server (2) to communicate that the current location, all slide information, and the thumbnail info have been sent. The **cSetQuestion, cSetOpenState, cSetResultsState,** and **cSetLocalVote** methods SHOULD have been called previously. SHOULD be called once per client.

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3.2.5 Message Processing Events and Sequencing Rules

This protocol's lower layer protocol description does not require a particular ordering of messages. However, a higher layer application can require this, but it is dependent on the particular message received. This is highlighted for each component. The client MUST process any incoming message in the order that it is received. Sometimes user input might be required prior to sending a response message, if required. In other cases, an immediate response might be required.

3.2.6 Timer Events

Because this protocol requires a lossless transport, there are no time-outs. No higher-layer timers exist that are specific to the client. See section 3.1.6 for timers that are common between the client and the server (2).

3.2.7 Other Local Events

In the event that a connection is terminated by the server (2), the client can choose to re-establish the connection by starting the connection process from the beginning.

3.3 Server Details

The server (2) is responsible for some conference state, and authorizing clients. At the messaging layer, there are minimal differences. See section 3.2.4 for details on specific server (2) functionality.

3.3.1 Abstract Data Model

This section describes a conceptual model of possible data organization that an implementation maintains to participate in this protocol. The described organization is provided to facilitate the explanation of how the protocol behaves. This document does not mandate that implementations adhere to this model as long as their external behavior is consistent with that described in this document.

The server (2) is composed of a set of higher-laver messages built on the PSOM messaging layer. Logically, the server (2) holds all conference state and allows clients to interact with that state, notifying other clients of any changes that take place.

3.3.2 Timers

There is a **ping** method called with no parameters that is used as a keepalive message sent every 30 seconds by the server (2) on the **ConnMgr** distributed object. For the **ConnMgr** definitions, see section 3.3.3.1.3. When the timer expires, a new one is set at the same interval period.

3.3.3 Initialization

When this protocol is initialized, it MUST begin connecting to a server (2) or a client, or wait for incoming connections from a server (2). The protocol has no state at this point, and no distributed objects are connected. At a higher layer, connection is established, and is followed by authentication (2), versioning, and finally root distributed object connection.

3.3.3.1 Connections

This describes the steps required for a server (2) to successfully negotiate a connection with a client. Connection entails three main components:

- Authentication (2).

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- Interface versioning.
- Root distributed object PSOM channel negotiation.

See section 3.2.3.1.1 for additional details about authentication (2) and interface versioning because there are required responses or actions for each message.

3.3.3.1.1 Authentication

Note that many of the fields used here are defined in [MS-CONFBAS] section 2.2.3.15 and section 3.2.3.1.

The server (2) MUST generate the appropriate **AddUser** response fields to an authorized user. Using these details, the client establishes a connection to the server (2). The server (2) MUST ensure that the **sAuthId** and any other token presented during this phase match the one presented to the user via **AddUser**. If the client does not do this within 120 seconds or does it with an invalid value, the server (2) MUST immediately terminate the incoming connection.

3.3.3.1.2 Interface Versioning

After authentication (2) has completed, the server (2) MUST exchange with the client hashes of each distributed object version that it supports. Because the root PSOM channel, channel 0, is set up implicitly, a special distributed object is used to exchange versioning information messages. This distributed object is referred to as **ConnMgr** and handles exchanging the supported list of distributed objects, which are to be connected on PSOM channel 2 at a later time. If at any time the version hashes do not match, the server (2) MUST terminate the connection immediately. A **break** message can be sent prior to closing the connection.

As the server (2) receives the **addProtocol** messages from the client, it MUST validate that the hashes match its own definitions. If the server (2) determines that the hashes are not equal, it MUST terminate the connection with a **close** or **break** message. If not, it MUST repeat the same sequence of RPC messages to the client, including its own hash information instead. Once the server (2) has sent **doneProtocols** to the client, the versioning phase is complete. At this point, the connection is established, and the server (2) has validated that it has protocol versions compatible with the client.

3.3.3.1.3 ConnMgr Distributed Object Interface Definition

```
[Name="Microsoft.Rtc.Server.DataMCU.Meeting.Pod.ConnMgr", Version=1]
DOInterface ConnMgr
{
    [Hash=-8221414758688209204L]
    ServerInterface
    {
        version(Int64 stubHash);

        addProtocol(String name, Int32[] versions, Int64[] hashes);

        doneProtocols();

        log(String msg);

        lookup(String name, String protocol, Int64 proxyHash);

        ping();
    }
```


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3.3.3.1.3.1 ConnMgr Server Methods

3.3.3.1.3.1.1 version

The first distributed object method call. This is used to communicate the overall client interface **ConnMgr** hash to the server (2).

stubHash (Int64): The hash code of the **ConnMgr ClientInterface**.

3.3.3.1.3.1.2 addProtocol

Allows the client to communicate the name, versions, and hashes for a given distributed object interface. The current implementation SHOULD only use arrays with one element. Some implementations might send multiple versions. Only the versions specified in the DOInterface tables should be sent, other values MUST be ignored. This method MUST NOT be called after **doneProtocols** is sent.

name (String): The name of the **DOInterface**, from the attribute **Name**.

versions (Int32[]): A list of versions. Only one element with the value 1 is supported.

hashes (Int64[]): A list of summed hashes for the corresponding client and server (2) interface versions, or client interface hash value plus server (2) interface hash value. Only one value MUST be sent.

3.3.3.1.3.1.3 doneProtocols

The **doneProtocols** method is received once all **addProtocol** calls are completed. This signals that the client is done sending protocol versions with **addProtocol**.

3.3.3.1.3.1.4 log

Deprecated. The **log** method does nothing.

msg (String): No meaning.

3.3.3.1.3.1.5 Lookup

Lookup is a special method call. It is used as part of the **rpcOpen** record message to indicate that a new PSOM channel is to be created.

name (String): Deprecated. No value required.

protocol (String): Deprecated. No value required.

proxyHash (Int64): Deprecated.

3.3.3.1.3.1.6 ping

This is used as a keep-alive mechanism. It is a no-op.

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3.3.4 Higher-Layer Triggered Events

This section details application PSOM channel events.

3.3.4.1 Distributed Objects

The following sections specify higher-layer triggered events for distributed objects.

3.3.4.1.1 Meeting

The server (2) piece of the **Meeting** distributed object MUST send distributed object connect messages for its child objects, **ContentUserManager** and **ContentManager**, immediately after connection. It MUST also call **cSetUrlBase** followed by **cMeetingReady** to complete the logical connection sequence.

3.3.4.1.1.1 Methods

sSetInfo: MUST NOT be called. This method is not currently supported.

info (String): Not defined.

3.3.4.1.2 ContentUserManager

No methods exist on the server (2) interface.

3.3.4.1.2.1 Methods

None.

3.3.4.1.3 ContentManager

The server (2) MUST respond to **sReserveTitle** with **cReserveTitleCompleted**.

For active presenter calls such as **sPresent**, which allows the client to become the active presenter, or **sStopPresenting**, which gives up the active presenter role, the server (2) only needs to indicate a change via **cSetActivePresenter**. If there is no change, such as when the request is not honored because of permissions or because it would have no effect, no response is required.

3.3.4.1.3.1 Methods

sDeleteContent: This method requests that the server (2) deletes the content.

contentId (Int64): The server-generated integer that uniquely identifies the content to be deleted.

sPresent: Claims the active presenter role. If a piece of content is currently being presented, that content is no longer presented.

sReleaseTitle: This method is called by clients to release a title reservation.

cookie (Int32): The client-generated integer that was sent as part of a previous **sReserveTitle** request.

sReserveTitle (1): This method is called by clients to reserve a title for a content.

title (String): The title to reserve.

