UPnP AV
The technology basis of DLNA

July 2014

Contents

- Audio video use cases
- UPnP Technical basics
- Technical basics applied to AV
- UPnP Forum
- DLNA

Audio/Video Use Cases

Pull scenario

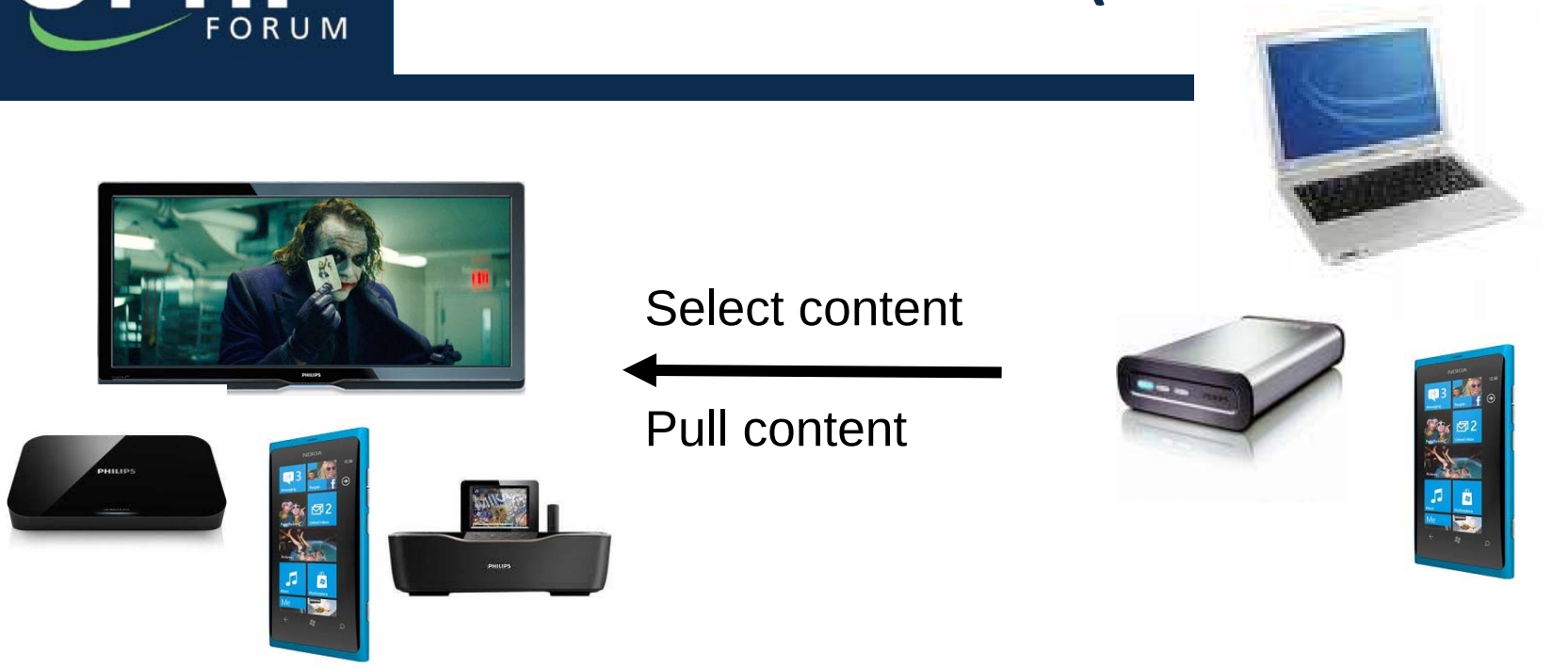
Select content

Pull content

TV uses Remote control to select content, and plays locally the content

- TV has control point
- PC has Media Server

Pull scenario (Generalized)



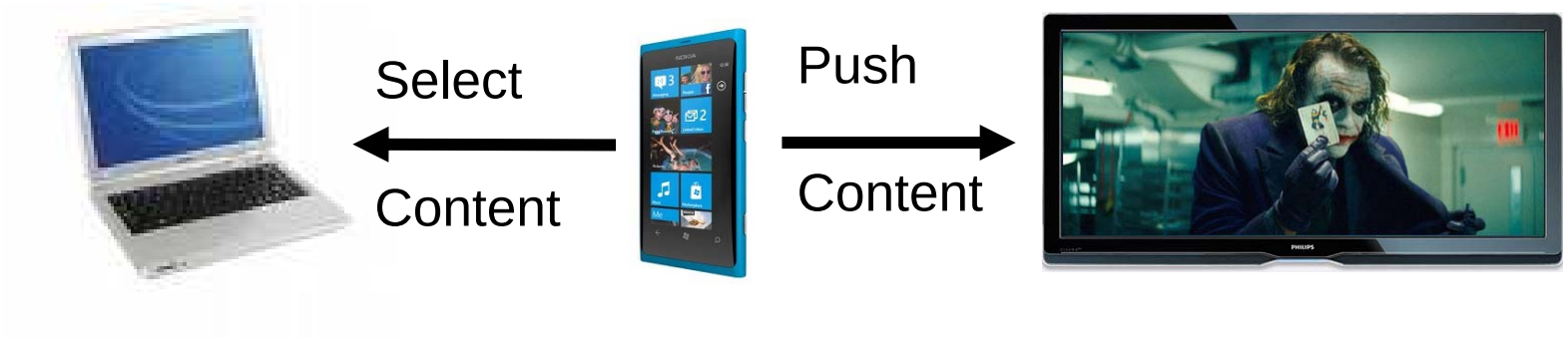
Player devices can be in any shape and size

