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INTERNATIONAL STANDARD

**Information technology – UPnP Device Architecture –
Part 4-11: Audio Video Device Control Protocol –
Level 2 – Connection Manager Service**

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INFORMATION TECHNOLOGY – UPNP DEVICE ARCHITECTURE –

Part 4-11: Audio Video Device Control Protocol – Level 2 – Connection Manager Service

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The list of all currently available parts of the ISO/IEC 29341 series, under the general title *Universal plug and play (UPnP) architecture*, can be found on the IEC web site.

This International Standard has been approved by vote of the member bodies, and the voting results may be obtained from the address given on the second title page.

ORIGINAL UPnP DOCUMENTS (informative)

Reference may be made in this document to original UPnP documents. These references are retained in order to maintain consistency between the specifications as published by ISO/IEC and by UPnP Implementers Corporation. The following table indicates the original UPnP document titles and the corresponding part of ISO/IEC 29341:

UPnP Document Title	ISO/IEC 29341 Part
UPnP Device Architecture 1.0	ISO/IEC 29341-1
UPnP Basic:1 Device	ISO/IEC 29341-2
UPnP AV Architecture:1	ISO/IEC 29341-3-1
UPnP MediaRenderer:1 Device	ISO/IEC 29341-3-2
UPnP MediaServer:1 Device	ISO/IEC 29341-3-3
UPnP AVTransport:1 Service	ISO/IEC 29341-3-10
UPnP ConnectionManager:1 Service	ISO/IEC 29341-3-11
UPnP ContentDirectory:1 Service	ISO/IEC 29341-3-12
UPnP RenderingControl:1 Service	ISO/IEC 29341-3-13
UPnP MediaRenderer:2 Device	ISO/IEC 29341-4-2
UPnP MediaServer:2 Device	ISO/IEC 29341-4-3
UPnP AV Datastructure Template:1	ISO/IEC 29341-4-4
UPnP AVTransport:2 Service	ISO/IEC 29341-4-10
UPnP ConnectionManager:2 Service	ISO/IEC 29341-4-11
UPnP ContentDirectory:2 Service	ISO/IEC 29341-4-12
UPnP RenderingControl:2 Service	ISO/IEC 29341-4-13
UPnP ScheduledRecording:1	ISO/IEC 29341-4-14
UPnP DigitalSecurityCamera:1 Device	ISO/IEC 29341-5-1
UPnP DigitalSecurityCameraMotionImage:1 Service	ISO/IEC 29341-5-10
UPnP DigitalSecurityCameraSettings:1 Service	ISO/IEC 29341-5-11
UPnP DigitalSecurityCameraStillImage:1 Service	ISO/IEC 29341-5-12
UPnP HVAC_System:1 Device	ISO/IEC 29341-6-1
UPnP HVAC_ZoneThermostat:1 Device	ISO/IEC 29341-6-2
UPnP ControlValve:1 Service	ISO/IEC 29341-6-10
UPnP HVAC_FanOperatingMode:1 Service	ISO/IEC 29341-6-11
UPnP FanSpeed:1 Service	ISO/IEC 29341-6-12
UPnP HouseStatus:1 Service	ISO/IEC 29341-6-13
UPnP HVAC_SetpointSchedule:1 Service	ISO/IEC 29341-6-14
UPnP TemperatureSensor:1 Service	ISO/IEC 29341-6-15
UPnP TemperatureSetpoint:1 Service	ISO/IEC 29341-6-16
UPnP HVAC_UserOperatingMode:1 Service	ISO/IEC 29341-6-17
UPnP BinaryLight:1 Device	ISO/IEC 29341-7-1
UPnP DimmableLight:1 Device	ISO/IEC 29341-7-2
UPnP Dimming:1 Service	ISO/IEC 29341-7-10
UPnP SwitchPower:1 Service	ISO/IEC 29341-7-11
UPnP InternetGatewayDevice:1 Device	ISO/IEC 29341-8-1
UPnP LANDevice:1 Device	ISO/IEC 29341-8-2
UPnP WANDevice:1 Device	ISO/IEC 29341-8-3
UPnP WANConnectionDevice:1 Device	ISO/IEC 29341-8-4
UPnP WLANAccessPointDevice:1 Device	ISO/IEC 29341-8-5
UPnP LANHostConfigManagement:1 Service	ISO/IEC 29341-8-10
UPnP Layer3Forwarding:1 Service	ISO/IEC 29341-8-11
UPnP LinkAuthentication:1 Service	ISO/IEC 29341-8-12
UPnP RadiusClient:1 Service	ISO/IEC 29341-8-13
UPnP WANCableLinkConfig:1 Service	ISO/IEC 29341-8-14
UPnP WANCommonInterfaceConfig:1 Service	ISO/IEC 29341-8-15
UPnP WANDSLLinkConfig:1 Service	ISO/IEC 29341-8-16
UPnP WANEthernetLinkConfig:1 Service	ISO/IEC 29341-8-17
UPnP WANIPConnection:1 Service	ISO/IEC 29341-8-18
UPnP WANPOTSLinkConfig:1 Service	ISO/IEC 29341-8-19
UPnP WANPPPConnection:1 Service	ISO/IEC 29341-8-20
UPnP WLANConfiguration:1 Service	ISO/IEC 29341-8-21
UPnP Printer:1 Device	ISO/IEC 29341-9-1
UPnP Scanner:1.0 Device	ISO/IEC 29341-9-2
UPnP ExternalActivity:1 Service	ISO/IEC 29341-9-10
UPnP Feeder:1.0 Service	ISO/IEC 29341-9-11
UPnP PrintBasic:1 Service	ISO/IEC 29341-9-12
UPnP Scan:1 Service	ISO/IEC 29341-9-13
UPnP QoS Architecture:1.0	ISO/IEC 29341-10-1
UPnP QoSDevice:1 Service	ISO/IEC 29341-10-10
UPnP QoSManager:1 Service	ISO/IEC 29341-10-11
UPnP QoSPolicyHolder:1 Service	ISO/IEC 29341-10-12
UPnP QoS Architecture:2	ISO/IEC 29341-11-1
UPnP QOS v2 Schema Files	ISO/IEC 29341-11-2

UPnP Document Title	ISO/IEC 29341 Part
UPnP QosDevice:2 Service	ISO/IEC 29341-11-10
UPnP QosManager:2 Service	ISO/IEC 29341-11-11
UPnP QosPolicyHolder:2 Service	ISO/IEC 29341-11-12
UPnP RemoteUIClientDevice:1 Device	ISO/IEC 29341-12-1
UPnP RemoteUIServerDevice:1 Device	ISO/IEC 29341-12-2
UPnP RemoteUIClient:1 Service	ISO/IEC 29341-12-10
UPnP RemoteUIServer:1 Service	ISO/IEC 29341-12-11
UPnP DeviceSecurity:1 Service	ISO/IEC 29341-13-10
UPnP SecurityConsole:1 Service	ISO/IEC 29341-13-11

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1 Overview and Scope

1.1 Introduction

This service definition is compliant with the UPnP Device Architecture version 1.0.

This service-type enables modeling of streaming capabilities of A/V devices, and binding of those capabilities between devices. Each device that is able to send or receive a stream according to the UPnP AV Architecture will have 1 instance of the ConnectionManager service. This service provides a mechanism for control points to:

1. Perform capability matching between source/server devices and sink/renderer devices,
2. Find information about currently ongoing transfers in the network,
3. Setup and teardown connections between devices (when required by the streaming protocol).

The ConnectionManager service is generic enough to properly abstract different kinds of streaming mechanisms, such as HTTP-based streaming, RTSP/RTP-based and 1394-based streaming.

The ConnectionManager enables control points to abstract from physical media interconnect technology when making connections. The term ‘stream’ used in this service template refers to both analog and digital data transfer.

1.2 Notation

- In this document, features are described as Required, Recommended, or Optional as follows:

The key words “MUST,” “MUST NOT,” “REQUIRED,” “SHALL,” “SHALL NOT,” “SHOULD,” “SHOULD NOT,” “RECOMMENDED,” “MAY,” and “OPTIONAL” in this specification are to be interpreted as described in [RFC 2119].

In addition, the following keywords are used in this specification:

PROHIBITED – The definition or behavior is an absolute prohibition of this specification. Opposite of **REQUIRED**.

CONDITIONALLY REQUIRED – The definition or behavior depends on a condition. If the specified condition is met, then the definition or behavior is **REQUIRED**, otherwise it is **PROHIBITED**.

CONDITIONALLY OPTIONAL – The definition or behavior depends on a condition. If the specified condition is met, then the definition or behavior is **OPTIONAL**, otherwise it is **PROHIBITED**.

These keywords are thus capitalized when used to unambiguously specify requirements over protocol and application features and behavior that affect the interoperability and security of implementations. When these words are not capitalized, they are meant in their natural-language sense.

- Strings that are to be taken literally are enclosed in “double quotes”.
- Words that are emphasized are printed in *italic*.
- Keywords that are defined by the UPnP AV Working Committee are printed using the *forum* character style.
- Keywords that are defined by the UPnP Device Architecture are printed using the *arch* character style.
- A double colon delimiter, “::”, signifies a hierarchical parent-child (parent::child) relationship between the two objects separated by the double colon. This delimiter is used in multiple contexts, for example: Service::Action(), Action()::Argument, parentProperty::childProperty.

1.2.1 Data Types

This specification uses data type definitions from two different sources. The UPnP Device Architecture defined data types are used to define state variable and action argument data types [DEVICE]. The XML Schema namespace is used to define property data types [XML SCHEMA-2].

For UPnP Device Architecture defined Boolean data types, it is strongly **RECOMMENDED** to use the value “**0**” for false, and the value “**1**” for true. However, when used as input arguments, the values “**false**”, “**no**”, “**true**”,

“yes” may also be encountered and MUST be accepted. Nevertheless, it is strongly RECOMMENDED that all state variables and output arguments be represented as “0” and “1”.

For XML Schema defined Boolean data types, it is strongly RECOMMENDED to use the value “0” for false, and the value “1” for true. However, when used as input properties, the values “false”, “true” may also be encountered and MUST be accepted. Nevertheless, it is strongly RECOMMENDED that all properties be represented as “0” and “1”.