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cookie (Int32): A client-generated integer that the clients can use to track the completion of this request.

sReserveTitle (2): This method is deprecated.

title (String): Deprecated.

cookie (Int32): Deprecated.

externalId (String): Deprecated.

sStopPresenting: If the requesting client is the current active presenter, relinquishes the stage.

3.3.4.1.4 UploadManager

When the server (2) receives a request from the client, it MUST respond with **cRejectUpload** or **cAcceptUpload**. In the **cRejectUpload** method, the server (2) MUST provide the rejection reason. If the server (2) accepts the upload, it MUST call the client's **cAcceptUpload** method, and it MUST provide the upload **cookie** and the distributed object **UploadStream**. The client can then use the **UploadStream** to send bytes that represent the package to the server (2).

When the server (2) receives **sUploadFinished**, it can parse the contents of the uploaded file and act appropriately.

The client can, at any time during the upload, cancel the upload. To do this, the client MUST call **sUploadFinished** with the **cancel** flag set to **true**. If the client has not uploaded all of the file's bytes, the server (2) MUST call the client's **cUploadFinished** method, with the appropriate upload finished reason.

3.3.4.1.4.1 Methods

sRequestUpload: This method is called by a client to initiate the upload of an OCP. The client MUST pass the size of the package file to be uploaded, and the cookie associated with the content to be created. This cookie is used to identify various uploads. After this call, the client MUST wait for a response from the server (2), as described in section 3.2.

length (Int64): The size of the content package file to be uploaded.

cookie (Int32): The unique cookie value that corresponds to the content to be created.

sUploadFinished: This method MUST be called by the client upon completion of the upload. and provide the same cookie as provided in **sRequestUpload**. This covers the case where the client has uploaded all the data, and the case in which the client cancels the upload.

cookie (Int32): The unique cookie value that corresponds to the content.

cancel (Boolean): When "false", the user has uploaded all the data. When "true" the server (2) MUST cancel the upload.

3.3.4.1.5 UploadStream

When the server (2) has received a data chunk that sent by the client, it acknowledges to the client by calling the **cWriteComplete** method. The server (2) MUST provide the received data size of the **sWrite** call it has received.

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3.3.4.1.5.1 Methods

sDisconnect: This method is called by the client to disconnect the **UploadStream** distributed object from the server (2).

sWrite: This method is called by the client to write a chunk of data to the server (2). The client MUST provide the data chunk as a byte array and a sequence number for the write, which MUST be an incrementing number.

Data (byte[]): The byte array is the data chunk to be uploaded.

packetNum (Int32): The sequence number of the data chunk to be uploaded.

3.3.4.1.6 Content

The server (2) MUST call **cSetTitleComplete** to inform clients when an attempt to rename the content via **sSetTitle** either succeeded or failed.

For active presenter calls such as **sPresent**, to become the active presenter, or **sStopPresenting**, to give up the active presenter role, the server (2) only needs to indicate a change via **cSetPresentInfo** or ContentManager's **cSetActiveContent**. If there is no change, such as when the request is not honored because of permissions or because it would have no effect, no response is required.

3.3.4.1.6.1 Methods

sForceSync: This method is not used.

sMakeHighestPresentationOrder: This method makes an already-presented content become the highest presentation order.

sPresent: This method claims the active presenter role for this piece of content. If it was not already presented, it becomes presented.

sSetTitle: This method requests the title be changed.

title (string): The title to use to rename the content.

sSetVisibility: This method sets the visibility for this content.

visibility (Int32 - ContentVisibility): The visibility to set the content.

sStopPresenting: If the requesting client is the active presenter for this content, this method stops presenting the content and removes the client from the active presenter role.

3.3.4.1.7 NativeFileOnlyContent

NativeFileOnlyContent's service interface has no messages defined. Messages MUST NOT be sent.

3.3.4.1.7.1 Methods

None.

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3.3.4.1.8 AnnotationContainer

The server (2) MUST respond to client requests for adding, removing and modifying annotations. It MUST respond by broadcasting the add or remove or modify to all the clients, and in the case of errors, it MUST respond with an error response to the originating client.

3.3.4.1.8.1 Methods

sAddAnnotation: This method is a request to the server (2) to add an annotation of the specified type, using the specified properties. The server (2) MUST validate the type and properties, and if valid, it MUST add this information to a collection for tracking purposes, because other operations involving this annotation can be sent to the server (2). At this point, a unique id MUST be assigned to the annotation that clients can use to refer to the annotation.

If there is an error while processing this operation, an error response MUST be sent to the client using the **cErrorAddAnnotation** method. If the annotation was successfully added, a notification response MUST be sent to all the clients using the **cAddAnnotationBatch** method. The server (2) can batch all such notifications and send them in batches from time to time.

Only "Drawing", "Text", and "Image" type annotations can be added to the container. The client MUST NOT send an add operation for a "Telepointer" annotation, or any non-supported type.

type (Int32): Type of annotation to add.

Value	Meaning
0	Drawing
1	Text
2	Image
3	Telepointer

properties (String [][]): Initial set of properties and values for the annotation.

sChangeProperties: This method is a request to the server (2) to change an existing annotation’s properties. If the annotation with the specified id is not found, the server (2) MUST send an error response to the client using the **cErrorChangeProperties** method. If an invalid generation number or properties are sent, the server (2) SHOULD disconnect the client. If valid parameters are received, the generation number MUST be incremented, and the changed properties MUST be sent to all the clients using the **cChangePropertiesBatch** method.

id (Int32): Identifier of the annotation to change.

gen (Int32): Current generation number.

properties (String [][]): Properties to change. This is a two-dimensional array of property names and property values.

sChangePropertyForGroup: This method is a request to the server (2) to change a property for a group of existing annotations. The specified property has the same value for all the annotations in the group. If any of the parameters are invalid, the server (2) SHOULD disconnect the client. If none of the annotations are found, the server (2) MUST send an error response to the client using the **cErrorChangePropertyForGroup** method. If individual annotations are not found, the server (2) MUST send an error response to the client using the

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cErrorChangeProperties method. If valid parameters are received and the annotations are found, the generation numbers MUST be incremented, and the changed property MUST be sent to all the clients using the **cChangePropertiesBatch** method.

ids (Int32 []): Identifiers of the annotations to change.

gens (Int32 []): Current generation numbers for the annotations.

property (String): The property that needs to be changed.

value (String): The new value of the property.

sChangePropertyForGroup: This method is a request to the server (2) to change a property for a group of existing annotations. The specified property can have a different value for each of the annotations in the group. If any of the parameters are invalid, the server (2) SHOULD disconnect the client. If none of the annotations are found, the server (2) MUST send an error response to the client using the **cErrorChangePropertyForGroup** method. If individual annotations are not found, the server (2) MUST send an error response to the client using the **cErrorChangeProperties** method. If valid parameters are received and the annotations are found, the generation numbers MUST be incremented, and the changed property MUST be sent to all the clients using the **cChangePropertiesBatch** method.

ids (Int32 []): Ids of the annotations to change.

gens (Int32 []): Current generation numbers for the annotations.

property (String): The property that needs to be changed.

values (String []): The new values of the property.

sChangeText: This method is a request to the server (2) to change the text property of a text annotation. This method MUST only be called for text annotations. The changes MUST be sent in the form of text deltas. If the annotation is not found, the server (2) MUST send an error response to the client using the **cErrorChangeText** method. If the text version is stale, the server (2) MUST reject the change but, because this is not an error, an error response MUST NOT be sent back to the client. If the text deltas are invalid, the server (2) SHOULD disconnect the client. If valid deltas are received and the annotation is found and the text version is not stale, the generation number MUST be incremented, and the deltas MUST be sent to all the clients using the **cChangeTextBatch** method.

id (Int32): Identifier of the text annotation to change.

gen (Int32): Current generation number.

textVersion (Int32): Text version that the change is based on.

begins (Int32 []): Beginning positions of the text deltas.

ends (Int32 []): Ending positions of the text deltas.

characters (String []): Characters in the text deltas. An empty string indicates that the delta is for a deleted sequence in the text.

sClearAnnotations: This method is a request to the server (2) to remove all the annotations. If there are no annotations to clear, an error response MUST be sent to the client using the **cErrorClearAnnotations** method. If the annotations are successfully cleared, the server (2) MUST send the **clear** operation to all the clients using the **cClearAnnotations** method. This method has no parameters.