- TV
- Video/Audio Media Players
- Phones

Server devices can be in any shape and size

- PC/Laptop
- Networked Attached Storage (NAS)
- Phones

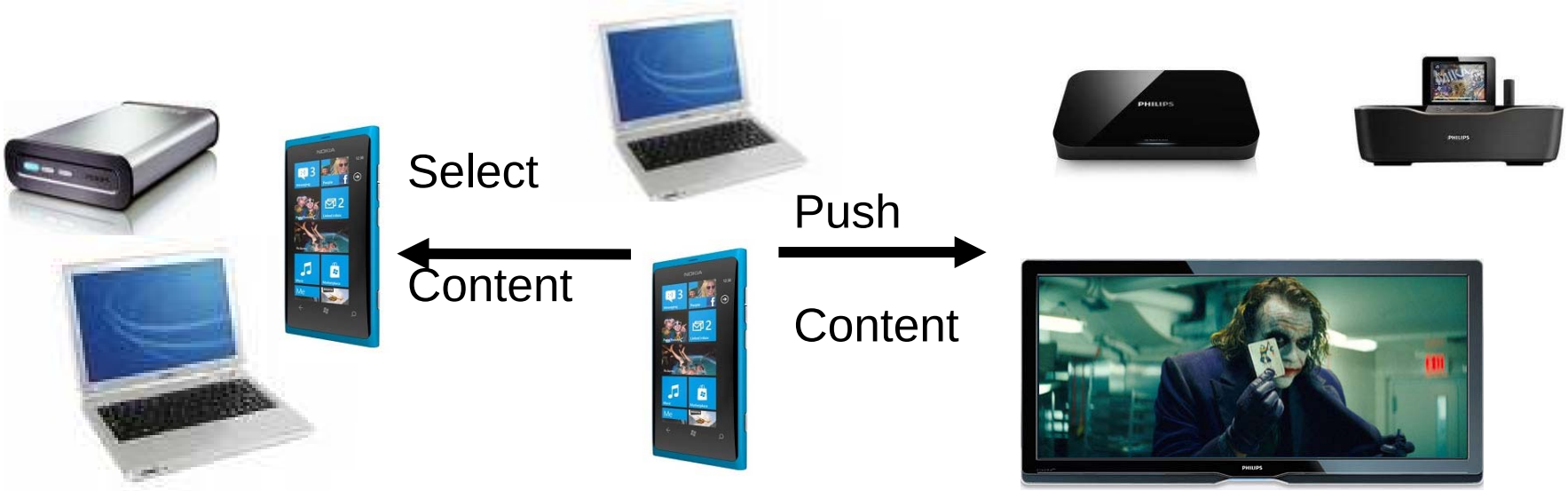
Push scenario



Phone selects content on PC, and pushes the content to the TV so that the TV plays the content

- PC has media server
- Phone has control point (UI) for selecting content on Media Server
- Phone has control point for pushing content to Media Renderer
- TV has Media Renderer

Push scenario (Generalized)



Control points can also have any shape and size

- PC
- Phone
- Tablets

Media Renderers can also have any shape and size

- TV
- Digital Media Renderers

What is needed to realize these scenarios?

Devices

- Devices should announce themselves on the network
- Devices should announce their capabilities
- Actions should be called on Devices
- State changes should be evented from the Devices

Control points

- Should detect devices automatically on the network
- Should use capabilities to perform a functionality
- Should invoke actions
- Should listen to events

AV specifications

Standardized Devices

UPnP AV Devices:

- Media Server
- Media Renderer

No 1 to 1 mapping with real world devices/boxes

- PC: Media Player + Media Server + Printer
- TV: Media Player + Media Renderer
- Phone: Media Player + Media Server

Any combination can exist !

(but does not always make sense)

Standardized Services

Media Server can have:

- Content Directory Service (CDS):
  Group of actions that allows for browsing and searching the content tree. (CDS is the most important service of a media server, hence often used as synonym for server)
- Connection Manager Service (CMS):
  Group of actions to support initial connection setup and transport type definitions
- AV Transport Service (AVT):
  Group of actions to control streaming and playback
- Scheduled Recording Service (SRS):
  Group of actions that allow to set up timed recordings (AV:2 option)

Media Renderer can have:

- Connection Manager Service (CMS) – reuse!
- AV Transport Service (AVT) – reuse!
- Rendering Control Service (RCS):
  Group of actions that affect how content is rendered (playback)

Control Points

The *part* of the UPnP stack

that discovers devices in the network and allows sending commands to these devices, and receive events from these devices

A control point is NOT a UPnP *device*.