1.2.2 Strings Embedded in Other Strings

Some string variables and arguments described in this document contain substrings that MUST be independently identifiable and extractable for other processing. This requires the definition of appropriate substring delimiters and an escaping mechanism so that these delimiters can also appear as ordinary characters in the string and/or its independent substrings. This document uses embedded strings in two contexts – Comma Separated Value (CSV) lists (see Section 1.3.1, “Comma Separated Value (CSV) Lists”) and property values in search criteria strings. Escaping conventions use the backslash character, “\” (character code U+005C), as follows:

- a. Backslash (“\”) is represented as “\\” in both contexts.
- b. Comma (“,”) is
 1. represented as “\,” in individual substring entries in CSV lists
 2. not escaped in search strings
- c. Double quote (“””) is
 1. not escaped in CSV lists
 2. not escaped in search strings when it appears as the start or end delimiter of a property value
 3. represented as “\”” in search strings when it appears as a character that is part of the property value

1.2.3 Extended Backus-Naur Form

Extended Backus-Naur Form is used in this document for a formal syntax description of certain constructs. The usage here is according to the reference [EBNF].

1.2.3.1 Typographic conventions for EBNF

Non-terminal symbols are unquoted sequences of characters from the set of English upper and lower case letters, the digits “0” through “9”, and the hyphen (“-”). Character sequences between 'single quotes' are terminal strings and MUST appear literally in valid strings. Character sequences between (*comment delimiters*) are English language definitions or supplementary explanations of their associated symbols. White space in the EBNF is used to separate elements of the EBNF, not to represent white space in valid strings. White space usage in valid strings is described explicitly in the EBNF. Finally, the EBNF uses the following operators:

Table 1-1: EBNF Operators

Operator	Semantics
: =	definition – the non-terminal symbol on the left is defined by one or more alternative sequences of terminals and/or non-terminals to its right.
	alternative separator – separates sequences on the right that are independently allowed definitions for the non-terminal on the left.
*	null repetition – means the expression to its left MAY occur zero or more times.
+	non-null repetition – means the expression to its left MUST occur at least once and MAY occur more times.
[]	optional – the expression between the brackets is optional.
()	grouping – groups the expressions between the parentheses.
-	character range – represents all characters between the left and right character operands inclusively.

1.3 Derived Data Types

This section defines a derived data type that is represented as a string data type with special syntax. This specification uses string data type definitions that originate from two different sources. The UPnP Device Architecture defined string data type is used to define state variable and action argument string data types. The XML Schema namespace is used to define property xsd:string data types. The following definition applies to both string data types.

1.3.1 Comma Separated Value (CSV) Lists

The UPnP AV services use state variables, action arguments and properties that represent lists – or one-dimensional arrays – of values. The UPnP Device Architecture, Version 1.0 [DEVICE], does not provide for either an array type or a list type, so a list type is defined here. Lists MAY either be homogeneous (all values are the same type) or heterogeneous (values of different types are allowed). Lists MAY also consist of repeated occurrences of homogeneous or heterogeneous subsequences, all of which have the same syntax and semantics (same number of values, same value types and in the same order). The data type of a homogeneous list is string or xsd:string and denoted by CSV (x), where x is the type of the individual values. The data type of a heterogeneous list is also string or xsd:string and denoted by CSV (x, y, z), where x, y and z are the types of the individual values. If the number of values in the heterogeneous list is too large to show each type individually, that variable type is represented as CSV (*heterogeneous*), and the variable description includes additional information as to the expected sequence of values appearing in the list and their corresponding types. The data type of a repeated subsequence list is string or xsd:string and denoted by CSV ($\{x, y, z\}$), where x, y and z are the types of the individual values in the subsequence and the subsequence MAY be repeated zero or more times.

- A list is represented as a string type (for state variables and action arguments) or xsd:string type (for properties).
- Commas separate values within a list.
- Integer values are represented in CSVs with the same syntax as the integer data type specified in [DEVICE] (that is: optional leading sign, optional leading zeroes, numeric ASCII)
- Boolean values are represented in state variable and action argument CSVs as either “0” for false or “1” for true. These values are a subset of the defined Boolean data type values specified in [DEVICE]: 0, false, no, 1, true, yes.
- Boolean values are represented in property CSVs as either “0” for false or “1” for true. These values are a subset of the defined Boolean data type values specified in [XML SCHEMA-2]: 0, false, 1, true.
- Escaping conventions for the comma and backslash characters are defined in Section 1.2.2, “Strings Embedded in Other Strings”.
- White space before, after, or interior to any numeric data type is not allowed.
- White space before, after, or interior to any other data type is part of the value.

Table 1-2: CSV Examples

Type refinement of string	Value	Comments
CSV (string) or CSV (xsd:string)	" +artist,-date"	List of 2 property sort criteria.
CSV (int) or CSV (xsd:integer)	"1,-5,006,0,+7"	List of 5 integers.
CSV (boolean) or CSV (xsd:Boolean)	"0,1,1,0"	List of 4 booleans
CSV (string) or CSV (xsd:string)	"Smith\, Fred,Jones\, Davey"	List of 2 names, "Smith, Fred" and "Jones, Davey"
CSV (i4 , string , ui2) or CSV (xsd:int, xsd:string, xsd:unsignedShort)	"-29837, string with leading blanks,0"	Note that the second value is " string with leading blanks"
CSV (i4) or CSV (xsd:int)	"3, 4"	Illegal CSV. White space is not allowed as part of an integer value.
CSV (string) or CSV (xsd:string)	" , ,"	List of 3 empty string values
CSV (heterogeneous)	"Alice,Marketing,5,Sue,R&D,21,Dave,Finance,7"	List of unspecified number of people and associated attributes. Each person is described by 3 elements: a name string , a department string and years-of-service ui2 or a name xsd:string, a department xsd:string and years-of-service xsd:unsignedShort.

1.4 Management of XML Namespaces in Standardized DCPs

UPnP specifications make extensive use of XML namespaces. This allows separate DCPs, and even separate components of an individual DCP, to be designed independently and still avoid name collisions when they share XML documents. Every name in an XML document belongs to exactly one namespace. In documents, XML names appear in one of two forms: qualified or unqualified. An unqualified name (or no-colon-name) contains no colon (":") characters. An unqualified name belongs to the document's default namespace. A qualified name is two no-colon-names separated by one colon character. The no-colon-name before the colon is the qualified name's namespace prefix, the no-colon-name after the colon is the qualified name's "local" name (meaning local to the namespace identified by the namespace prefix). Similarly, the unqualified name is a local name in the default namespace.

The formal name of a namespace is a URI. The namespace prefix used in an XML document is *not* the name of the namespace. The namespace name is, or should be, globally unique. It has a single definition that is accessible to anyone who uses the namespace. It has the same meaning anywhere that it is used, both inside and outside XML documents. The namespace prefix, however, in formal XML usage, is defined only in an XML document. It must be locally unique to the document. Any valid XML no-colon-name may be used. And, in formal XML usage, no two XML documents are ever required to use the same namespace prefix to refer to the same namespace. The creation and use of the namespace prefix was standardized by the W3C XML Committee in [XML-NMSP] strictly as a convenient local shorthand replacement for the full URI name of a namespace in individual documents.

All AV object properties are represented in XML by element and attribute names, therefore, all property names belong to an XML namespace.

For the same reason that namespace prefixes are convenient in XML documents, it is convenient in specification text to refer to namespaces using a namespace prefix. Therefore, this specification declares a “standard” prefix for all XML namespaces used herein. In addition, this specification expands the scope where these prefixes have meaning, beyond a single XML document, to all of its text, XML examples, and certain string-valued properties. This expansion of scope *does not* supercede XML rules for usage in documents, it only augments and complements them in important contexts that are out-of-scope for the XML specifications.

All of the namespaces used in this specification are listed in the Tables “Namespace Definitions” and “Schema-related Information”. For each such namespace, Table 1-3, “Namespace Definitions” gives a brief description of it, its name (a URI) and its defined “standard” prefix name. Some namespaces included in these tables are not directly used or referenced in this document. They are included for completeness to accommodate those situations where this specification is used in conjunction with other UPnP specifications to construct a complete system of devices and services. The individual specifications in such collections all use the same standard prefix. The standard prefixes are also used in Table 1-4, “Schema-related Information”, to cross-reference additional namespace information. This second table includes each namespace’s valid XML document root elements (if any), its schema file name, versioning information (to be discussed in more detail below), and links to the entries in the Reference section for its associated schema.

The normative definitions for these namespaces are the documents referenced in Table 1-3. The schemas are designed to support these definitions for both human understanding and as test tools. However, limitations of the XML Schema language itself make it difficult for the UPnP-defined schemas to accurately represent all details of the namespace definitions. As a result, the schemas will validate many XML documents that are not valid according to the specifications.

The Working Committee expects to continue refining these schemas after specification release to reduce the number of documents that are validated by the schemas while violating the specifications, but the schemas will still be informative, supporting documents. Some schemas might become normative in future versions of the specifications.

Table 1-3: Namespace Definitions

Standard Name-space Prefix	Namespace Name	Namespace Description	Normative Definition Document Reference
<i>AV Working Committee defined namespaces</i>			
av:	urn:schemas-upnp-org:av:av	Common data types for use in AV schemas	[AV-XSD]
avs:	urn:schemas-upnp-org:av:avs	Common structures for use in AV schemas	[AVS-XSD]
avdt:	urn:schemas-upnp-org:av:avdt	Datastructure Template	[AVDT]
avt-event:	urn:schemas-upnp-org:metadata-1-0/AVT/	Evented <i>LastChange</i> state variable for AVTransport	[AVT]
didl-lite:	urn:schemas-upnp-org:metadata-1-0/DIDL-Lite/	Structure and metadata for ContentDirectory	[CDS]
rsc-event:	urn:schemas-upnp-org:metadata-1-0/RCS/	Evented <i>LastChange</i> state variable for RenderingControl	[RCS]
srs:	urn:schemas-upnp-org:av:srs	Metadata and structure for ScheduledRecording	[SRS]
srs-event:	urn:schemas-upnp-org:av:srs-event	Evented <i>LastChange</i> state variable for ScheduledRecording	[SRS]
upnp:	urn:schemas-upnp-org:metadata-1-0/upnp/	Metadata for ContentDirectory	[CDS]
<i>Externally defined namespaces</i>			
dc:	http://purl.org/dc/elements/1.1/	Dublin Core	[DC-TERMS]
xsd:	http://www.w3.org/2001/XMLSchema	XML Schema Language 1.0	[XML SCHEMA-1] [XML SCHEMA-2]
xsi:	http://www.w3.org/2001/XMLSchema-instance	XML Schema Instance Document schema	Sections 2.6 & 3.2.7 of [XML SCHEMA-1]
xml:	http://www.w3.org/XML/1998/namespace	The “xml:” Namespace	[XML-NS]