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sRemoveAnnotation: This method is a request to the server (2) to remove an annotation. If the annotation is not found, an error response MUST be sent to the client using the **cErrorRemoveAnnotation** method. If the operation is successful, the server (2) MUST send the **remove** operation to all the clients using the **cRemoveAnnotation** method.

id (Int32): Identifier of the annotation to remove.

sRemoveAnnotations: This method is a request to the server (2) to remove a group of annotations. If there are no annotations to remove, an error response MUST be sent to the client using the **cErrorRemoveAnnotations** method. If any annotations are removed successfully, the server (2) MUST send a **remove** operation with the ids of the annotations that were actually removed to all the clients, using the **cRemoveAnnotations** method.

ids (Int32 []): Identifiers of the annotations to remove.

cookie (Int32): Cookie sent by the client. This cookie is opaque to the server (2).

sSetTelepointer: This method is a request to the server (2) to set the **Telepointer's** properties. If the **Telepointer** is visible, and if it has been previously added to the server's collection, it MUST be updated. Otherwise, a new **Telepointer** MUST be created and added to the server's collection for tracking purposes. This **Telepointer's** information MUST be sent to all the clients using the **cSetTelepointer** method.

If the **Telepointer** is not visible, it MUST be removed from the server's collection, and the information MUST be sent to all clients using the **cSetTelepointer** method.

anchor (String): Anchor property that describes the location of the **Telepointer**.

visible (Boolean): Visibility property that describes whether the **Telepointer** is visible.

3.3.4.1.9 WhiteboardContent

No methods exist on the server (2) interface.

3.3.4.1.9.1 Methods

None.

3.3.4.1.10 PptContent

The server-side **PptContent** distributed object is responsible for receiving and fanning out changes to the **PptLocation**, and alerting clients of resource availability and errors. Resources that are uploaded through **UploadManager** for this particular content have availability and status communicated out to clients via client-side methods such as **cSetFullPpt** info or **cSetResourceError** code.

3.3.4.1.10.1 Methods

sSetLocation: This method allows a client to attempt to change the location of the **PptContent**.

location (String): New location information to be set for **PptContent**. MUST conform to the **PptContentLocation** schema in section 3.1.4.1.11 or be the value "INITIAL_LOCATION". When the **PptContent's** location is successfully changed, the server (2) SHOULD call **cSetLocation** with the new location on all clients.

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sSetResourceErrorCode: This method allows the client to communicate to the server (2) that there was an error while adding a particular resource, and that the resource is not available. The server (2) SHOULD call **cSetResourceErrorCode** for each client with the same information, in response to **sSetResourceErrorCode**.

beginSlide (Int32): The beginning index, inclusive, of the slide range for the error. MUST be greater than or equal to zero, less than the number of slides for the **PptContent**, and less than or equal to **endSlide**.

endSlide (Int32): The ending index. inclusive, of the slide range for the error. MUST be greater than or equal to zero, less than the number of slides for the **PptContent**, and greater than or equal to **beginSlide**.

format (Int32): The resource format that the error is for. MUST be one of the values specified in the **ResourceFormat** enumeration.

errorCode (Int32): Error code for the failure. MUST be one of the values specified in the **ResourceErrorCode** enumeration.

3.3.4.1.11 PollContent

The server-side **PollContent** distributed object is responsible for receiving votes, state updates, and question andchoice changes and fanning out changes to select clients that are allowed to see that information. The server (2) SHOULD persist votes andresult counts across conferences. The server (2) SHOULD enforce certain limits on vote counts and question length. Ffor example, the server (2) can either ignore calls or send back a distributed object call that reflects the state the server (2) determines all clients should have.

Methods such as **cSetQuestion** and **cSetOpenState** are shared objects that certain clients can modify. They are used to share the value of a given distributed property.

3.3.4.1.11.1 Methods

The methods for the **PollContent** distributed object are as follows:

sClearVotes: This method instructs the server (2) to clear all existing votes for the poll. When the server (2) receives this call, the server (2) MUST send updated results to all users that can receive them (**cSetResults**).

sModify: This method allows clients with permission to change the existing question and choices. When this is called and the server (2) has determined that the client can make changes and that the values are within appropriate ranges, it MUST send **cSetQuestion** messages to all clients.

question (String): The text of the poll's question.

choices (String[]): The choices for the poll. Each position corresponds to the choice value specified in **sVote**.

rememberPastUsers (Boolean): MUST be "true". Provided for future extensibility.

customizationXml (String): MUST be an empty string. Provided for future extensibility.

sSetOpenState: This method allows clients with sufficient permission to modify whether or not the poll is open. **cSetOpenState** MUST be sent to all clients if the value changes.

open (Boolean): "True" if all users are able to vote by calling **sVote**.

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sSetResultsState: This method allows clients with sufficient permission to modify whether or not attendees can view results.

> **visibleToAll (Boolean):** When "true", all attendees can view results. **cSetResults** MUST be sent to clients with updated results. When "false", only presenters can view results. **cSetResults** MUST be sent to clients that are no longer able to view results and the accompanying results array must contain zeroes for all values.

sVote: This method allows clients to vote for a given choice.

> **choice (Int32):** A valid vote is a value from zero ("0") up to the length of the **choices** array in **cSetQuestion**, inclusive. A value of "-1" indicates a lack of a vote. When a user votes for choice zero, the value communicated in the **cSetResults** array position zero SHOULD increase by "1". If the poll is closed, this SHOULD NOT change result values. The server (2) MUST acknowledge client votes by sending **cSetVote** back to the client with the recorded vote value. If the poll is closed, it SHOULD send the value stored before **sVote** was called by that given client.

3.3.4.2 Upload Packaging

The file uploaded through **UploadManager** as part of the process of sending a file from the client to the server (2) is designated as an "upload package." This package MUST be in the format of an Open Packaging Convention (OPC) container file. See section 7 for a sample package.

OPC is defined in [ISO/IEC-29500:2008] Part 2 and in [ECMA-376].

The upload package, known as an Office Communicator Package (OCP), MUST contain a manifest file called "OcpManifest.xml." The client can include additional files if they are referenced in the manifest file. This manifest file contains instructions for the server (2) to use to create a content instance or an image annotation, or to update a **PptContent** in chunks. Any file referred to in the manifest MUST be present in the root level of the OCP file. See the schema in the following section for details of the format of the manifest.