A control point is NOT visible on the network.

A control point is NOT a control point ☺

It is used to control other devices, hence the implementation depends on *what* can be controlled.

E.g.: Control point for Media server

Control point for Media server + Media Renderer

Control point for light control

Content Serving by a Media Server

- The Content Directory Service (CDS) provides a *tree of meta data* objects
- The meta data objects describe *object properties* and provides *links to the content*
- The hierarchy of meta data objects can be defined by the application (server)
- The presentation of the meta data objects is determined by the UI of the client

It is not a file system and not a file system hierarchy

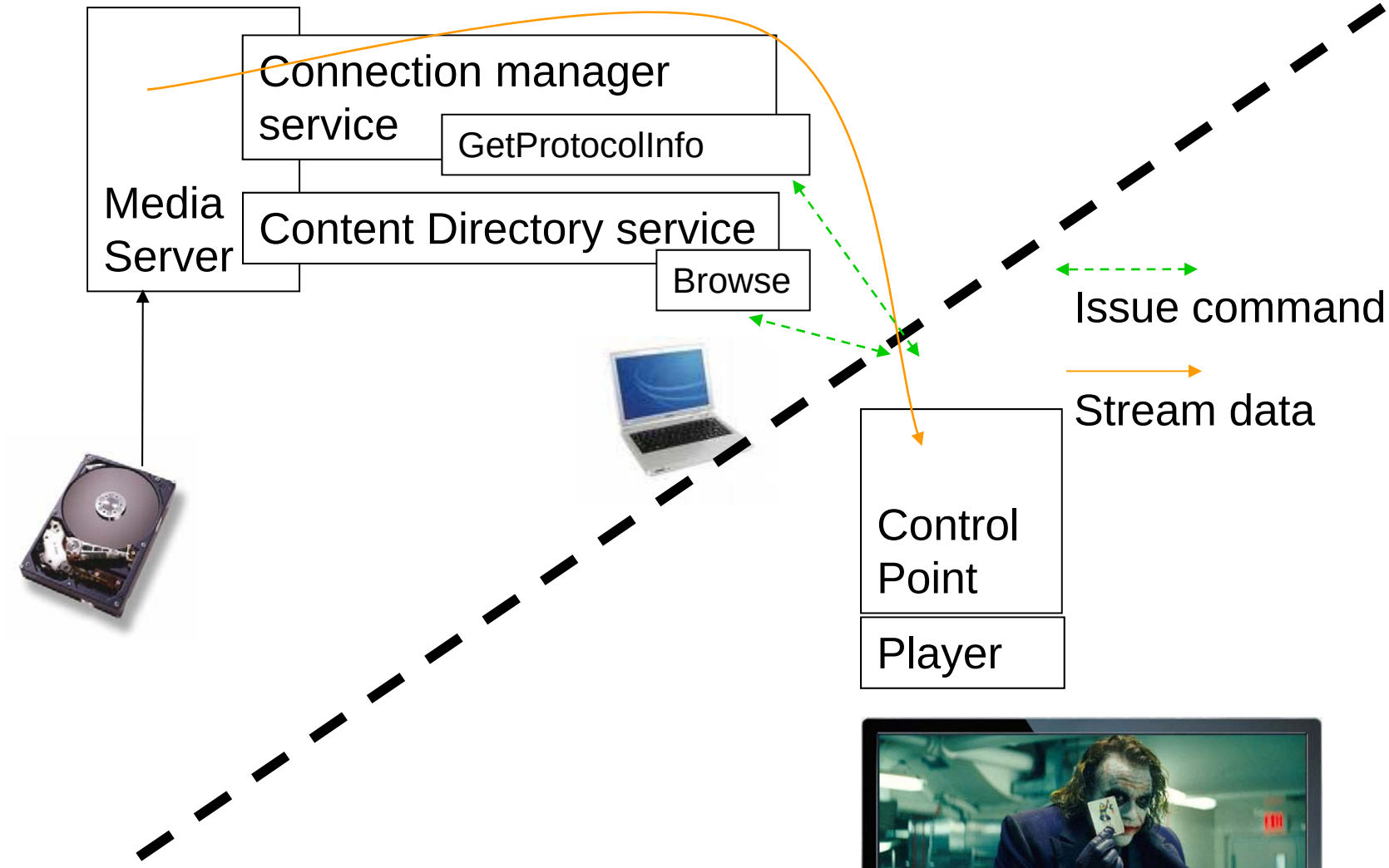
Important functions:

- Browse command
- Search command

These API functions will return a list of objects defined by the hierarchy of the server, the list is bound to a subset of a container.