Table 1-4: Schema-related Information

Standard Name-space Prefix	Relative URI and File Name		Schema Reference
	• Form 1	• Form 2	
Valid Root Element(s)			
AV Working Committee Defined Namespaces			
av:	- av-vn-yyyyymmdd.xsd - av-vn.xsd	n/a	[AV-XSD]
avs:	- avs-vn-yyyyymmdd.xsd - avs-vn.xsd	<Features> <stateVariableValuePairs>	[AVS-XSD]
avdt:	- avdt-vn-yyyyymmdd.xsd - avdt-vn.xsd	<AVDT>	[AVDT]
avt-event:	- avt-event-vn-yyyyymmdd.xsd - avt-event-vn.xsd	<Event>	[AVT-EVENT-XSD]
didl-lite:	- didl-lite-vn-yyyyymmdd.xsd - didl-lite-vn.xsd	<DIDL-Lite>	[DIDL-LITE-XSD]
rcs-event:	- rcs-event-vn-yyyyymmdd.xsd - rcs-event-vn.xsd	<Event>	[RCS-EVENT-XSD]
srs:	- srs-vn-yyyyymmdd.xsd - srs-vn.xsd	<srs>	[SRS-XSD]
srs-event:	- srs-event-vn-yyyyymmdd.xsd - srs-event-vn.xsd	<StateEvent>	[SRS-EVENT-XSD]
upnp:	- upnp-vn-yyyyymmdd.xsd - upnp-vn.xsd	n/a	[UPNP-XSD]
Externally Defined Namespaces			
dc:	Absolute URL: http://dublincore.org/schemas/xmls/simpledc20021212.xsd		[DC-XSD]
xsd:	n/a	<schema>	[XMLSCHEMA-XSD]
xsi:	n/a		n/a
xml:	n/a		[XML-XSD]

1.4.1 Namespace Prefix Requirements

There are many occurrences in this specification of string data types that contain XML names (property names). These XML names in strings will not be processed under namespace-aware conditions. Therefore, all occurrences in instance documents of XML names in strings MUST use the standard namespace prefixes as declared in Table 1-3. In order to properly process the XML documents described herein, control points and devices MUST use namespace-aware XML processors [XML-NMSP] for both reading and writing. As allowed by [XML-NMSP], the namespace prefixes used in an instance document are at the sole discretion of the document creator. Therefore, the declared prefix for a namespace in a document MAY be different from the standard prefix. All devices MUST be able to correctly process any valid XML instance document, even when it uses a non-standard prefix for ordinary XML names. It is strongly RECOMMENDED that all devices use these standard prefixes for all instance documents to avoid confusion on the part of both human and machine readers. These standard prefixes are used in all descriptive text and all XML examples in this and related UPnP specifications. Also, each individual specification may assume a default namespace for its descriptive text. In that case, names from that namespace may appear with no prefix.

The assumed default namespace, if any, for each UPnP AV specification is given in Table 1-5, “Default Namespaces for the AV Specifications”.

Note: all UPnP AV schemas declare attributes to be “unqualified”, so namespace prefixes are never used with AV Working Committee defined attribute names.

Table 1-5: Default Namespaces for the AV Specifications

AV Specification Name	Default Namespace Prefix
AVTransport:2	avt-event:
ConnectionManager:2	n/a
ContentDirectory:2	didl-lite:
MediaRenderer:2	n/a
MediaServer:2	n/a
RenderingControl:2	rcs-event:
ScheduledRecording:1	srs:

1.4.2 Namespace Names, Namespace Versioning and Schema Versioning

Each namespace that is defined by the AV Working Committee is named by a URN.

In order to enable both forward and backward compatibility, the UPnP TC has established the general policy that namespace names will not change with new versions of specifications, even when the specification changes the definition of a namespace. But, namespaces still have version numbers that reflect definitional changes. Each time the definition of a namespace is changed, the namespace's version number is incremented by one.

Therefore, namespace version information must be provided with each XML instance document so that the document's receiver can properly understand its meaning. This is achieved by the following rules:

- Every release of a schema is identified by a version number and date of the form “*n-yyyymmdd*”, where *n* corresponds to the namespace definition version number and *yyyymmdd* is the year, month and day in the Gregorian calendar that the schema is released.

For example, the new version numbers of the pre-existing “DIDL-Lite” and “upnp” schemas are “2”. Versions for new schemas, such as “srs” are “1”.

For each schema, the version-date will appear in two places:

1. In the schema file name, according to the naming structure shown in Table 1-4, “Schema-related Information”.
2. As the value of the `version` attribute of each schema's schema root element.

Namespaces are referenced in both schema and XML instance documents by namespace name. The namespace name appears as the value of an `xmlns` attribute. The `xmlns` attribute also declares a namespace prefix that will be used to qualify names from each namespace. Schemas are referenced in both schema and XML instance documents by URI in the `schemaLocation` attribute. See section 1.4.3, “Namespace Usage Examples”. Two different forms of URI are available, each with a different meaning. All UPnP AV-defined schema URIs share a common base path of “<http://www.upnp.org/schemas/av/>”. Each schema URI has two unique relative forms (see Table 1-4, “Schema-related Information”), according to which version of a namespace and its representative schema is of interest. The allowed relative URI forms are:

1. *schema-root-name* “-v” *version-date*
where *version-date* is a full version-date of the form *n-yyyymmdd*. This form references the schema whose “root” name (typically the standardized prefix name used for the namespace that the schema represents) and version-date match *schema-root-name* and *version-date*, respectively.
2. *schema-root-name* “-v” *version*
where *version* is an integer representing the namespace's version number. This form references the most recent version of the schema whose root name and namespace version number match *schema-root-name* and the *version*, respectively.

Usage rules for schema location URIs are as follows:

- All instance documents, whether generated by a service or a control point, MUST use Form 1.
- All UPnP AV published schemas that reference other UPnP AV schemas will also use Form 1.
- Validation of XML instance documents in UPnP AV systems potentially serves two purposes. The first is based on standard XML and XML Schema semantics: the document's creator asserts that the

document is syntactically correct with respect to the referenced schema. The receiving processor can confirm this with a validating parser that uses the referenced schema(s). The second is based on UPnP AV namespace semantics. The receiving processor knows that the XML instance document is supposed to conform to one or more specific UPnP AV specifications. Since the second context is actually the more important context for instance document processing, the receiving processor MAY validate the instance document against any version of a schema that satisfies its needs in assessing the acceptability of the received instance document.

1.4.3 Namespace Usage Examples

The `schemaLocation` attribute for XML instance documents comes from the XML Schema instance namespace “`http://www.w3.org/2002/XMLSchema-instance`”. A single occurrence of the attribute can declare the location of one or more schemas. The `schemaLocation` attribute value consists of a whitespace separated list of values: namespace name followed by its schema location URL. This pair-sequence is repeated as necessary for the schemas that need to be located for this instance document.

Example 1:

Sample *DIDL-Lite XML Document*. This document assumes version-date 2-20060531 of the “`didl-lite:`” namespace/schema combination and (a possible later) version 2-20061231 of “`upnp:`”. The lines with the gray background show how to express this versioning information in the instance document.

```
<?xml version="1.0" encoding="UTF-8"?>
<DIDL-Lite
  xmlns:dc="http://purl.org/dc/elements/1.1/"
  xmlns="urn:schemas-upnp-org:metadata-1-0/DIDL-Lite/"
  xmlns:upnp="urn:schemas-upnp-org:metadata-1-0/upnp/"
  xmlns:xsi="http://www.w3.org/2001/XMLSchema-instance"
  xsi:schemaLocation="
    urn:schemas-upnp-org:metadata-1-0/DIDL-Lite/
      http://www.upnp.org/schemas/av/didl-lite-v2-20060531.xsd
    urn:schemas-upnp-org:metadata-1-0/upnp/
      http://www.upnp.org/schemas/av/upnp-v2-20061231.xsd">
  <item id="18" parentID="13" restricted="0">
    ...
  </item>
</DIDL-Lite>
```

Example 2:

Sample *srs XML Document*. This document assumes version 1-20060531 of the “`srs:`” namespace/schema combination. Again, the lines with the gray background show how to express this versioning information in the instance document.

```
<?xml version="1.0" encoding="UTF-8"?>
<srs
  xmlns="urn:schemas-upnp-org:av:srs"
  xmlns:xsi="http://www.w3.org/2001/XMLSchema-instance"
  xsi:schemaLocation="
    urn:schemas-upnp-org:av:srs
      http://www.upnp.org/schemas/av/srs-v1-20060531.xsd">
  ...
</srs>
```

1.5 Vendor-defined Extensions

Whenever vendors create additional vendor-defined state variables, actions or properties, their assigned names and XML representation MUST follow the naming conventions and XML rules as specified in [DEVICE], Section 2.5, “Description: Non-standard vendor extensions”.

1.6 References

This section lists the normative references used in the UPnP AV specifications and includes the tag inside square brackets that is used for each such reference:

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2 Service Modeling Definitions

2.1 ServiceType

The following service type identifies a service that is compliant with this template:

urn:schemas-upnp-org:service:ConnectionManager:2

2.2 State Variables

Table 2-6: State Variables

Variable Name	R/O ¹	Data Type	Allowed Value	Default Value	Eng. Units
<u>SourceProtocolInfo</u>	<u>R</u>	<u>string</u>	CSV ² (<u>string</u>)		
<u>SinkProtocolInfo</u>	<u>R</u>	<u>string</u>	CSV (<u>string</u>)		
<u>CurrentConnectionIDs</u>	<u>R</u>	<u>string</u>	CSV (<u>ui4</u>)		
<u>A_ARG_TYPE_ConnectionStatus</u>	<u>R</u>	<u>string</u>	“OK”, “ContentFormatMismatch”, “InsufficientBandwidth”, “UnreliableChannel”, “Unknown”, vendor-defined		
<u>A_ARG_TYPE_ConnectionManager</u>	<u>R</u>	<u>string</u>			
<u>A_ARG_TYPE_Direction</u>	<u>R</u>	<u>string</u>	“Output”, “Input”		
<u>A_ARG_TYPE_ProtocolInfo</u>	<u>R</u>	<u>string</u>			
<u>A_ARG_TYPE_ConnectionID</u>	<u>R</u>	<u>i4</u>			
<u>A_ARG_TYPE_AVTransportID</u>	<u>R</u>	<u>i4</u>			
<u>A_ARG_TYPE_RcsID</u>	<u>R</u>	<u>i4</u>			
Non-standard state variables implemented by a UPnP vendor go here	<u>X</u>	TBD	TBD	TBD	TBD

¹ R = REQUIRED, O = OPTIONAL, X = Non-standard.