3.3.4.2.1 Schema

The schema for **Package** is as follows:

```
<?xml version="1.0" encoding="UTF-8"?>

<xs:schema
  version="1.0"
  targetNamespace="http://schemas.microsoft.com/2008/12/ocp"
  xmlns:tns="http://schemas.microsoft.com/2008/12/ocp"
  xmlns:xs="http://www.w3.org/2001/XMLSchema"
  xmlns:ms="urn:microsoft-cpp-xml-serializer"

  elementFormDefault="qualified"
  attributeFormDefault="unqualified"
  >

  <xs:annotation>
    <xs:documentation>Schema file for the OC Package manifest file between client and server 
for Data MCU.</xs:documentation>
  </xs:annotation>

  <!-- Ocp root element definition -->
  <xs:element name="ocp" type="tns:ocp-type" ms:className="CXmlOcpDocument"/>
```


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```
  <!-- ocp-type definition for root element -->
  <xs:complexType name="ocp-type" ms:className="CXmlOcp">
    <xs:sequence>
      <xs:choice minOccurs="1" maxOccurs="1">
        <xs:element name="createContent" type="tns:create-content-type" 
ms:propertyName="CreateContent"/>
        <xs:element name="createAnnotation" type="tns:create-annotation-type" 
ms:propertyName="CreateAnnotation"/>
        <xs:element name="createPptContentResource" type="tns:create-ppt-content-resource-
type" ms:propertyName="CreatePptContentResource"/>
      </xs:choice>
    </xs:sequence>
  </xs:complexType>

  <!-- content-creation-type definition for contentCreation node -->
  <xs:complexType name="create-content-type" ms:className="CXmlCreateContent">
    <xs:sequence>
      <xs:element name="upgrade" type="tns:upgrade-type" ms:propertyName="Upgrade" 
minOccurs="0" maxOccurs="1" />
      <xs:element name="common" type="tns:common-type" ms:propertyName="Common" />
      <xs:element name="contentDetail" type="tns:content-detail-type" 
ms:propertyName="ContentDetail" />
    </xs:sequence>
  </xs:complexType>

  <!-- common-type definition for contentCreation node -->
  <xs:complexType name="common-type" ms:className="CXmlCommon">
    <xs:sequence>
      <xs:element name="title" type="xs:string" ms:propertyName="Title" />
      <xs:element name="nativeFile" type="xs:string" ms:propertyName="NativeFile" />
      <xs:element name="visibility" type="tns:visibility-type" ms:propertyName="Visibility" 
minOccurs="0" />
      <xs:element name="presented" type="xs:boolean" ms:propertyName="Presented" 
minOccurs="0" />
    </xs:sequence>
  </xs:complexType>

  <xs:simpleType name="visibility-type" ms:className="CXmlVisibilityType">
    <xs:restriction base="xs:string">
      <xs:enumeration value="MeetingOrganizer"/>
      <xs:enumeration value="Presenters"/>
      <xs:enumeration value="Everyone"/>
    </xs:restriction>
  </xs:simpleType>

  <!-- upgrade-type definition for contentCreation node -->
  <xs:complexType name="upgrade-type" ms:className="CXmlUpgradeType">
    <xs:attribute name="contentId" type="xs:long" ms:propertyName="ContentId" />
  </xs:complexType>

  <!-- content-detail-type definition for contentCreation node -->
  <xs:complexType name="content-detail-type" ms:className="CXmlContentDetail">
    <xs:sequence>
      <xs:any namespace="##other" processContents="lax" minOccurs="0"></xs:any>
    </xs:sequence>
    <xs:attribute name="type" type="tns:content-type-type" ms:propertyName="Type"/>
  </xs:complexType>
```


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```
  <xs:simpleType name="content-type-type" ms:className="CXmlContentType">
    <xs:restriction base="xs:string">
      <xs:enumeration value="Content.Ppt"/>
      <xs:enumeration value="Content.Whiteboard"/>
      <xs:enumeration value="Content.NativeFileOnly"/>
      <xs:enumeration value="Content.Poll"/>
    </xs:restriction>
  </xs:simpleType>

  <!-- annotation-creation-type definition for createAnnotation node -->
  <xs:complexType name="create-annotation-type" ms:className="CXmlCreateAnnotation">
    <xs:sequence>
      <xs:element name="creationProperties" type="tns:creationProperties-type"
ms:propertyName="CreationProperties" />
      <xs:element name="annotationDetail" type="tns:annotation-detail-type"
ms:propertyName="AnnotationDetail" />
    </xs:sequence>
  </xs:complexType>

  <!-- creationProperties-type definition for createAnnotation node -->
  <xs:complexType name="creationProperties-type" ms:className="CXmlCreationProperties">
    <xs:sequence>
      <xs:element name="parentId" type="xs:string" ms:propertyName="ParentId" />
    </xs:sequence>
  </xs:complexType>

  <!-- annotation-detail-type definition for createAnnotation node -->
  <xs:complexType name="annotation-detail-type" ms:className="CXmlAnnotationDetail">
    <xs:sequence>
      <xs:any namespace="##other" processContents="lax" minOccurs="0"></xs:any>
    </xs:sequence>
  </xs:complexType>

  <!-- create-ppt-content-resource-type definition -->
  <xs:complexType name="create-ppt-content-resource-type"
ms:className="CXmlCreatePptContentResource">
    <xs:sequence>
      <xs:element name="contentId" type="xs:long" ms:propertyName="ContentId" />
      <xs:element name="resourceDetail" type="tns:ppt-content-resource-detail-type"
ms:propertyName="ResourceDetail" />
    </xs:sequence>
  </xs:complexType>

  <!-- annotation-detail-type definition for createAnnotation node -->
  <xs:complexType name="ppt-content-resource-detail-type"
ms:className="CXmlPptContentResourceDetail">
    <xs:sequence>
      <xs:any namespace="##other" processContents="lax" minOccurs="0"></xs:any>
    </xs:sequence>
  </xs:complexType>

</xs:schema>
```

The schema for content-specific portions of the OC Package manifest is as follows:

```
<?xml version="1.0" encoding="UTF-8"?>

<xs:schema
```


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```
  version="1.0"
  targetNamespace="http://schemas.microsoft.com/2008/12/ocp-content-detail"
  xmlns:tns="http://schemas.microsoft.com/2008/12/ocp-content-detail"
  xmlns:xs="http://www.w3.org/2001/XMLSchema"
  xmlns:ms="urn:microsoft-cpp-xml-serializer"

  elementFormDefault="qualified"
  attributeFormDefault="unqualified"
  >

  <xs:annotation>
    <xs:documentation>Schema for content-specific portions of the OC Package
manifest.</xs:documentation>
  </xs:annotation>

  <xs:element name="chunkedPptContent" type="tns:chunked-ppt-content-detail-type"
ms:className="CXmlChunkedPptContentDetailDocument" />

  <xs:complexType name="chunked-ppt-content-detail-type"
ms:className="CXmlChunkedPptContentDetail">
    <xs:sequence>
        <xs:element name="numSlides" type="xs:nonNegativeInteger" ms:propertyName="NumSlides"
/>
        <xs:element name="previewThumbnailFile" type="xs:string"
ms:propertyName="PreviewThumbnailFile" />

        <!-- The initial set of resources that can be optionally sent during content creation
-->
        <xs:element name="pptContentResources" type="tns:ppt-content-resources-type"
minOccurs="0" maxOccurs="1" ms:className="CXmlPptContentResourcesDocument" />
    </xs:sequence>
  </xs:complexType>


  <xs:element name="pptContentResources" type="tns:ppt-content-resources-type"
ms:className="CXmlPptContentResourcesDocument" />

  <xs:complexType name="ppt-content-resources-type" ms:className="CXmlPptContentResources">
    <xs:sequence>
      <xs:element name="pptContentResource" type="tns:ppt-content-resource-type"
ms:propertyName="PptContentResourceList" minOccurs="1" maxOccurs="unbounded"
ms:className="CXmlPptContentResource">
      </xs:element>
    </xs:sequence>
  </xs:complexType>