The Media Server (CDS) has no state, except for changes in the CDS hierarchy

2 box model



2-Box Play Scenario (1)

CP

Server

Select Server

Browse

Select Item
Select resource

Http-get “Url”

Play Stream

Media Server

Connection Manager Service	AV Transport Service	Content Directory Service

GetSearchCapabilities:	M	On what meta-data can we search
GetSortCapabilities:	M	On what meta-data can we sort
GetSystemUpdateId:	M	Return current SystemUpdateID for polling for changes in stored content
Browse:	M	Browse tree of meta-data descriptions
Search:	O	Search CDS tree, returns list
more functions…	O	

Functions

Connection Manager Service:1

GetProtocolInfo	R
PrepareForConnection	O
ConnectionComplete	O
GetCurrentConnectionIDs	R
GetCurrentConnectionInfo	R

Possible formats

Connection information

Only Interested in GetProtocolInfo, because it provides Information about what the media renderer can play or media server can provide

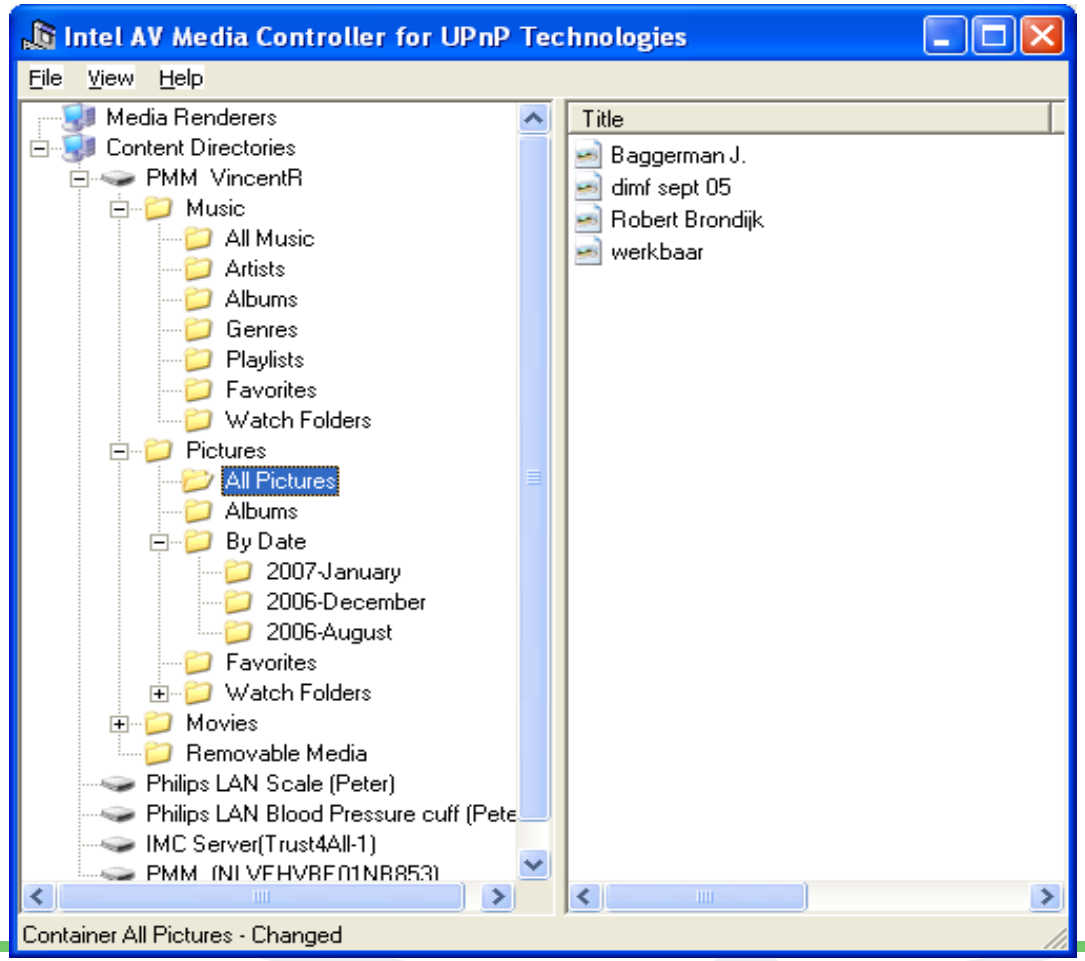
Based on the protocolInfo definition:
<Transport:*:Mime:AdditionalFlags>

Content Directory Service:1

• GetSearchCapabilities	R	Capabilities
• GetSortCapablities	R	
• GetSortExtensionCapabilities	O	
• GetFeatureList	R	
• GetSystemUpdateID	R	
• Browse	R	Tree browsing
• Search	O	
• DestroyObject	O	Data Management
• UpdateObject	O	
• MoveObject	O	
• CreateReference	O	
• CreateObject	O	Importing/Exporting data
• ImportResource	O	
• ExportResource	O	
• DeleteResource	O	
• StopTransferResource	O	
• GetTransferProgress	O	

Objects: Hierarchy

CDS exposes tree of meta data objects



- Hierarchy maintained by @id and parentID
- Hierarchy Starts with Object “0”
- Rest of @id will automatically be retrieved by browse for children
- Objects can be Containers or Items
- Containers can contain Containers or Items