² CSV stands for Comma-Separated Value list. The type between brackets denotes the UPnP data type used for the elements inside the list. The CSV list concept is defined more formally in the ContentDirectory service template.

Note: State variables [A_ARG_TYPE_ConnectionID](#), [A_ARG_TYPE_AVTransportID](#), and [A_ARG_TYPE_RcsID](#) are specified as being of data type [i4](#) to accommodate the fact that some actions REQUIRE these arguments to contain the special value -1. This special value is used as a return value to indicate that the service is not implemented on the device or is not needed for a particular connection. It can also be used as an [InstanceID](#) input argument when the actual [InstanceID](#) value is not (yet) known or the service does not exist.

Action [GetCurrentConnectionIDs\(\)](#) in this specification and all [InstanceIDs](#) in other services (AVTransport service, RenderingControl service, ...) use data type [ui4](#) to specify [InstanceID](#) variables. However, this does not present a problem since a valid [InstanceID](#) value is always a non-negative integer and is always generated through an argument that is of type [i4](#), effectively limiting the valid range for any [InstanceID](#) to $[0, 2^{31}-1]$. This range always fits in the valid range of an argument of data type [ui4](#) (range is $[0, 2^{32}-1]$) so that an 'out-of-range' error will never occur during assignment.

2.2.1 [SourceProtocolInfo](#)

This state variable contains a Comma-Separated Value (CSV) list of information on protocols this ConnectionManager supports for 'sourcing' (sending) data, in its current state. (The content of the CSV list can change over time, for example due to local resource restrictions on the device.) Besides the traditional notion of the term 'protocol', the protocol-related information provided by the connection also contains other information such as supported content formats. See Section 2.5, "Theory of Operation" for a general discussion on the notion of protocol info. See the table in Section 2.5.2, "[ProtocolInfo](#) Concept" for specific allowed values for this state variable. If the device does not support sourcing data, this state variable MUST be set to the empty string.

During normal operation, a MediaServer SHOULD ensure that there is consistency between what is reported in the [SourceProtocolInfo](#) state variable and all the [res@protocolInfo](#) properties of the items that populate the ContentDirectory; that is: at least all protocols that are used by any of the content items SHOULD be enumerated in the [SourceProtocolInfo](#) state variable. (Wildcards ("*") can be used in [SourceProtocolInfo](#) to limit the number of entries in the CSV list.) Additional protocols that are supported by the MediaServer but are not currently used by any of the content items MAY also be listed.

Control points can use the [SourceProtocolInfo](#) CSV list to quickly find out what type of content this MediaServer is capable of serving to the network.

A MediaServer can report temporary unavailability of a protocol (for example, HTTP server temporarily down or codec not available) by removing the appropriate entries from the [SourceProtocolInfo](#) CSV list.

2.2.2 [SinkProtocolInfo](#)

This state variable contains a Comma-Separated Value (CSV) list of information on protocols this ConnectionManager supports for 'sinking' (receiving) data, in its current state. (The content of the CSV list can change over time, for example due to local resource restrictions on the device.) The format and allowed value list are the same as for the [SourceProtocolInfo](#) state variable. If the device does not support 'sinking' data, this state variable MUST be set to the empty string.

A MediaRenderer can report temporary unavailability of a protocol (for example, codec not available) by removing the appropriate entries from the [SinkProtocolInfo](#) CSV list.

2.2.3 [CurrentConnectionIDs](#)

Comma-Separated Value list of references to current active Connections. This list MAY change without explicit actions invoked by control points, for example by out-of-band cleanup or termination of finished connections.

If OPTIONAL action [PrepareForConnection\(\)](#) is not implemented then this state variable MUST be set to "0", indicating that this ConnectionManager service only supports a single connection identified by ConnectionID = 0.

2.2.4 A ARG TYPE ConnectionStatus

This state variable is introduced to provide type information for the Status argument in the GetCurrentConnectionInfo() action. This status MAY change dynamically due to changes in the network.

2.2.5 A ARG TYPE ConnectionManager

This state variable is introduced to provide type information for the PeerConnectionManager argument in actions PrepareForConnection() and GetCurrentConnectionInfo(). A ConnectionManager reference takes the form of a UDN/serviceId pair (the slash is the delimiter). A control point can use UPnP discovery (SSDP) to obtain a ConnectionManager's description document from the UDN. Subsequently, the ConnectionManager's service description can be obtained by using the serviceId part of the reference.

2.2.6 A ARG TYPE Direction

This state variable is introduced to provide type information for the Direction argument in action PrepareForConnection().

2.2.7 A ARG TYPE ProtocolInfo

This state variable is introduced to provide type information for the RemoteProtocolInfo argument in action PrepareForConnection() and the ProtocolInfo argument in action GetCurrentConnectionInfo().

2.2.8 A ARG TYPE ConnectionID

This state variable is introduced to provide type information for the ConnectionID argument in actions PrepareForConnection(), ConnectionComplete() and GetCurrentConnectionInfo().

2.2.9 A ARG TYPE AVTransportID

This state variable is introduced to provide type information for the AVTransportID argument in actions: PrepareForConnection() and GetCurrentConnectionInfo(). It identifies a logical instance of the AVTransport service associated with a Connection. See AVTransport:1 Specification, Section 2.5.6, "Supporting multiple virtual Transports" for more information.

2.2.10 A ARG TYPE RcsID

This state variable is introduced to provide type information for the RcsID argument in actions PrepareForConnection() and GetCurrentConnectionInfo(). It identifies a logical instance of the Rendering Control service associated with a Connection. See RenderingControl:1 Specification, Section 1.2, "Multi-input Devices" and Section 2.5.1, "Multi-input Devices" for more information.

2.3 Eventing and Moderation

Table 2-7: Event Moderation

Variable Name	Evented	Moderated Event	Max Event Rate ¹	Logical Combination	Min Delta per Event ²
<u>SourceProtocolInfo</u>	<u>YES</u>	<u>NO</u>			
<u>SinkProtocolInfo</u>	<u>YES</u>	<u>NO</u>			
<u>CurrentConnectionIDs</u>	<u>YES</u>	<u>NO</u>			
<i>Non-standard state variables implemented by a UPnP vendor go here</i>	<i>TBD</i>	<i>TBD</i>	<i>TBD</i>	<i>TBD</i>	<i>TBD</i>

¹ Determined by N, where Rate = (Event)/(N secs).

² (N) * (allowedValueRange Step).

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2.4 Actions

Immediately following this table is detailed information about these actions, including short descriptions of the actions, the effects of the actions on state variables, and error codes defined by the actions.

Table 2-8: Actions

Name	R/O ¹
<u><i>GetProtocolInfo()</i></u>	<u>R</u>
<u><i>PrepareForConnection()</i></u>	<u>O</u>
<u><i>ConnectionComplete()</i></u>	<u>O</u>
<u><i>GetCurrentConnectionIDs()</i></u>	<u>R</u>
<u><i>GetCurrentConnectionInfo()</i></u>	<u>X</u>
<i>Non-standard actions implemented by a UPnP vendor go here</i>	<u>X</u>

¹ R = REQUIRED, O = OPTIONAL, X = Non-standard.

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Note: Non-standard actions MUST be implemented in such a way that they do not interfere with the basic operation of the ConnectionManager service; that is: these actions MUST be optional and do not need to be invoked for the ConnectionManager service to operate normally.

2.4.1 GetProtocolInfo()

This action returns the protocol-related info that this ConnectionManager supports in its current state, as a Comma-Separated Value list of strings according to Table 2-19, “Defined Protocols and their associated ProtocolInfo”. Protocol-related information for ‘sourcing’ data is returned in the Source argument and protocol-related information for ‘sinking’ data is returned in the Sink argument. When this ConnectionManager resides in a device that only supports ‘sourcing’ of data, the Sink argument MUST return the empty string. Likewise, when this ConnectionManager resides in a device that only supports ‘sinking’ of data, the Source argument MUST return the empty string.

2.4.1.1 Arguments

Table 2-9: Arguments for GetProtocolInfo()

Argument	Direction	relatedStateVariable
<u>Source</u>	<u>OUT</u>	<u>SourceProtocolInfo</u>
<u>Sink</u>	<u>OUT</u>	<u>SinkProtocolInfo</u>

2.4.1.2 Dependency on State

None.

2.4.1.3 Effect on State

None.

2.4.1.4 Errors

None

2.4.2 PrepareForConnection()

This OPTIONAL action is used to allow the device to prepare itself to connect to the network for the purposes of sending or receiving media content (for example, a video stream). PrepareForConnection() also allows the device to indicate whether or not it can establish a connection based on the current status of the device and/or the current conditions of the network.

The RemoteProtocolInfo input argument identifies the protocol, network, and format that MUST be used to transfer the content.

- If PrepareForConnection() is invoked on a MediaServer device, the RemoteProtocolInfo argument MUST be set to one of the ProtocolInfo entries from the CSV list obtained from the peer MediaRenderer device via the GetProtocolInfo() action. (See Section 2.5.2, “ProtocolInfo Concept” for details.) If the peer device does not implement GetProtocolInfo() (because it is not a MediaRenderer or not even a UPnP device), then the RemoteProtocolInfo argument MUST be set to one of the ProtocolInfo entries returned by the GetProtocolInfo() action on the local MediaServer device.
- If PrepareForConnection() is invoked on a MediaRenderer device, the RemoteProtocolInfo argument MUST be set to the value of the protocolInfo attribute of the content item (located in the ContentDirectory on the peer MediaServer device) that is going to be played. (See Section 2.5.2, “ProtocolInfo Concept” for details.) If the peer device does not implement a ContentDirectory service (because it is not a MediaServer or not even a UPnP device), then the RemoteProtocolInfo argument MUST be set to one of the ProtocolInfo entries returned by the GetProtocolInfo() action on the local MediaRenderer device.

The ConnectionID out argument is used to identify the connection that was prepared by the device in response to this invocation. The ConnectionID is a device-specific value and is NOT unique throughout the network. Therefore, the ConnectionIDs returned by the two end-points of the same connection will generally NOT be the same value. Refer to GetCurrentConnectionIDs() and/or the UPnP AV Device Architecture document for additional information. The AVTransportID and RcsID out arguments are used to identify the AVTransport and RenderingControl services that are associated with the connection. The returned values are the InstanceIDs that need to be used when invoking subsequent invocations of the AVTransport and RenderingControl Services. An InstanceID value of -1 indicates the device did not associate an AVTransport and/or RenderingControl service with this connection. The returned ConnectionID, AVTransportID, and RcsID become invalid when the device closes the connection. This will occur when ConnectionComplete() is invoked or any other time the device decides to close the connection (a.k.a auto-cleanup). Refer to ConnectionComplete() for additional information.