 <xs:complexType name="ppt-content-resource-type" ms:className="CXmlPptContentResource">
      <xs:choice>
          <xs:element name="pptThumbnailPackage" type="tns:ppt-thumbnail-package-type"
ms:propertyName="PptThumbnailPackage" />
          <xs:element name="pptNotesPackage" type="tns:ppt-notes-package-type"
ms:propertyName="PptNotesPackage" />
          <xs:element name="pptDhtmlMarkupPackage" type="tns:ppt-dhtml-markup-package-type"
ms:propertyName="PptDhtmlMarkupPackage"/>
          <xs:element name="pptDhtmlResourcesPackage" type="tns:ppt-dhtml-resources-package-
type" ms:propertyName="PptDhtmlResourcesPackage" />
          <xs:element name="pptJpegPackage" type="tns:ppt-jpeg-package-type"
ms:propertyName="PptJpegPackage" />
          <xs:element name="partialPptFile" type="tns:ppt-partial-ppt-package-type"
ms:propertyName="PptPartialPptPackage" />
```


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```
            <xs:element name="fullPptFile" type="tns:ppt-full-ppt-package-type"
ms:propertyName="PptFullPptPackage" />
            <xs:element name="nativeFile" type="xs:string"   ms:propertyName="NativeFile" />
        </xs:choice>
        <xs:attribute name="resourceId" type="xs:long" ms:propertyName="ResourceId" />
    </xs:complexType>

    <xs:complexType name="ppt-thumbnail-package-type" ms:className="CXmlPptThumbnailPackage">
        <xs:sequence>
            <xs:element name="thumbnailPackageFile"  type="xs:string"
ms:propertyName="ThumbnailPackageFile" />
            <xs:element name="pptThumbnailSlides" type="tns:ppt-thumbnail-slide-type"
ms:propertyName="PptThumbnailSlideList" minOccurs="1" maxOccurs="unbounded"
ms:className="CXmlPptThumbnailSlide" />
        </xs:sequence>
    </xs:complexType>

    <xs:complexType name="ppt-thumbnail-slide-type"  ms:className="CXmlPptThumbnailSlide">
        <xs:attribute name="slideNumber"   type="xs:nonNegativeInteger"
ms:propertyName="SlideNumber"/>
        <xs:attribute name="thumbnailFile"  type="xs:string"  ms:propertyName="ThumbnailFile"
/>
    </xs:complexType>

    <xs:complexType name="ppt-notes-package-type" ms:className="CXmlPptNotesPackage">
        <xs:sequence>
            <xs:element name="pptNotesSlides" type="tns:ppt-notes-slide-type"
ms:propertyName="PptNotesSlideList" minOccurs="1" maxOccurs="unbounded"
ms:className="CXmlPptNotesSlide"/>
        </xs:sequence>
        <xs:attribute name="notesPackageFile"  type="xs:string"
ms:propertyName="NotesPackageFile" />
    </xs:complexType>

    <xs:complexType name="ppt-notes-slide-type"  ms:className="CXmlPptNotesSlide">
        <xs:attribute name="slideNumber"   type="xs:nonNegativeInteger"
ms:propertyName="SlideNumber"/>
        <xs:attribute name="notesFile"  type="xs:string"  ms:propertyName="NotesFile" />
    </xs:complexType>

    <xs:complexType name="ppt-dhtml-markup-package-type"
ms:className="CXmlPptDhtmlMarkupPackage">
        <xs:sequence>
            <xs:element name="pptSlideMarkup" type="tns:ppt-dhtml-slide-markup-type"
ms:propertyName="PptDhtmlMarkupList" minOccurs="1" maxOccurs="unbounded"
ms:className="CXmlPptDhtmlMarkup"/>
         </xs:sequence>
    </xs:complexType>

    <xs:complexType name="ppt-dhtml-slide-markup-type" ms:className= "CXmlPptDhtmlMarkup">
        <xs:sequence>
            <xs:element name="pptDhtmlResource" type="tns:ppt-dhtml-resource"
ms:propertyName="PptDhtmlResourceList"  minOccurs="0" maxOccurs="unbounded"
ms:className="CXmlDhtmlResource"/>
        </xs:sequence>
        <xs:attribute name="slideNumber" type="xs:nonNegativeInteger"
ms:propertyName="SlideNumber" />
        <xs:attribute name="numClicks" type="xs:nonNegativeInteger" ms:propertyName="NumClicks"
/>
        <xs:attribute name="dhtmlMarkupPackageFile" type="xs:string"
ms:propertyName="DhtmlMarkupPackageFile" />
```


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```
  </xs:complexType>

  <xs:complexType name="ppt-dhtml-resource" ms:className="CXmlPptDhtmlResource">
      <xs:attribute name="resourceFileName" type="xs:string"
ms:propertyName="ResourceFileName" />
  </xs:complexType>

  <xs:complexType name="ppt-dhtml-resources-package-type"
ms:className="CXmlPptDhtmlResourcesPackage">
      <xs:sequence>
          <xs:element name="pptDhtmlResource" type="tns:ppt-dhtml-resource"
ms:propertyName="PptDhtmlResourceList"  minOccurs="1" maxOccurs="unbounded"
ms:className="CXmlDhtmlResource"/>
      </xs:sequence>
  </xs:complexType>

  <xs:complexType name="ppt-jpeg-package-type" ms:className="CXmlPptJpegPackage">
      <xs:sequence>
          <xs:element name="pptJpegSlides" type="tns:ppt-jpeg-slide-type"
ms:propertyName="PptJpegSlideList" minOccurs="1" maxOccurs="unbounded"
ms:className="CXmlPptJpegSlide" />
      </xs:sequence>
  </xs:complexType>

  <xs:complexType name="ppt-jpeg-slide-type" ms:className="CXmlPptJpegSlide">
      <xs:attribute name="slideNumber"   type="xs:nonNegativeInteger"
ms:propertyName="SlideNumber"/>
      <xs:attribute name="jpegFile"  type="xs:string"  ms:propertyName="JpegFile" />
  </xs:complexType>

  <xs:complexType name="ppt-partial-ppt-package-type"
ms:className="CXmlPptPartialPptPackage">
      <xs:sequence>
          <xs:element name="slideNumber" type="xs:nonNegativeInteger"
ms:propertyName="SlideNumberList" minOccurs="1" maxOccurs="unbounded" />
      </xs:sequence>
      <xs:attribute name="partialPptFile"  type="xs:string"
ms:propertyName="PartialPptFile" />
  </xs:complexType>

  <xs:complexType name="ppt-full-ppt-package-type" ms:className="CXmlPptFullPptPackage">
      <xs:attribute name="fullPptFile"  type="xs:string"   ms:propertyName="FullPptFile" />
      <xs:attribute name="useAsNativeFileAlso" type="xs:boolean"
ms:propertyName="UseAsNativeFileAlso" />
  </xs:complexType>

  <!-- WhiteboardContent-specific schema -->
  <xs:element name="whiteboardContent" type="tns:whiteboard-content-detail-type"
ms:className="CXmlWhiteboardContentDetailDocument" />

  <xs:complexType name="whiteboard-content-detail-type"
ms:className="CXmlWhiteboardContentDetail">
    <xs:sequence>
      <xs:element name="whiteboardType" type="tns:whiteboard-type"
ms:propertyName="WhiteboardType" />
    </xs:sequence>
  </xs:complexType>

  <xs:simpleType name="whiteboard-type" ms:className="CXmlWhiteboardType">
    <xs:restriction base="xs:string">
```


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```
        <xs:enumeration value="empty"/>
      </xs:restriction>
    </xs:simpleType>

    <!-- NativeFileOnlyContent-specific schema -->
    <xs:element name="nativeFileOnlyContent" type="tns:nativeFileOnly-content-detail-type"
  ms:className="CXmlNativeFileOnlyContentDetailDocument" />

    <xs:complexType name="nativeFileOnly-content-detail-type"
  ms:className="CXmlNativeFileOnlyContentDetail">
      <xs:sequence>
        <xs:element name="nativeFileOnlyType" type="tns:nativeFileOnly-type"
  ms:propertyName="NativeFileOnlyType" />
      </xs:sequence>
    </xs:complexType>

    <xs:simpleType name="nativeFileOnly-type" ms:className="CXmlNativeFileOnlyType">
      <xs:restriction base="xs:string">
        <xs:enumeration value="empty"/>
      </xs:restriction>
    </xs:simpleType>

    <!-- PollContent-specific schema -->
    <xs:element name="pollContent" type="tns:poll-content-detail-type"
  ms:className="CXmlPollContentDetailDocument" />

    <xs:complexType name="poll-content-detail-type" ms:className="CXmlPollContentDetail">
      <xs:sequence>
        <xs:element name="question" type="xs:string" ms:propertyName="Question" />
        <xs:element name="choices" type="tns:poll-content-choices-type"
  ms:propertyName="Choices" />
        <xs:element name="rememberPastUsers" type="xs:boolean"
  ms:propertyName="RememberPastUsers" />
        <xs:element name="customizationXml" type="xs:string" ms:propertyName="CustomizationXml"
  />
      </xs:sequence>
    </xs:complexType>

    <xs:element name="choices" type="tns:poll-content-choices-type"
  ms:className="CXmlPollContentChoicesDocument" />

    <xs:complexType name="poll-content-choices-type" ms:className="CXmlPollContentChoices">
      <xs:sequence>
        <xs:element name="choice" type="xs:string" ms:propertyName="PollContentChoiceList"
  minOccurs="1" maxOccurs="unbounded" ms:className="CXmlPollContentChoices">
        </xs:element>
      </xs:sequence>
    </xs:complexType>

  </xs:schema>
```