Objects: properties

Have required properties:

- @id

  Unique object identification in the hierarchy
- @parentID

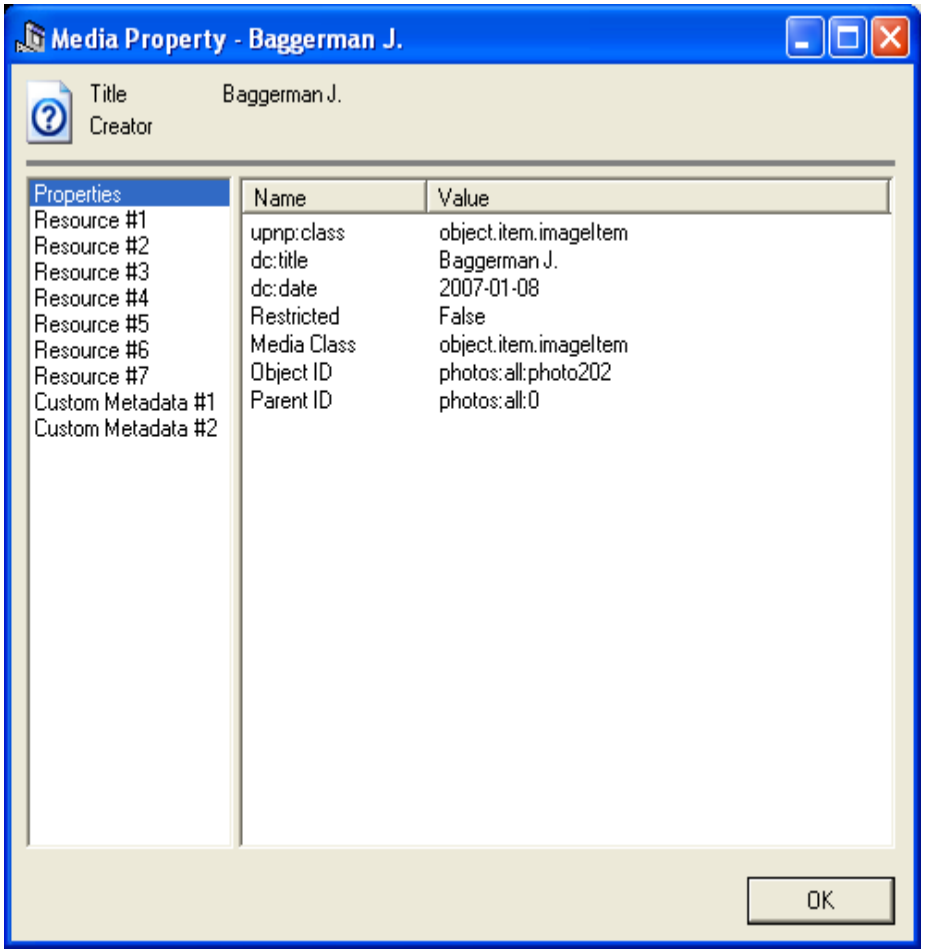
  The objectID of the container above
- dc:title

  The title to present to the user
- upnp:class

  Definition of what kind of object it is

  (Example: videoItem, albumContainer)

- Many more properties according the class specification



Container object classes

object.container, the generic container object

Can be extended with more specific definitions:

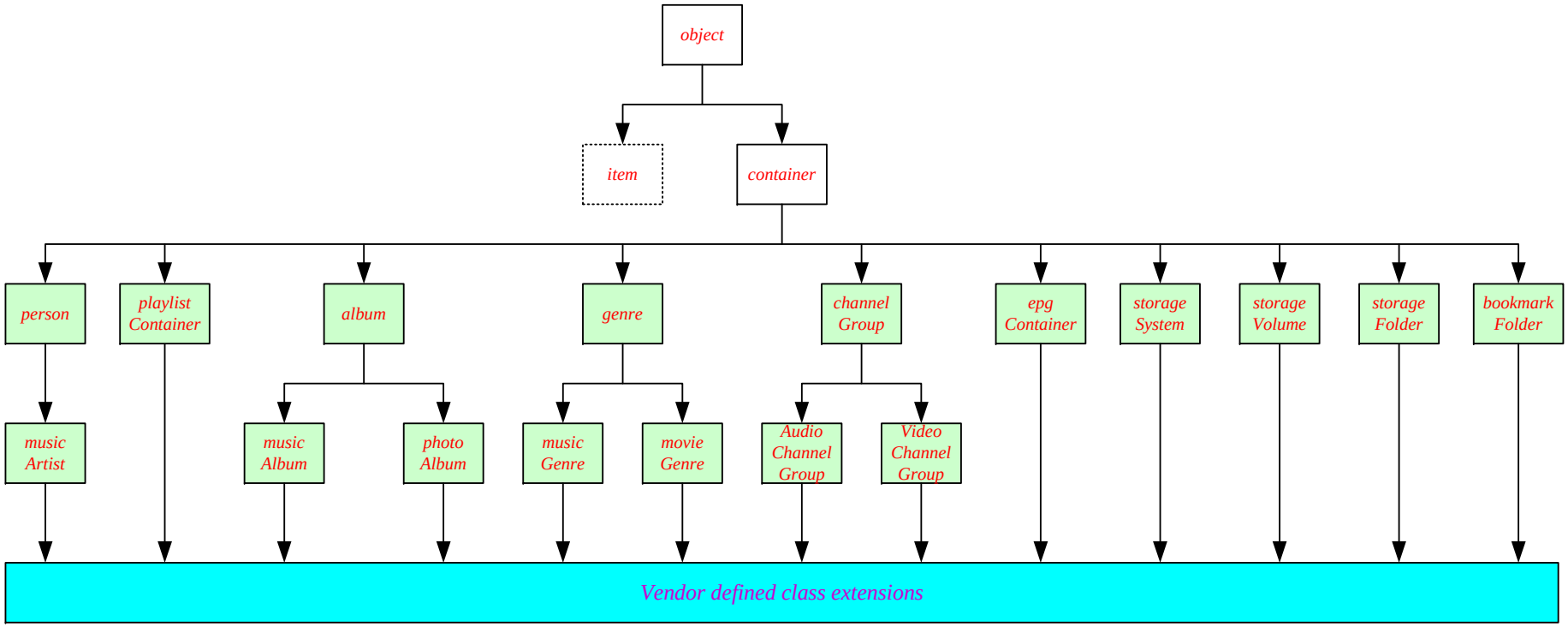
- object.container.album.musicAlbum: contains an audio collection
- object.container.album.imageAlbum: contains an image collection
- object.container.channelGroup.videoChannelGroup: containing video broadcast items
- object.container.epgContainer: containing EPG items

A more precise definition restricts the content in a container

Example:

```
<container id="4" parentID="1" childCount="3" restricted="false">
        <dc:title>Brand New Day</dc:title>
        <upnp:class>object.container.album.musicAlbum</upnp:class>
</container>
```

Class tree containers



Item object classes

- *object.item* is the generic item
- Items have a defined set of meta data properties
- The items can have resources, a reference to an URL to be played
- Dependent on the class definition the item should have:
  - 0 or more resources
  - set of metadata properties

Example:

```
<item id="8" parentID="3" restricted="false">
        <dc:title>Drown</dc:title>
        <dc:artist>Smashing Pumpkins</dc:artist>
        <upnp:class>object.item.audioItem.musicTrack</upnp:class>
  </item>
```

Item: Resources

Items can contain resource descriptions

- A Resource contains the URL and attributes to define a “file” which can be retrieved for playback
- Items can have zero or more resources, designating to the same content, but in different (content) formats, sizes, transport protocols, etc
- Protocol info:

<Transport:*:Mime:DLNAFlags>

```
<item id="24_0" parentID="0/IROOT/IALL" restricted="1">
  <dc:title>109-0974B_IMG</dc:title>
  <upnp:class>object.item.imageItem</upnp:class>
  <dc:date>2004-02-21T16:41:13</dc:date>
  <res protocolInfo="http-get:*:image/jpeg:*" size="888322" resolution="1600x1200"
  colorDepth="24">http://130.145.203.202:49153/content/C:/wouter/content/mixed/109-
  0974B_IMG.jpg</res>
 <res protocolInfo="http-get:*:image/jpeg*" size=“48322" resolution=“320x240"
  colorDepth="24">http://130.145.203.202:49153/content/C:/wouter/content/mixed/109-
  0974B_IMG_TN.jpg</res>
</item>
```