This action is marked OPTIONAL which means that each device manufacturer decides whether or not to implement it. Therefore, some devices will implement PrepareForConnection() while other devices will not. Since PrepareForConnection() allows a device to prepare itself to connect to the network, if a device has implemented that action, control points need to invoke PrepareForConnection() before attempting to stream any content; that is: before invoking AVTransport::SetAVTransportURI() (See Section 2.5.3, “Typical Control Point Operations”). Otherwise, the device may not operate correctly because it has not been properly configured. Additionally, control points need to invoke PrepareForConnection(), if implemented, so that the device can inform the control point, via an error code, that the device’s current operating environment is not able to accommodate the requested stream.

Once a connection has been prepared, it can be used to transfer several pieces of the content before calling ConnectionComplete() as long as each content item is compatible with the RemoteProtocolInfo argument that was passed into PrepareForConnection(); that is: each content item has the same media format as specified in RemoteProtocolInfo.

If a device does not implement PrepareForConnection(), it MUST only support a single connection at any time. This connection is implicitly assumed to be always present and is identified by ConnectionID = 0.

2.4.2.1 Arguments

Table 2-10: Arguments for PrepareForConnection()

Argument	Direction	relatedStateVariable
<u>RemoteProtocolInfo</u>	<u>IN</u>	<u>A_ARG_TYPE_ProtocolInfo</u>
<u>PeerConnectionManager</u>	<u>IN</u>	<u>A_ARG_TYPE_ConnectionManager</u>
<u>PeerConnectionID</u>	<u>IN</u>	<u>A_ARG_TYPE_ConnectionID</u>
<u>Direction</u>	<u>IN</u>	<u>A_ARG_TYPE_Direction</u>
<u>ConnectionID</u>	<u>OUT</u>	<u>A_ARG_TYPE_ConnectionID</u>
<u>AVTransportID</u>	<u>OUT</u>	<u>A_ARG_TYPE_AVTransportID</u>
<u>RcsID</u>	<u>OUT</u>	<u>A_ARG_TYPE_RcsID</u>

2.4.2.2 Dependency on State

None.

2.4.2.3 Effect on State

This action prepares the device to stream content to or from the specified peer ConnectionManager, according to the specified direction and protocol information. The PeerConnectionManager input argument identifies the ConnectionManager service on the other side of the connection. The PeerConnectionID input argument identifies the specific connection on that ConnectionManager

service. This information allows a control point to *link* a connection on device A to the corresponding connection on device B, via action [GetCurrentConnectionInfo\(\)](#). If the [PeerConnectionID](#) is not known by a control point (for example, this is the first of the two [PrepareForConnection\(\)](#) actions), or the peer device doesn't implement [PrepareForConnection\(\)](#) then this value MUST be set to reserved value -1.

This action returns a locally unique ID for the established Connection in the [ConnectionID](#) argument, and adds that [ConnectionID](#) to state variable [CurrentConnectionIDs](#). This [ConnectionID](#) might be used by a control point to manually terminate the established Connection through (OPTIONAL) action [ConnectionComplete\(\)](#). It can also be used to retrieve information associated with the Connection via action [GetCurrentConnectionInfo\(\)](#). Value -1 is reserved, and MUST NOT be returned.

OPTIONALLY, this action returns a virtual [InstanceID](#) of a local AVTransport service in the [AVTransportID](#) argument. This [AVTransportID](#) MUST be passed as an input argument to the local AVTransport service action invocations. If the returned [AVTransportID](#) is -1 (reserved value), then there is no AVTransport service on this device that can be used to control the established connection. This is dependent on the 'push' or 'pull' nature of the streaming protocol.

OPTIONALLY, this action returns a virtual [InstanceID](#) of a local RenderingControl service in the [RcsID](#) argument. This [RcsID](#) MUST be passed as an input argument to the local RenderingControl service action invocations. If the returned [RcsID](#) is -1 (reserved value), then there is no RenderingControl service on this device, for example, because the device is a source device (MediaServer) rather than a sink device (MediaRenderer).

Due to local restrictions on the device running the ConnectionManager, state variables [SourceProtocolInfo](#) and/or [SinkProtocolInfo](#) MAY change (for example, certain physical ports on the device are not available anymore for new connections) as a result of this action.

2.4.2.4 Errors

Table 2-11: Error Codes for [PrepareForConnection\(\)](#)

errorCode	errorDescription	Description
400-499	TBD	See UPnP Device Architecture section on Control.
500-599	TBD	See UPnP Device Architecture section on Control.
600-699	TBD	See UPnP Device Architecture section on Control.
701	Incompatible protocol info	The connection cannot be established because the protocol info argument is incompatible.
702	Incompatible directions	The connection cannot be established because the directions of the involved ConnectionManagers (source/sink) are incompatible.
703	Insufficient network resources	The connection cannot be established because there are insufficient network resources (bandwidth, channels, etc.).
704	Local restrictions	The connection cannot be established because of local restrictions in the device. This might happen, for example, when physical resources on the device are already in use by other connections.
705	Access denied	The connection cannot be established because the client is not permitted to access the specified ConnectionManager.
707	Not in network	The connection cannot be established because the ConnectionManagers are not part of the same physical network.
708	Connection Table overflow	The connection cannot be established because the specified ConnectionManager has instantiated the maximum number of simultaneous connections it has room for in its internal data structures. Closing one connection will resolve the issue.

errorCode	errorDescription	Description
709	Internal processing resources exceeded	The connection cannot be established because the device does not have sufficient internal processing resources to handle the new connection. Closing one or more connections on this device may resolve the issue.
710	Internal memory resources exceeded	The connection cannot be established because the device does not have sufficient internal memory resources to handle the new connection. Closing one or more connections on this device may resolve the issue.
711	Internal storage system capabilities exceeded	The connection cannot be established because the device does not have sufficient internal storage system capabilities to handle the new connection. Closing one or more connections on this device may resolve the issue.

2.4.3 ConnectionComplete()

This OPTIONAL action is used to inform the device that the specified connection, which was previously allocated by PrepareForConnection(), is no longer needed. Any resources that were allocated for that connection during PrepareForConnection() can be freed by the device at its discretion.

In some situations, ConnectionComplete() may never be invoked; for example, the control point spontaneously goes away. In order to prevent an unused connection from permanently consuming resources, the device SHOULD automatically cleanup unused connections. The process for determining when a connection SHOULD be automatically cleaned up is implementation dependent. For example, a device MAY decide to close a connection after the connection has been inactive for a certain period of time. Alternatively, a device MAY decide to close a connection when it needs to free the resources that are associated with the connection. See Section 2.5.5, “PrepareForConnection() and ConnectionComplete()” for additional information.

2.4.3.1 Arguments

Table 2-12: Arguments for ConnectionComplete()

Argument	Direction	relatedStateVariable
<u>ConnectionID</u>	<u>IN</u>	<u>A_ARG_TYPE_ConnectionID</u>

2.4.3.2 Dependency on State

None.

2.4.3.3 Effect on State

This action removes the connection referenced by argument ConnectionID by modifying state variable CurrentConnectionIDs, and (if necessary) performs any protocol-specific cleanup actions such as releasing network resources. See Annex A, “**(normative)**

Protocol Specifics” for more details.

Due to local restrictions on the device running the ConnectionManager, state variables SourceProtocolInfo and/or SinkProtocolInfo MAY change (for example, certain physical ports on the device are freed up for new connections).

2.4.3.4 Errors

Table 2-13: Error Codes for ConnectionComplete()

errorCode	errorDescription	Description
400-499	TBD	See UPnP Device Architecture section on Control.
500-599	TBD	See UPnP Device Architecture section on Control.
600-699	TBD	See UPnP Device Architecture section on Control.
706	Invalid connection reference	The connection reference argument does not refer to a valid connection established by this service.

2.4.4 GetCurrentConnectionIDs()

This action returns a Comma-Separated Value list of ConnectionIDs of currently ongoing Connections. A ConnectionID can be used to manually terminate a Connection via action ConnectionComplete(), or to retrieve additional information about the ongoing Connection via action GetCurrentConnectionInfo().

If a device does not implement PrepareForConnection(), this action MUST return the single value "0".

2.4.4.1 Arguments

Table 2-14: Arguments for GetCurrentConnectionIDs()

Argument	Direction	relatedStateVariable
<u>ConnectionIDs</u>	<u>OUT</u>	<u>CurrentConnectionIDs</u>

2.4.4.2 Dependency on State

None.

2.4.4.3 Effect on State

None.

2.4.4.4 Errors

Table 2-15: Error Codes for GetCurrentConnectionIDs()

errorCode	errorDescription	Description
400-499	TBD	See UPnP Device Architecture section on Control.
500-599	TBD	See UPnP Device Architecture section on Control.
600-699	TBD	See UPnP Device Architecture section on Control.

2.4.5 GetCurrentConnectionInfo()

This action returns associated information of the connection referred to by the ConnectionID input argument. The AVTransportID argument MAY be the reserved value -1 and the PeerConnectionManager argument MAY be the empty string in cases where the connection has been setup completely out of band, not involving a PrepareForConnection() action.

If OPTIONAL action PrepareForConnection() is not implemented then (limited) connection information can be retrieved for ConnectionID 0. The device MUST return all known information:

- RcsID MUST be 0 (a single instance of the RenderingControl service is implemented) or -1 (RenderingControl Service is not implemented)

- AVTransportID MUST be 0 (a single instance of the AVTransport service is implemented) or -1 (AVTransport service is not implemented)
- ProtocolInfo MUST contain accurate information if it is known, otherwise it MUST be the empty string
- PeerConnectionManager MUST be the empty string
- PeerConnectionID MUST be -1
- Direction MUST be “Input” or “Output”
- Status MUST be “OK” or “Unknown”

2.4.5.1 Arguments

Table 2-16: Arguments for GetCurrentConnectionInfo()

Argument	Direction	relatedStateVariable
<u>ConnectionID</u>	<u>IN</u>	<u>A_ARG_TYPE_ConnectionID</u>
<u>RcsID</u>	<u>OUT</u>	<u>A_ARG_TYPE_RcsID</u>
<u>AVTransportID</u>	<u>OUT</u>	<u>A_ARG_TYPE_AVTransportID</u>
<u>ProtocolInfo</u>	<u>OUT</u>	<u>A_ARG_TYPE_ProtocolInfo</u>
<u>PeerConnectionManager</u>	<u>OUT</u>	<u>A_ARG_TYPE_ConnectionManager</u>
<u>PeerConnectionID</u>	<u>OUT</u>	<u>A_ARG_TYPE_ConnectionID</u>
<u>Direction</u>	<u>OUT</u>	<u>A_ARG_TYPE_Direction</u>
<u>Status</u>	<u>OUT</u>	<u>A_ARG_TYPE_ConnectionStatus</u>

2.4.5.2 Dependency on State

None.