3.3.4.3 File Download

Files MUST be made available to clients through a file **Web server** over HTTP or **Hypertext Transfer Protocol over Secure Sockets Layer (HTTPS)**, as specified in [RFC2616].

The message **cSetUrlBase** MUST indicate the root of this Web server. When any other message contains a file name as a parameter, the specified **fileName** MUST be appended to download the

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referenced file. The files MUST be encrypted with the **Advanced Encryption Standard (AES)**, as defined in [FIPS197], when they are made available on the file Web Server. The decryption keys are distributed to clients through various messages where terms such as **key** and **iv**, or initialization vector, are used.

3.3.5 Message Processing Events and Sequencing Rules

All messages MUST be processed in the order that they are received. The server (2) MUST respond to any messages that require a response before reading any additional messages from other clients.

3.3.6 Timer Events

The server (2) has the timer mentioned in section 3.1.3.1 through the **ping** message. Additionally, any **sAuthId** that is not redeemed within 120 seconds SHOULD be expired so the client can no longer connect with that token.

3.3.7 Other Local Events

None.

3.4 Proxy Details

Any non-PSOM proxies that exist MUST relay the data as it is and SHOULD NOT modify the traffic in any way.

The only supported proxy is silent. It MUST make no changes to traffic. The only difference between the proxy and the server (2) is that an extra authentication (2) token is required upon connection. All other interactions are identical. See section 3.3.3.1 for details.

3.4.1 Abstract Data Model

This is not applicable because there is no relay proxy component.

3.4.2 Timers

This is not applicable because there is no relay proxy component.

3.4.3 Initialization

This is not applicable because there is no relay proxy component.

3.4.4 Higher-Layer Triggered Events

This is not applicable because there is no relay proxy component.

3.4.5 Message Processing Events and Sequencing Rules

This is not applicable because there is no relay proxy component.

3.4.6 Timer Events

This is not applicable because there is no relay proxy component.

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3.4.7 Other Local Events

This is not applicable because there is no relay proxy component.

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4 Protocol Examples

This section details a sample session and divides it into three segments:

- Connection up until the root distributed object is about to be connected.
- Root distributed object and child object connection.
- Client and server (2) exchange an RPC message.

The examples are all sequential; however, the server (2) authentication (2) response could come at any time after the client has sent the authentication (2) token, but before any other data from the server (2).

4.1 Connection of PSOM Channel 0 (Prior to Root Distributed Object)

In the following example, a client with an authorization token of "3000000000000000E36032154C544908" is used to authenticate the connection. The following protocols are defined:

- **ConnMgr** is defined as in section 3.1.3.1.
- **Meeting** is defined as in section 3.1.4.1.6, but no child objects are connected in this example.

4.1.1 Client to Server Authentication

The client sending data to the server (2) through **AuthenticationToken** has the following format.

0	1	2	3	4	5	6	7	8	9	10	1	2	3	4	5	6	7	8	9	20	1	2	3	4	5	6	7	8	9	30	1
Signature																															
AuthenticationVersion																															
AuthenticationTokenLen																															
AuthenticationToken (variable) 0x45333630;0x33323135;0x34433534;0x34393038																															
...																															

Signature (4 bytes): Set to 0x70773200.

AuthenticationVersion (4 bytes): Set to 0x00000000.

AuthenticationTokenLen (4 bytes): Set to 0x00000020.

AuthenticationToken (variable): Set to the following:

```
0x33303030;
0x30303030;
0x30303030;
```


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```
0x30303030
```

4.1.2 Server to Client Authentication Response

The server (2) sending data in response to the action in the previous section for a successful **token** submission has the following format.

0	1	2	3	4	5	6	7	8	9	10	1	2	3	4	5	6	7	8	9	20	1	2	3	4	5	6	7	8	9	30	1
Signature																															

Signature (4 bytes): Set to 0x70773200.

4.1.3 Client to Server Channel Creation

The client sending data to the server (2) in response to successful authentication (2) confirmation to create channel zero has the following format.

0	1	2	3	4	5	6	7	8	9	10	1	2	3	4	5	6	7	8	9	20	1	2	3	4	5	6	7	8	9	30	1
SetChannel								ChannelId																							
...																															

SetChannel (1 byte): Header for message type; defined as 0x04.

ChannelId (4 bytes): The representation of the channel identifier to be set. This PSOM channel is used for all messages that follow this one, with the exception of other **SetChannel** messages.

4.1.4 Client to Server Versioning

The client to server (2) versioning sequence represents some of the messages sent by the client to the server (2) during the connection negotiation phase. This illustrates the 3 key messages:

- **version**
- **addProtocol**
- **doneProtocols**

The **addProtocol** message is sent multiple times with different parameters for each registered distributed object.

In the non-block sequence diagrams, there is a number in parentheses. This number is the byte count of the payload.

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4.1.4.1 version(stubHash)

This version represents the client notifying the server (2) of its **ConnMgr** client interface hash version, which is -8221414758688209204. This has the following format.

<table>
<tr><td>0</td><td>1</td><td>2</td><td>3</td><td>4</td><td>5</td><td>6</td><td>7</td><td>8</td><td>9</td><td>10</td><td>1</td><td>2</td><td>3</td><td>4</td><td>5</td><td>6</td><td>7</td><td>8</td><td>9</td><td>20</td><td>1</td><td>2</td><td>3</td><td>4</td><td>5</td><td>6</td><td>7</td><td>8</td><td>9</td><td>30</td><td>1</td></tr>
<tr><td colspan="8">RpcMessage</td><td colspan="24">MessageLength</td></tr>
<tr><td colspan="8">...</td><td colspan="8">ProxyId</td><td colspan="8">MethodIndex</td><td colspan="8">Parameter 1</td></tr>
<tr><td colspan="24">...</td><td colspan="8">AuthenticationToken</td></tr>
<tr><td colspan="32">...</td></tr>
</table>

RpcMessage (1 byte): Set to 0x16.

MessageLength (3 bytes): Set to 0x0000000b.

ProxyId (1 byte): Set to 0x00.

MethodIndex (1 byte): Set to 0x01.

Parameter 1 (1 byte): Int64 stubHash 0x(87,73,7d,da,8b,97,1e,72,85)

AuthenticationToken (variable): Set to the following:

```
0x33303030;
0x30303030;
0x30303030;
0x30303030
0x45333630;
0x33323135;
0x34433534;
0x34393038
```

4.1.4.2 addProtocol(name, versions, hashes)

The **addProtocol** message sends the following over PSOM channel zero, which is the connection PSOM channel:

name: Microsoft.Rtc.Server.DataMCU.Meeting.Pod.ConnMgr

Versions: 1

Hashes: 100633220832999761. This is the sum of the server (2) and client interface hashes:

8221414758688209204 + 8322047979521208965 == 100633220832999761

Data flow:

- RpcMessage (1)

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- 0x16
- Message Length (4)
  - 0x00000040
- ProxyId (1)
  - 0x00
- MethodIndex (1)
  - 0x02
- **Parameter 1:** name
  - Length of string (2)
    - 0x0030
  - Payload (48)
    - 0x 9d,88,91,71,7b,56,59,21,2c,47,
    - 0x 28,ff,ff,83,ed,aa,92,87,67,61,
    - 0x 0a,71,27,23,09,34,c9,ce,82,f0,
    - 0x ab,ba,84,68,7c,44,1a,15,39,03,
    - 0x 56,ca,f5,c5,d2,80,b9,9d,
- **Parameter 2:** versions
  - Length of array (1)
    - 0x01
  - Value of only entry in array encoded as Int32 (1)
    - 0x01
- **Parameter 3:** hashes
  - Length of array (1)
    - 0x01
  - Value of only entry in array encoded as Int64 (9)
    - 0x 87,01,65,85,61,94,5a,b9,51

4.1.4.3 doneVersioning

The **doneVersioning** is represented as follows.

Data flow:

- RpcMessage (1)

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- 0x16
- Message Length (4)
  - 0x00000002
- ProxyId (1)
  - 0x00
- MethodIndex (1)
  - 0x03

Because there are no arguments, this is the only data sent.

4.1.5 Server to Client Versioning

Server (2) to client versioning is very similar to client to server (2) versioning messages.

The following is a **version** RPC call (16 bytes).

```
0x 16,00,00,00,0b,00,01,8f,72,18,55,2a,02,c3,b9,34
```

The following is an **addProtocol** message in a **ConnMgr** RPC call (69 bytes).

```
0x16,00,00,00,40,00,02,00,30,9d,88,91,71,7b,56,59,21,2c,47,28,ff,ff,83,ed,aa,92,87,67,61,0a,7
1,27,23,09,34,c9,ce,82,f0,ab,ba,84,68,7c,44,1a,15,39,03,56,ca,f5,c5,d2,80,b9,9d,01,01,01,87,0
1,65,85,61,94,5a,b9,51
```

addProtocol: Meeting RPC Call (65 bytes)

```
0x16,00,00,00,3c,00,02,00,2c,59,4c,55,35,37,1a,15,ed,e8,83,ec,bb,83,df,51,76,56,43,23,25,46,3
d,eb,ef,cd,f0,8d,8a,de,4c,77,46,40,2c,38,00,56,c4,ff,ce,c8,a4,b0,88,01,01,01,8f,1b,db,fa,2d,b
c,55,32,5a
```

doneVersioning: RPC Call (6 bytes)

```
0x 16,00,00,00,02,00,03
```

4.2 PSOM Channel 2 Distributed Object Root Connection

The **Lookup** message is sent from client to server (2) once versioning is complete. This is a special message that creates a new logical PSOM channel, with id=2, for the application distributed objects to communicate. The total length of this sequence is 49 bytes.

- rpcOpenMessage (1 byte)
  - 0x37
- Channel Id = 2 (u32Arg) (4 bytes)
  - 0x00 00 00 02

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- Open Message Length (value == 40 decimal) (4 bytes)
  - 0x00 00 00 28
- ProxyId (1 byte)
  - 0x00
- MethodIndex (for lookup) (1 byte)
  - 0x05
- Parameter 1 – Name (string) – Unused (20 bytes)
  - 0x 00,12,9a,90,b4,4e,3f,51,4d,24,38,01,19,a4,e8,ce,d1,a2,a8,8a
- Parameter 2 – Protocol (string) – Unused (9 bytes)
  - 0x 00,07,c7,f5,df,e9,be,bb,8b,
- Parameter 3 – Hash (Int64) (9 bytes)
  - 0x 8f,6e,14,7b,cb,cb,37,8e,f7

4.3 Server to Client RPC Message Exchange

This example demonstrates the server (2) to client flow for setting up the root distributed object, which is **Meeting**. The sequence is as follows:

- **SetChannel**
- **cSetUrlBase**
- Connect **ContentUserManager**
  - Note that other **Connect** messages would be sent here. They are omitted for brevity.
- **cMeetingReady**

SetChannel: Represents a PSOM channel-level request to set the current PSOM channel for all following messages.

- SetChannel (1 byte)
  - 0x04
- ChannelId u32Arg (4 bytes)
  - 0x 00 00 00 02

cSetUrlBase Message: Represents a server (2) to client message with a string payload of "http://example.com/conference/1015".

- RpcMessage (1 byte)
  - 0x16
- Length (4 bytes)

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- 0x 00 00 00 26
- ProxyId (1 byte)
  - 0x00
- MethodIndex (1 byte)
  - 0x04
- Parameter 1 – string (34 bytes)
  - String Length
    - 0x 00 22
  - String payload
  - 0xd6,bb,94,81,38,3c,0b,50,3e,36
  - 0x05,09,e6,fe,82,de,a1,b2,df,62
  - 0x7d,4d,52,20,24,02,16,ea,ff,84
  - 0x8d,fd,ef,da

Connect ContentUserManager

- RpcMessage (1 byte)
  - 0x16
- Length (4 bytes)
  - 0x 00 00 00 1f
- RPC message type (Connect) (1 byte)
  - 0x84
- Destination ProxyId (1 byte)
  - 0x00
- Connection String
  - Length
    - 0x 00 12
  - Payload ("ContentUserManager")
    - 0x ad,b0,9e,75,77,4d,40,10,25,02,
    - 0x 0a,c4,fb,c5,dd,aa,bb,9d,
- Server (2) hash code for distributed object to connect (Int64)
  - 0x 87,49,d5,9c,18,ed,9d,9e,0c

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cMeetingReady Message: Signals the distributed object connection routine is complete for the **Meeting** distributed object.

- RpcMessage (1 byte)
  - 0x16
- Length (4 bytes)
  - 0x 00 00 00 02
- ProxyId (1 byte)
  - 0x00
- MethodIndex (1 byte) – corresponds to cMeetingReady (no parameters)
  - 0x01

sReserveTitle Message: This is a sample client to server (2) message requesting a title reservation. This message follows a **ping** message that was sent by the server (2), which is not included. This means the client sets the PSOM channel to 2, because pings are received on PSOM channel 0. The title to be reserved is "Hello World".

- SetChannel (1 byte)
  - 0x04
- ChannelId (4 bytes)
  - 0x 00 00 00 02
- RpcMessage (1 byte)
  - 0x16
- Length (4 bytes)
  - 0x 00 00 00 10
- ProxyId (1 byte) – recall this is encoded as a PSOM Int32 (and has value -2)
  - 0x fe
- MethodIndex (1 byte)
  - 0x 05
- Parameter 1 – Title (string) (13 bytes)
  - 0x 00,0b,0d,33,0b,14,e6,ba,fc,d3,bf,b2,8b
- Parameter 2 – Cookie (1 byte)
  - 0x 01

Possible messages from the server: This is a possible set of messages that can be received following a title reservation request. This is sent from server (2) to client.

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cContentUserAdded Message

- RpcMessage
  - 0x 16
- Length
  - 0x 00 00 00 3b
- ProxyId
  - 0x 01
- MethodIndex
  - 0x 01
- Parameter 1 – Array with Id
  - 0x 01,01
- Parameter 2 – Array with Uris
  - 0x01,00,26,09,e2,ec,97,cc,b6,81,9f,64,23,64,47,32,34,0c,1c,fc,b5,c2,c9,ba,ba,83,75,3c,4e,5d,26,24,08,0b,e6,fc,df,92,ae,b1,82
- Parameter 3 – Array with Name
  - 0x 01,00,0b,17,2f,06,16,b9,ba,ed,dd,bf,b3,df

cTitleReservationCompleted Message

- RpcMessage
  - 0x 16
- Length
  - 0x 00 00 00 06
- ProxyId
  - 0x 02
- MethodIndex
  - 0x 05
- Parameter 1 – Status (value corresponds to "ReservedForCreation")
  - 0x 01
- Parameter 2 – Cookie
  - 0x 01
- Parameter 3 – contentId

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- 0x 00

- Parameter 4 – owningUserId
  - 0x 01

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5 Security

5.1 Security Considerations for Implementers

SHA-1 is used as a file hash to optimize for downloads, but is not used for security purposes.

AES is used to encrypt and decrypt files stored on the file Web server.

5.2 Index of Security Parameters

Because this protocol requires a secure transport, the only unique piece is the authorization token.

Security parameter	Section
Authorization token (**AuthId**)	Section 3.3.3.1.1

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6 Appendix A: Encoding Algorithms

This appendix covers the various specialized encoding algorithms used by this protocol to represent several primitive types.

6.1 GenericInt

This algorithm optimizes on length for smaller, meaning closer to zero, numbers. The following rules apply:

- Numbers in the range -112 to 127 are represented by one byte, which is their value.
- Numbers outside of that range are represented in variable length unsigned big-endian notation.
  - The lead byte gives their length and sign.
  - The lead byte is 0x80 plus (8 if negative or plus 0 otherwise) plus (*nbytes* minus 1), where *nbytes* is the number of data bytes following, and includes the numbers 1, 2, 3, 4, 6, and 8.

The following table lists some examples:

Number	Representation
0	0x00
255	0x80 0xFF
-255	0x88 0xFF
256	0x81 0x01 0x00

The two numbers in the following table are encoded irregularly because of twos-complement arithmetic:

Number	Representation
-(2^31)	0x88 0x00
-(2^63)	0x8d 0x00 0x00 0x00 0x00 0x00 0x00

6.1.1 Pseudo-Code

The following code sample demonstrates how to encode a **GenericInt** into a variable length byte array.