Example of a music object

Properties for object.item.audioItem

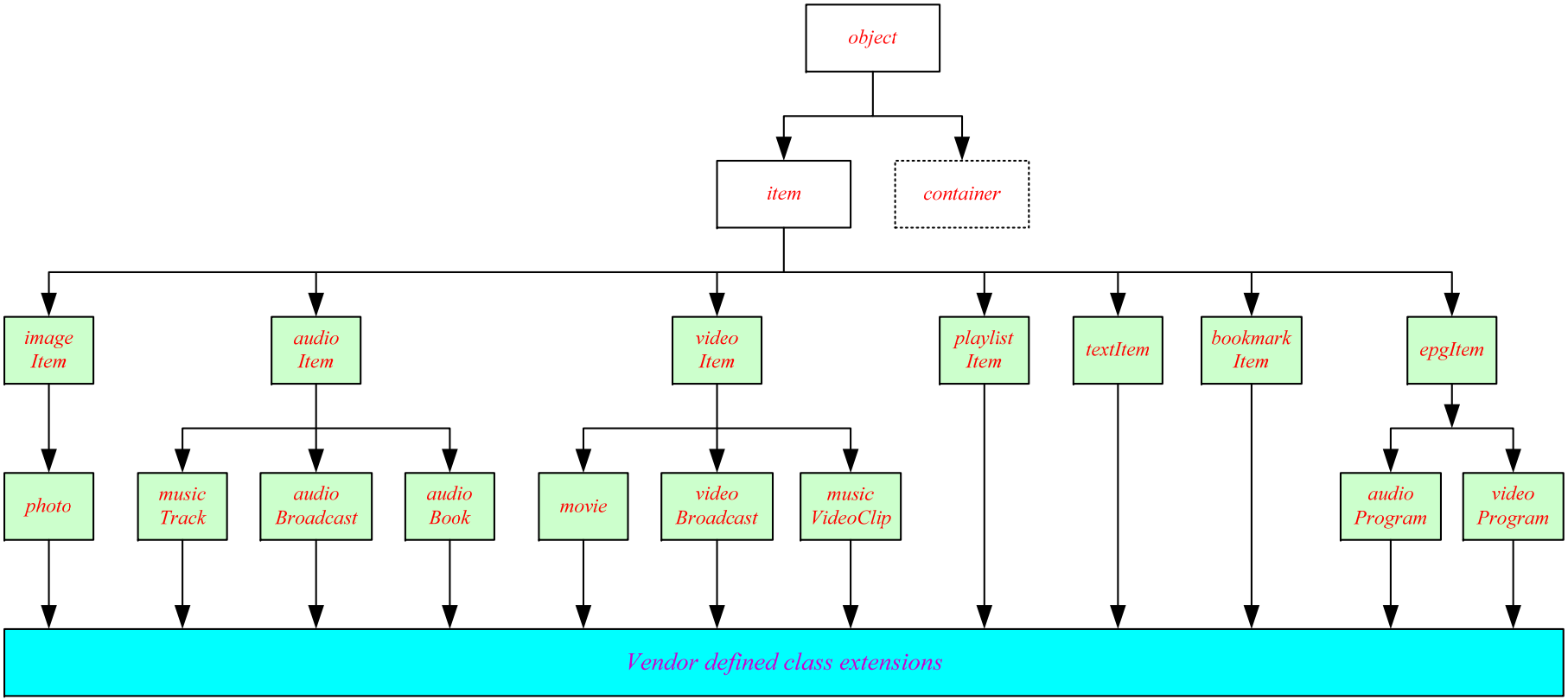
- upnp:genre
- dc:description
- dc:longDescription
- dc:publisher
- dc:language
- dc:relation
- dc:rights
- At least one resource element

Extra Properties for object.item.audioItem.musicTrack

- upnp:artist
- upnp:album
- upnp:originalTrackNumber
- upnp.playlist
- upnp:storageMedium
- dc:contributor
- dc:date

DLNA has also a list of properties per class definition

Class tree for items



Getting content from the server

Using

- Browse
  - Normal traversal over the predefined hierarchy
- Search
  - Searching for item in the hierarchy

Browse Command

Browse(ObjectID, BrowseFlag, Filter,StartingIndex, RequestedCount, SortCriteria, Result, NumberReturned, TotalMatches, UpdateID)

- ObjectID: @id: the identification in the tree
- BrowseFlag: browse the current object (for metadata) or the descendants
- Filter: Filtering of the parameters in the result
- StartIndex: Limiting output: start giving the result back from StartIndex
- RequestedCount: Limiting output: amount of objects in the result
- SortCriteria: the sorting order of the items in the Result
- Result: the list of objects returned
- NumberReturned: the amount of objects in the list
- TotalMaches: the amount of items in the container
- UpdateID: the current updateID of the CDS

Search Command

Search(ContainerID, SearchCriteria, Filter,StartingIndex, RequestedCount, SortCriteria, Result, NumberReturned, TotalMatches, UpdateID)

- ContainerID: @id: the container to search from
- SearchCriteria: browse the current object (for metadata) or the descendants
- Filter: Filtering of the parameters in the result
- StartIndex: Limiting output, start giving the result back from StartIndex
- RequestedCount: Limiting output, amount of objects in the result
- SortCriteria: the sorting order of the items in the Result
- Result: the list of objects returned
- NumberReturned: the amount of objects in the returned list
- TotalMaches: the total amount of items specified by the searchCriteria
- UpdateID: current updateID of the CDS

Media Renderer

- Contains the AV Transport Service (AVT)

  Is being used for player control functionality
  - Setting an URL for playback: SetAVTransportURI(URL,Item)
  - Play(speed),Stop,Pause, Next, Previous
  - Trickmodes are done by issuing play speeds with the Play command
    - Should be implemented on client, but can make use of server side impl.
- Contains the Connection Manager Service (CMS)

  Informs control points of the capabilities of the media renderer
  - Codec support
  - Transport protocol support

  GetProtocolInfo(Source,Sink)
- Rendering Control Service (RCS)
  - Control of how the playback is renderered

    Presets,Audio and Video settings

Media Renderer

Connection Manager Service	Rendering Control	AV Transport Service

SetAVTransportURI	M	Tell the renderer from where a stream should be obtained
Play:	M	Start Playing the URI
Stop:	M	Stop Playing URI
Previous:	M	Play previous URI
Next:	M	Play Next URI
SetNextAVTransportURI: plenty more optional functions	O	Set next URI already