2.4.5.3 Effect on State

None.

2.4.5.4 Errors

Table 2-17: Error Codes for GetCurrentConnectionInfo()

errorCode	errorDescription	Description
400-499	TBD	See UPnP Device Architecture section on Control.
500-599	TBD	See UPnP Device Architecture section on Control.
600-699	TBD	See UPnP Device Architecture section on Control.
706	Invalid connection reference	The connection reference argument does not refer to a valid connection established by this service.

2.4.6 Common Error Codes

The following table lists error codes common to actions for this service type. If an action results in multiple errors, the most specific error SHOULD be returned.

Table 2-18: Common Error Codes

errorCode	errorDescription	Description
400-499	TBD	See UPnP Device Architecture section on Control.
500-599	TBD	See UPnP Device Architecture section on Control.
600-699	TBD	See UPnP Device Architecture section on Control.
701	Incompatible protocol info	The connection cannot be established because the protocol info argument is incompatible.
702	Incompatible directions	The connection cannot be established because the directions of the involved ConnectionManagers (source/sink) are incompatible.
703	Insufficient network resources	The connection cannot be established because there are insufficient network resources (bandwidth, channels, etc.).
704	Local restrictions	The connection cannot be established because of local restrictions in the device. This might happen, for example, when physical resources on the device are already in use by other connections.
705	Access denied	The connection cannot be established because the client is not permitted to access the specified ConnectionManager.
706	Invalid connection reference	The connection reference argument does not refer to a valid connection established by this service.
707	Not in network	The connection cannot be established because the ConnectionManagers are not part of the same physical network.
708	Connection Table overflow	The connection cannot be established because the specified ConnectionManager has instantiated the maximum number of simultaneous connections it has room for in its internal data structures. Closing one connection will resolve the issue.
709	Internal processing resources exceeded	The connection cannot be established because the device does not have sufficient internal processing resources to handle the new connection. Closing one or more connections on this device may resolve the issue.
710	Internal memory resources exceeded	The connection cannot be established because the device does not have sufficient internal memory resources to handle the new connection. Closing one or more connections on this device may resolve the issue.
711	Internal storage system capabilities exceeded	The connection cannot be established because the device does not have sufficient internal storage system capabilities to handle the new connection. Closing one or more connections on this device may resolve the issue.

Note 1: The errorDescription field returned by an action does not necessarily contain human-readable text (for example, as indicated in the second column of the Error Code tables.) It may contain machine-readable information that provides more detailed information about the error. It is therefore not advisable for a control point to blindly display the errorDescription field contents to the user.

Note 2: 800-899 Error Codes are not permitted for standard actions. See UPnP Device Architecture section on Control for more details.

2.5 Theory of Operation

2.5.1 Purpose

The purpose of the ConnectionManager is to enable control points to:

1. perform capability matching between source/server devices and sink/renderer devices. This involves both:
 - a. content-format matching (for example, mp3 – mp3)
 - b. transport (streaming) protocol matching (for example, http – http)
2. find information about currently ongoing streams in the network, for example:
 - a. find the source device sending content to a given renderer device
 - b. find the renderer devices served by a given source device or content resource
 - c. find all streams going on in the network
3. setup and teardown connections between devices (when required by the streaming protocol)

2.5.2 ProtocolInfo Concept

While the UPnP Architecture describes, and prescribes, many aspects of devices that are required for a certain level of interoperability, it does not describe anything related to streaming between devices. The purpose of the ConnectionManager service is to make these aspects of devices explicit, so that control points are able to make intelligent choices, present intelligent user interfaces, and initiate (and terminate) streams between controlled devices via UPnP actions. UPnP-defined protocols are used to initiate (and terminate) the stream, even though they are not used to stream the actual data *packets*.

The ConnectionManager service defines the notion of ProtocolInfo as information needed by a control point in order to determine (a certain level of) compatibility between the streaming mechanisms of two UPnP controlled devices. For example, it contains the transport protocols supported by a device, for input or output, as well as other information such as the content formats (encodings) that can be sent, or received, via the transport protocols. Note that, while UPnP prescribes the use of HTTP for controlling devices via SOAP, it does NOT REQUIRE HTTP to be used for all kinds of (Audio and Video) streaming in a UPnP network.

In the context of this document, the term ProtocolInfo is used to describe a string formatted as:

<protocol>“:”<network>“:”<contentFormat>“:”<additionalInfo>

where each of the 4 elements MAY be a wildcard “*”. Control points can match ProtocolInfo by (protocol-independent) string comparison operations on the <protocol>, <network> and <contentFormat> elements, taking into account the “*” wildcard, which matches with anything. It is RECOMMENDED that control points perform string matching using case-insensitive comparison. However, devices are REQUIRED to provide the <protocol>, <network>, and <contentFormat> strings exactly as prescribed by this and other specifications.

When performing protocol matching, control points have basically three different sources for protocol information:

- The value of the res@protocolInfo property of the content item to be played, which is exposed by the ContentDirectory service.
- The Comma Separated Value list maintained in the SinkProtocolInfo state variable of the MediaRenderer device.
- The Comma Separated Value list maintained in the SourceProtocolInfo state variable of the MediaServer device.

Control points should match the content item’s res@protocolInfo property value to one of the ProtocolInfo entries in the MediaRenderer’s SinkProtocolInfo CSV list. In addition, a control point

may want to check whether the content item's *res@protocolInfo* property value matches one of the entries in the MediaServer's *SourceProtocolInfo* CSV list to ensure that the MediaServer is currently capable of serving this content item.

The <additionalInfo> part does not need to match between source and sink. Its purpose is to convey any additional information needed to set up the out of band stream (for example, 1394 addresses). The structure of this 4th field is described later in this section.

The following table summarizes how the protocol info strings are defined for the protocols currently standardized by the ConnectionManager service, as well as for vendor-defined protocols. Annex A, “**(normative)**

Protocol Specifics”, provides a more detailed explanation per protocol.

Table 2-19: Defined Protocols and their associated *ProtocolInfo* Values

Protocol Name	protocol	network	contentFormat	additionalInfo	Ref.
HTTP GET	<i>“http-get”</i>	<i>“*”</i> ¹	MIME-type.	Vendor-defined, MAY be <i>“*”</i> .	App. Annex A
RTSP/RTP/UDP	<i>“rtsp-rtp-udp”</i>	<i>“*”</i> ²	Name of RTP payload type.	Vendor-defined, MAY be <i>“*”</i> .	App. A.2
INTERNAL	<i>“internal”</i>	IP address of the device hosting the Connection-Manager.	Vendor-defined, MAY be <i>“*”</i> .	Vendor-defined, MAY be <i>“*”</i> .	App. A.3
IEC61883_EX1	<i>“iec61883_ex1”</i>	GUID of the 1394 bus Isochronous Resource Manager.	Name standardized by IEC61883.	upnp.org_GUID = <GUID-value>;<PCR-index>. See definitions below.	App. A.4
IEC61883	<i>“iec61883”</i>	GUID of the 1394 bus Isochronous Resource Manager.	Name standardized by IEC61883.	GUID and PCR index of the 1394 device. See IEC61883 exception below.	App. A.4
VENDOR	Registered ICANN domain name of vendor	Vendor-defined, MAY be <i>“*”</i> .	Vendor-defined, MAY be <i>“*”</i> .	Vendor-defined, MAY be <i>“*”</i> .	App. A.5

¹ Since all devices supporting HTTP GET belong to the same IP network, the network does not need to be specified.

² Since all devices supporting RTSP/RTP/UDP belong to the same IP network, the network does not need to be specified.

2.5.2.1 4th Field – <additionalInfo>

Except for the IEC61883 protocol, the 4th field of the *ProtocolInfo* string contains either an asterisk character (“*”) or a list of name-value pairs. An asterisk indicates that the 4th field does not contain any meaningful data and should be ignored. A list of name-value pairs indicates that there is some additional information beyond the first three fields. In this case, the 4th field MUST contain one or more name-value pairs (separated by a semi-colon “;”) with each name-value pair having the following format:

<org-name>_<token-name>=<value>

where

<org-name> is the ICANN registered domain name of the organization that has defined the semantic of the name-value pair. For example, the UPnP Forum would use an <org-name> of “upnp.org”. Case-insensitive comparison is used.

<token-name> identifies the additional data that is being defined. It consists of one or more alpha-numeric characters (i.e. ‘a’-‘z’, ‘A’-‘Z’, ‘0’-‘9’, ‘_’) and MUST be unique within the context of the specified <org-name>. Case-insensitive comparison is used.

<value> is the value of the additional data. In addition to the escaping rule defined for attributes in [XML], the following rules also apply:

- All semi-colons (“;”) within <value> MUST be escaped with a backslash (“\”). This is necessary since a semi-colon is used to separate multiple name-value pair occurrences. For example, in order to represent a value of “yours;mine;ours”, <value> MUST be set to “yours\;mine\;ours”.
- All original backslash (“\”) characters within <value> MUST be escaped with a (second) backslash (“\\”). Obviously, backslash characters that have been added as an escape character are themselves not double escaped. For example, in order to represent a value of “yours\mine\ours”, <value> MUST be set to “yours\\mine\\ours”.

Multiple name-value pairs are separated by a semi-colon (“;”) and have the layout below. When multiple name-value pairs are specified, the order of occurrence of the name-value pair is not relevant. Additionally, the same value of <org-name> MAY occur multiple times and the same value of <token-name> MAY occur multiple times. However, each <org-name>_<token-name> combination MUST appear at most once within the list of name-value pairs contained by the 4th field. The following example shows three name value pairs: two of which are defined by the UPnP Forum and one of which is defined by a fictitious organization called “VendorA”:

upnp.org_resolution=1080i;VendorA.com_resolution=super_high_quality;upnp.org_sample_rate=30FPS

As described before, the <additionalInfo> field may be used for any purpose and contains name-value pairs which the control point may or may not understand. Since the semantics of the unknown name-value pairs are unknown, it SHOULD ignore unknown name-value pairs and only known name-value pairs MAY be used during comparison.