```
byte[] EncodeGenericInt(int x)
{
    if (-112 <= x && x <= 127)
    {
        return x as byte;
    }

    Int64 absX = AbsoluteValue(x);
    Int32 size = (absX <= 0xFF ? 0
               : (absX <= 0xFFFF ? 1
```


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```
                : (absX <= 0xFFFFFF ? 2
                : (absX <= 0xFFFFFFFF ? 3
                : (absX <= 0xFFFFFFFFFFFF ? 5
                : 7 )))));

    byte[] baseBytes = new byte[9];
    Int32 basePosition = 0;

    baseBytes[basePosition++] = ((x >= 0 ? 0x80 : 0x88) + size) as byte;
    if (size >= 7) baseBytes[basePosition++] = ((absX >> 0x38) & 0xFF) as byte;
    if (size >= 6) baseBytes[basePosition++] = ((absX >> 0x30) & 0xFF) as byte;
    if (size >= 5) baseBytes[basePosition++] = ((absX >> 0x28) & 0xFF) as byte;
    if (size >= 4) baseBytes[basePosition++] = ((absX >> 0x20) & 0xFF) as byte;
    if (size >= 3) baseBytes[basePosition++] = ((absX >> 0x18) & 0xFF) as byte;
    if (size >= 2) baseBytes[basePosition++] = ((absX >> 0x10) & 0xFF) as byte;
    if (size >= 1) baseBytes[basePosition++] = ((absX >> 0x08) & 0xFF) as byte;
    if (size >= 0) baseBytes[basePosition++] = ((absX >> 0x00) & 0xFF) as byte;

    byte[] toReturn = SubsetOf(baseBytes from 0 to (size + 2));
    return toReturn;
}
```

6.2 String

This section describes the encoding algorithm for generating PSOM strings as parameters, given a UTF-8 string as input. The first two bytes are reserved for an encoded version of the length, which is not greater than 0xFFFF.

- Define varIncrement equals -17.
- Define Int32 (signed) varvalue equals 0.
- For each byte in the UTF-8 encoded string:
  - Increment **varValue** by **varIncrement**.
  - The byte in the string should be **XOR**’ed with **varValue**.
- UTF-8 encoding for wide characters:
  - Characters in the range 0x0001 to 0x007F:
    - Encoded as 1 byte, which matches the character’s byte value.
  - Characters in the range 0x0080 to 0x07FF:
    - The wide character is divided into two parts, "x" and "y" as shown in binary "0000 0xxx xxyy yyyy".
    - The first byte is represented as binary "110x xxxx".
      - This is the equivalent of **OR**’ing bits 6 and 10 with 0xC0.
    - The second byte is represented as "10yy yyyy".
      - This is the equivalent of **OR**’ing bits 0 and 5 with 0x80.
  - Characters in the range 0x0800 to 0xFFFF:

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- The wide character is divided into three parts, which can be represented as "xxxx yyyy yyzz zzzz".
- The first byte is "1110 xxxx".
  - This is the equivalent of **OR**'ing bits 12 and 15 with 0xE0.
- The second byte is "10yy yyyy".
  - This is the equivalent of **OR**'ing bits 6 and 11 with 0x80.
- The third byte is "10zz zzzz".
  - This is the equivalent of **OR**'ing bits 0 and 5]with 0x80.

- Because the maximum size of the string is 0xFFFF, the first two bytes of the string segment are the unsigned integer big-endian representation of the length.
  - Example: A string "pptdemo2.pptx" with a length of 13 becomes 0x00 0x0D in the length header.

Following is an example of a generated PSOM string:

- A string "pptdemo2.pptx" becomes, in hexadecimal:

  00,0d,53,44,31,32,02,15,e6,a8,85,cc,bd,aa,97

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7 Appendix B: Sample Upload Package

An OC Package is composed of a manifest, with the name "OcpManifest.xml", and any other files that are referenced by the manifest. In the case of creating content with a single file attached to it, the upload package contains two parts. Note that this is an OPC file, so there might be additional metadata files per the specification. This example includes a jpeg-encoded image named "Ryan’s Fun Day.jpg". Note that the contents and type of this file is irrelevant to the example.

OcpManifest.xml:

```
<ocp xmlns="http://schemas.microsoft.com/2008/12/ocp">
    <createContent>
        <common>
            <title>Ryan’s Fun Day.jpg</title>
            <nativeFile>native.file</nativeFile>
        </common>
        <contentDetail type="Content.NativeFileOnly">
            <nativeFileOnlyContent xmlns="http://schemas.microsoft.com/2008/12/ocp-content-
detail">
                <nativeFileOnlyType>empty</nativeFileOnlyType>
            </nativeFileOnlyContent>

        </contentDetail>
    </createContent>
</ocp>
```

native.file: Binary payload of any file to share. In this case, the file is a jpeg-encoded image.

Before this is uploaded, the client sends an **sReserveTitle** message and receives a **cTitleReserved** response from the server (2) with a positive confirmation of the title reservation, with a title that matches the title specified in the preceding **XML fragment**.

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8 Appendix C: Product Behavior

The information in this specification is applicable to the following Microsoft products or supplemental software. References to product versions include released service packs:

- Microsoft® Lync™ Server 2010
- Microsoft® Lync™ 2010

Exceptions, if any, are noted below. If a service pack or Quick Fix Engineering (QFE) number appears with the product version, behavior changed in that service pack or QFE. The new behavior also applies to subsequent service packs of the product unless otherwise specified. If a product edition appears with the product version, behavior is different in that product edition.

Unless otherwise specified, any statement of optional behavior in this specification that is prescribed using the terms SHOULD or SHOULD NOT implies product behavior in accordance with the SHOULD or SHOULD NOT prescription. Unless otherwise specified, the term MAY implies that the product does not follow the prescription.

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9 Change Tracking

No table of changes is available. The document is either new or has had no changes since its last release.

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Release: Sunday, December 19, 2010

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