2.5.2.2 IEC61883 Exception

When the IEC61883 protocol was first introduced into the specification, the structure of the 4th field was not yet defined. Therefore, the additional data that was needed for this protocol was simply placed directly in the 4th field without any higher-level constructs. In order to maintain compatibility with existing implementations of this specification, the definition of the 4th field for the IEC61883 protocol can not be changed in order to comply with the 4th field layout defined above. However, to eventually deprecate this non-conformant protocol designation, a new protocol designation has been defined for IEC61883 which does conform to the above layout. It has been named IEC61883_EX1 with the “_EX1” suffix indicating “Extension #1”. All future implementations that support the IEC61883 protocol MUST use the new designator (IEC61883_EX1) as well as the original designator (IEC61883).

2.5.2.3 Formal EBNF for the 4th field

The formal EBNF for the 4th field is as follows:

```

4th-field          ::=  '*' | name-value-pair-list | IEC61883-
exception

name-value-pair-list ::=  name-value-pair ( ';' name-value-pair ) *
name-value-pair     ::=  org-name '_' token-name '=' value

org-name            ::=  ( * ICANN registered domain name
                           including the top-level domain suffix
                           (e.g. ".com", ".org", ".netv, etc.) * )

token-name          ::=  ( 'a'-'z' | 'A'-'Z' | '0'-'9' | '_' ) +

value               ::=  ( unicode-char-except-backslash-semicolon |
                           escaped-backslash | escaped-semicolon ) *

unicode-char-except-backslash-semicolon
                   ::=  ( * any Unicode-4 character except a
                           '\ ' or ' ; ' character * )

escaped-backslash   ::=  '\\ '
escaped-semicolon   ::=  '\ ; '

IEC61883-exception  ::=  GUID-value ';' PCR-index

GUID-value          ::=  ( * hex encoding of the device's
                           IEC61883_node_vendor_id and chip_id
                           (total of 64-bits) * )

PCR-index           ::=  ( * zero-based integer index identifying
                           the plug within the device * )

```

2.5.2.4 ProtocolInfo Conventions for Protected Content

2.5.2.4.1 3rd Field - MIME Type Format

MIME types for protected content resources appear in the third field, <contentFormat>, of the ProtocolInfo string. Since protected files may be described by both a content protection MIME type as well as a MIME type associated with the underlying media, the following convention for extended MIME types will be used for MIME types that describe protected resources:

<content_protection_MIME_type>;CONTENTFORMAT=<underlying_media_MIME_type>

Example 1. The following example describes a MPEG2-TS resource that is protected with DTCP-IP when streaming. The extended MIME type is:

application/x-dtcp1;CONTENTFORMAT=video/MP2T

The full resulting ProtocolInfo string additionally indicates that the stream is http-get:

ProtocolInfo = "http-get:*.application/x-dtcp1;CONTENTFORMAT=video/MP2T:*"

Finally, the form of the <res> element content is (per DTCP Volume 1 Supplement E Revision 1.0):

```

<res protocolInfo=
  "http-get:*.application/x-dtcp1;CONTENTFORMAT=video/MP2T:*"
  allowedUse="PLAY,5"
  validityStart="2004-05-30T14:30:00"
  validityEnd="2004-06-04T14:30:00">
  http://10.0.0.1:88/MyCollection/movie7829.mp2t?
  CONTENTPROTECTIONTYPE=DTCP1&DTCP1HOST=1.2.3.4&DTCP1PORT
  =97
</res>

```

Example 2. The following example extended MIME type describes a MPEG2-PS resource that is delivered as an OMA DCF file:

```
"application/vnd.oma.drm.dcf;CONTENTFORMAT=video/MP2P"
```

The resulting *ProtocolInfo* string containing the extended MIME type additionally indicates that the file is transferred with http-get:

```
ProtocolInfo = "http-get:*:application/vnd.oma.drm.dcf;CONTENTFORMAT=video/MP2P:*"
```

Finally, the form of the <res> element content is as follows:

```
<res protocolInfo=
"http-
get:*:application/vnd.oma.drm.dcf;CONTENTFORMAT=video/MP2P:*"
  allowedUse="PLAY,5"
  validityStart="2004-05-30T14:30:00"
  validityEnd="2004-06-04T14:30:00">
  http://10.0.0.1:88/MyCollection/movie8126.dcf
</res>
```

Example 3. The following example describes a MPEG2-PS resource that is delivered as an OMA DCF file and can be exported to a DTCP content protection system:

The rights object of the content includes the permissions for enabling the translation into the new DRM system and will be represented as two separate <res> elements representing the same content:

```
<res protocolInfo=
"http-
get:*:application/vnd.oma.drm.dcf;CONTENTFORMAT=video/MP2P:*"
  allowedUse="PLAY,5"
  validityStart="2004-05-30T14:30:00"
  validityEnd="2004-06-04T14:30:00">
  http://10.0.0.1:88/MyCollection/movie8126.dcf
</res>

<res protocolInfo=
"http-get:*:application/*-dtcp1;CONTENTFORMAT=video/MP2T:*"
  allowedUse="PLAY,5"
  validityStart="2004-05-30T14:30:00"
  validityEnd="2004-06-04T14:30:00">
  http://10.0.0.1:88/MyCollection/movie9736.mp2t?
  CONTENTPROTECTIONTYPE=DTCP1&DTCP1HOST=1.2.3.4&DTCP1PORT
=97</res>
```

2.5.2.4.2 4th Field - Convention for Protected Content

The UPnP AV:WC additionally defines the following convention for placing information in the fourth field of the *ProtocolInfo* string. The fourth field is used to convey additional information in cases when MIME type is not sufficient for the purpose of capability matching. In these cases the fourth field MUST contain additional DRM information for the purpose of more precise compatibility checking between the media sink and the content properties. Two cases are possible. In the first case, it is only required to identify the vendor or the standards group that defines the DRM scheme. In this case, the DRM organization or vendor is specified as the value of a upnp-domain variable:

```
upnp.org_DRMInfo=<ICANN-DRM-ORG-NAME>
```

In the second case, the DRM scheme also requires one or more parameters associated with the DRM scheme to be enumerated. In this case, the following convention is used:

```
upnp.org_DRMInfo=<ICANN-DRM-ORG-NAME>;
<ICANN-DRM-ORG-NAME>_<parameter1>=<parameter1 value>;
<ICANN-DRM-ORG-NAME>_<parameter2>=<parameter2 value>;
...
<ICANN-DRM-ORG-NAME>_<parameterN>=<parameterN value>
```

Example 4: A ProtocolInfo string utilizes the fourth field to indicate that the MPEG-4 content is protected by a (fictitious) DRM scheme associated with ICANN name “XYZ.ORG”:

ProtocolInfo = “http-get*:video/mp4:upnp.org_DRMInfo=XYZ.ORG”

Example 5: A ProtocolInfo string for an OMA dcf file also indicates the OMA version in the fourth field:

ProtocolInfo = “http-get*:application/vnd.oma.drm.dcf;CONTENTFORMAT=video/MP2P:upnp.org_DRMInfo=OMA.ORG;OMA.ORG_VERSION=2”

For maximal compatibility checking, both third and fourth fields (when present) of the ProtocolInfo string should be matched. In general, older control points may not be capable of checking the fourth field of the ProtocolInfo string. For that reason, it is recommended that content listings in the CDS for DRM content should use the MIME conventions described above as much as possible for inserting DRM information on the given content item into the third field of the ProtocolInfo string.

2.5.3 Typical Control Point Operations

This section briefly outlines some typical control point operations on a ConnectionManager service.

2.5.3.1 Establishing a New Connection

The process for establishing a streaming connection involves:

1. Find ConnectionManager services via SSDP
2. Determine compatibility between the source (sending) and the sink (receiving) device (See Section 2.4.1)
3. Invoke PrepareForConnection() on the source and/or sink devices, if the action is implemented by the device (See Section 2.4.2)
4. Transfer content from source to sink device. (See note below).
5. When the connection is no longer needed, invoke ConnectionComplete() on the source and/or sink devices, if the action is implemented by the device. (See Section 2.4.3)

Refer to the UPnP AV Architecture document for additional details.

Once a connection has been prepared, it can be used to transfer several pieces of content before calling ConnectionComplete() as long as each content item is compatible with the RemoteProtocolInfo argument that was passed into PrepareForConnection(); that is: each content item has the same media format as specified in RemoteProtocolInfo.

2.5.3.2 Dealing with Ongoing Connections

A number of interesting scenarios require a control point to find information about all currently ongoing connections in the network, including those that it did not establish itself. This is supported by the ConnectionManager as follows. Each connection explicitly established by any control point in the network is identified by a connection identifier on both the source (sending) device and the sink (receiving) device. State variable CurrentConnectionIDs holds a Comma-Separated Value list of these identifiers. Given an identifier, a control point can call GetConnectionInfo() to obtain:

- The ProtocolInfo of the connection. This includes the streaming protocol and the content format.
- The ‘other end’ of the connection, expressed as a UDN/serviceId pair. Using the UDN, a control point can use SSDP to find the device description of the other UPnP device involved in the connection. This way, a control point can find out, for example, that turning off a particular source device is going to affect one or more sink devices.
- The connection status.

- The AVTransportID of the connection, which indicates the AVTransport service instance controlling the playback and recording through the connection. This service can be used for many purposes, for example to:
 - subscribe to events in order to monitor the transport state
 - actually change the transport state, for example, stopping or pausing an existing stream
 - obtain a URI reference to the content resource currently flowing through the connection
 - obtain any meta data embedded in the content resource flowing through the connection.

See the AVTransport service description for more details.

- The RcsID of the connection, which indicates the RenderingControl service instance controlling the rendering properties of the content. This can be used, for example, to implement a 'mute all streams' function in a control point.

2.5.4 Relation to Devices without ConnectionManagers

In some cases, it is desirable to establish a stream connection between devices where one device implements a UPnP ConnectionManager service, and the other device doesn't implement this service or isn't even a UPnP device. In such cases, a control point can only call PrepareForConnection() and ConnectionComplete() actions on the first device. The PeerConnectionManager input argument to PrepareForConnection() is defined as the UDN of the connecting UPnP device followed by a slash ('/') and the serviceId of the connecting device's ConnectionManager service. In case the connecting UPnP device has no ConnectionManager service, the serviceId part of the argument is left blank. In case the connecting device is not a UPnP device (for example, an Internet streaming server), the whole PeerConnectionManager argument is left blank.

2.5.5 PrepareForConnection() and ConnectionComplete()

2.5.5.1 PrepareForConnection()

The purpose of PrepareForConnection() is to allow a device to perform a set of tasks prior to transferring the content. The specific tasks performed by a device are implementation dependent, but may include the following:

- Determine whether or not the device is able to stream content using the current environment (for example, device status, network conditions, etc.)
- Allocating some resources that are needed to establish the out-of-band connection between the source/sink devices for example, in an IEEE-1394/IEC-61883 environment, this may include allocating an IEEE-1394 isochronous channel.
- Allocating a unique ConnectionID that identifies those resources which were allocated for a specific connection.
- Allocating a new virtual instance of the AVTransport and/or RenderingControl service and binding it to the connection so that the flow of the content and the rendering characteristics of the content can be controlled.

If a control point wants to interoperate with all UPnP AV devices, prior to initiating the transfer of content, for example, invoking AVTransport::SetAVTransportURI(), the control point needs to invoke PrepareForConnection(), if the action is implemented by the device. Otherwise, the device may not operate correctly because it is not yet properly configured. Additionally, the control point will not know whether or not the current environment is able to support the upcoming streaming request.

2.5.5.2 ConnectionComplete()

The purpose of ConnectionComplete() is to allow a device to terminate a specific connection and/or to perform any cleanup tasks that are needed for the connection as a result of a previous invocation of PrepareForConnection(). As with PrepareForConnection(), the set of tasks performed by a device when ConnectionComplete() is invoked is implementation-dependent, but may include the following:

- Releasing the resources that were allocated to establish the out-of-band connection between the source and sink devices (for example, in a IEEE-1394/IEC-61883 environment, this may include releasing the IEC-61883 isochronous channel that was allocated when PrepareForConnection() was invoked earlier on the same device).
- Releasing the unique ConnectionID that identifies those resources that were allocated by a previous invocation of PrepareForConnection().
- Releasing the virtual instance of the AVTransport and/or RenderingControl service, if any, that were allocated during a previous invocation of PrepareForConnection() in order to control the content flowing over the associated connection.

Since control points may turn off after a connection is established, control points may not always invoke the ConnectionComplete() action. Therefore, the device needs to automatically perform any cleanup tasks for the connection so that those resources that were allocated during PrepareForConnection() are not *leaked*.

2.5.5.3 General Usage Model

As mentioned earlier, each device performs an arbitrary set of implementation-dependent tasks during PrepareForConnection() and ConnectionComplete(). Some of these tasks may be crucial to the proper operation of the device while other tasks may be secondary to the device's core functionality. However, since each implementation of PrepareForConnection() and ConnectionComplete() are specific to each device, it is very difficult (if not impossible) for a control point to determine whether or not it is safe to by-pass PrepareForConnection()/ConnectionComplete() for a given device. Therefore, the safest and simplest way for a control point to interoperate with all UPnP AV devices is to always invoke PrepareForConnection() and ConnectionComplete() if they are implemented by the device. Otherwise, those devices may not function properly as described above.

2.5.5.4 Relationship to AVTransport and RenderingControl Services

As described in the "Theory of Operation" sections of the AVTransport and RenderingControl service specifications, some device are designed to support multiple virtual instances of the AVTransport and/or RenderingControl service. With these types of devices, the allocation and binding of these virtual instances occur during PrepareForConnection().

As described in the AVTransport specification, the responsibility for providing the AVTransport service for a given connection varies between the source and sink devices depending on the type of connection (that is: the type of transfer protocol that is being used). When a *push* protocol is being used (for example, IEEE-1394), the source device is responsible for providing the AVTransport service and when a *pull* protocol is being used (for example, HTTP GET), the sink device is responsible for providing the AVTransport service. When a source device wants to support multiple instances of a *push* protocol or a sink device wants to support multiple instances of a *pull* protocol, the device's PrepareForConnection() is responsible for allocating a new virtual instance of the AVTransport service for each new instance of that connection-type. Additionally, PrepareForConnection() MUST perform the necessary binding operations that link the allocated AVTransport instance with the connection.

For example, in a IEEE-1394/IEC-61883 (*push*) environment, if a source device wants to support multiple 1394/61883 streams, then its PrepareForConnection() MUST allocate a unique virtual instance of the AVTransport service and bind it to the newly allocated IEEE-1394/IEC-61883 connection. Similarly, in an HTTP GET *pull* environment, if a sink device wants to support multiple simultaneous connections, its PrepareForConnection() implementation MUST allocate a new virtual instance of the AVTransport service and bind it to the newly allocated connection.

Note: This implies that the sink device's PrepareForConnection() MUST perform some type of pre-allocation of the TCP/IP socket so that it can be distinguished from the other connections of that type.

With regards to the RenderingControl service, the sink device is always responsible for providing it regardless of the underlying protocol. If a sink device is designed to support multiple simultaneous connections then its implementation of PrepareForConnection() MUST be designed to allocate a new virtual instance of the RenderingControl service for each connection that is created. Additionally, it MUST bind each instance to the newly created connection so that a control point can control the rendering characteristics of the content that is being transferred over that connection.

Note: This implies that the sink device's PrepareForConnection() MUST perform some type of pre-allocation of the TCP/IP socket so that it can be distinguished from the other connections of that type.

When a device's PrepareForConnection() is designed to allocate and bind virtual instances of the AVTransport and/or RenderingControl services, the device's ConnectionComplete() MUST be designed to un-bind and release these virtual instances. For example, if a source device allocates an AVTransport service and binds it to a IEEE-1394 channel, the device's ConnectionComplete() action MUST undo the binding operation, as appropriate, and it MUST release the IEEE-1394 channel.

2.5.5.5 ConnectionIDs

A ConnectionID is a device-specific identifier that is used to uniquely identify a connection which has been prepared on a device via PrepareForConnection(). When PrepareForConnection() is invoked, a ConnectionID is allocated by the device and assigned to the newly configured connection. Since ConnectionIDs are allocated by individual devices, a given ConnectionID is valid only within the context of that device. Therefore, a ConnectionID assigned by one device can not be used when interacting with another device. When the two end-point devices of a given connection are setup via PrepareForConnection(), the ConnectionIDs returned by the two devices are completely independent from each other and are almost certainly going to have different values even though they happen to refer to the same connection.

On a given device, the algorithm used to allocate ConnectionIDs is vendor-specific. Hence, the numerical value of a ConnectionID is completely meaningless except to the device itself. Once a ConnectionID has been allocated, it is generally valid until the associated connection is torn down. Typically, this happens in response to an invocation of ConnectionComplete() or as a result of the device's OPTIONAL auto-cleanup mechanism.

Devices SHOULD NOT return the same ConnectionID value on subsequent invocations of PrepareForConnection(). After a connection has been torn down, its associated ConnectionID, which is no longer valid, can be reassigned by the device to another connection. However, in order to minimize the potential of a stale ConnectionID being misinterpreted as a valid ConnectionID, it is RECOMMENDED that each device not reassign a ConnectionID value until all other valid values have been used.

Once a ConnectionID has been allocated, any control point may use the ConnectionID to uniquely identify the associated connection even when invoking ConnectionComplete(). However, in order to provide predictable device behavior, it is RECOMMENDED that each control point use only those connections that it has prepared. Notable exceptions to this recommendation include those control points that are able to coordinate with one another, via some non-UPnP mechanism, or those control points that are explicitly designed to perform connection clean up tasks, for example, a network management tool.

2.5.5.6 AVTransportIDs and RcsIDs

When a connection is prepared via PrepareForConnection(), the device MAY choose to return an AVTransportID and/or an RcsID. These IDs are used to identify the (unique and independent) virtual instance of the AVTransport service and/or RenderingControl service that has been associated with the newly prepared connection. As with the connection's ConnectionID, the value of the AVTransportID and/or RcsID have no meaning outside of the context of the allocating device. Similarly, AVTransportIDs and RcsIDs are valid until their associated connection is torn down, generally in response to an invocation of ConnectionComplete() or as a result of the device's OPTIONAL auto-cleanup mechanism.

Once allocated, AVTransportIDs and RcsIDs are used in conjunction with the AVTransport service and RenderingControl service, respectively, to invoke various control actions on the stream that is being

carried over the associated connection. As with ConnectionIDs, control points should use only the AVTransportIDs and RcsIDs that are associated with the connections that the control point has prepared via PrepareForConnection(). The AVTransport and RenderingControl services allow any control point to use any valid AVTransportIDs and/or RcsIDs. However, when multiple control points use the same AVTransportID and/or RcsID, these control points should coordinate their activities with one another. Otherwise, the devices may behave unexpectedly thus causing a poor end-user experience.

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3 XML Service Description

```

<?xml version="1.0"?>
<scpd xmlns="urn:schemas-upnp-org:service-1-0">
  <specVersion>
    <major>1</major>
    <minor>0</minor>
  </specVersion>
  <actionList>
    <action>
      <name>GetProtocolInfo</name>
      <argumentList>
        <argument>
          <name>Source</name>
          <direction>out</direction>
          <relatedStateVariable>
            SourceProtocolInfo
          </relatedStateVariable>
        </argument>
        <argument>
          <name>Sink</name>
          <direction>out</direction>
          <relatedStateVariable>
            SinkProtocolInfo
          </relatedStateVariable>
        </argument>
      </argumentList>
    </action>
    <action>
      <name>PrepareForConnection</name>
      <argumentList>
        <argument>
          <name>RemoteProtocolInfo</name>
          <direction>in</direction>
          <relatedStateVariable>
            A_ARG_TYPE_ProtocolInfo
          </relatedStateVariable>
        </argument>
        <argument>
          <name>PeerConnectionManager</name>
          <direction>in</direction>
          <relatedStateVariable>
            A_ARG_TYPE_ConnectionManager
          </relatedStateVariable>
        </argument>
        <argument>
          <name>PeerConnectionID</name>
          <direction>in</direction>
          <relatedStateVariable>
            A_ARG_TYPE_ConnectionID
          </relatedStateVariable>
        </argument>
        <argument>
          <name>Direction</name>
          <direction>in</direction>
          <relatedStateVariable>
            A_ARG_TYPE_Direction
          </relatedStateVariable>
        </argument>
        <argument>
          <name>ConnectionID</name>
          <direction>out</direction>

```