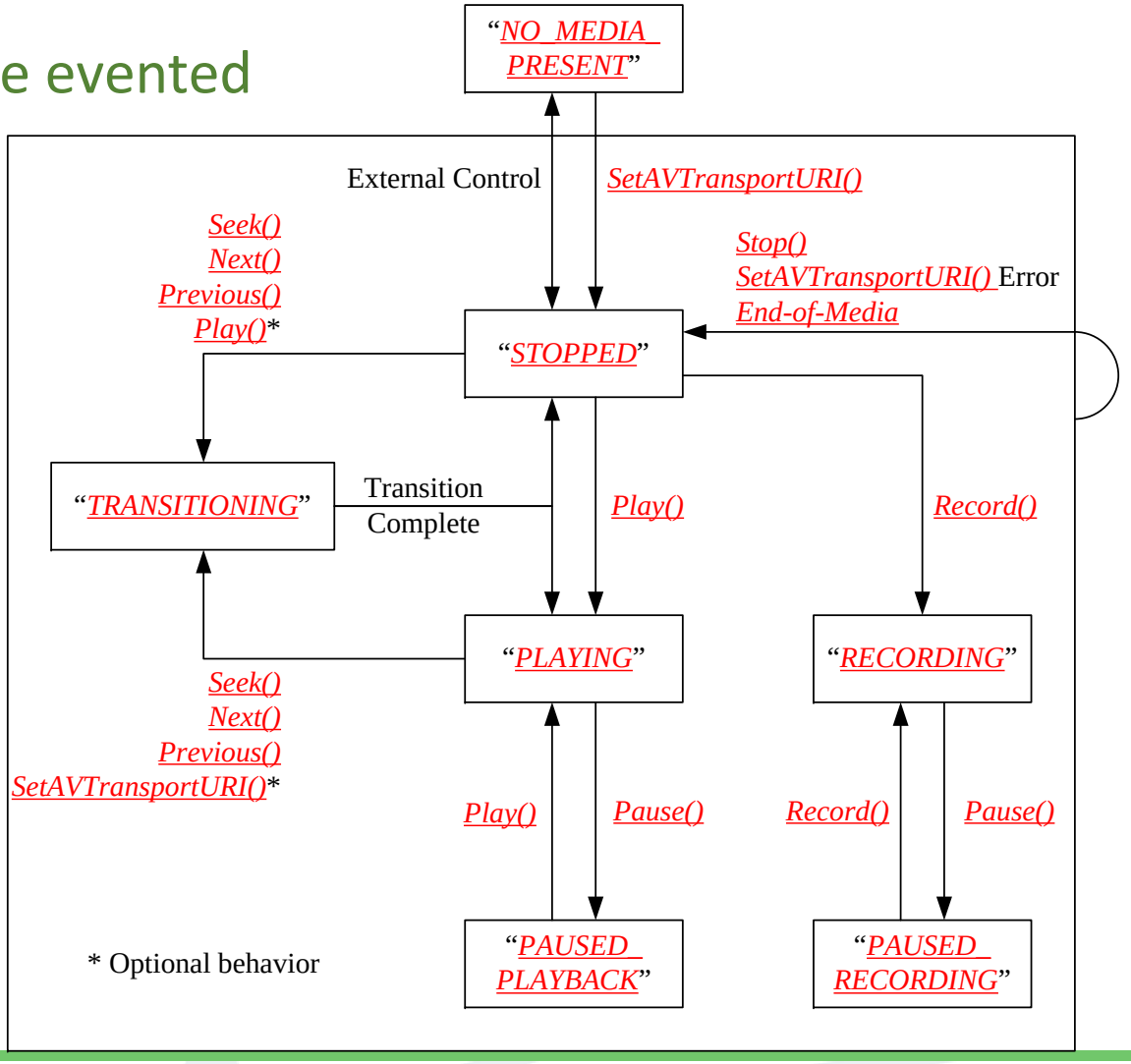
Semantics

AV Transport Service:1

SetAVTransport	R	Media Controls
Play	R	
Stop	R	
Pause	O	
Next	R	
Previous	R	
Seek	R	
SetNextAVTransportURI	O	
SetPlayMode	O	
Record	O	
GetMediaInfo	R	Reporting Capabilities on current play
GetMediaInfo_Ext	R	
GetTransportInfo	R	
GetPositionInfo	R	
GetTransportSettings	R	Reporting Capabilities for next play
GetCurrentTransportActions	O	
GetDeviceCapabilities	R	
SetRecordQualityMode	O	
GetDRMState	O	
GetStateVariables	O	
SetStateVariables	O	

AVT has State

State changes will be evented



Media Renderer

Connection Manager Service	Rendering Control	AV Transport Service

ListPresets	M	List presets that the device supports
SetPresets	M	Set a preset
Get/Set VideoOptions	O	set a video playback option
Get/Set AudioOptions	O	set an audio playback option

Semantics

Rendering Control Service:1

• ListPresets	R	Presets
• SelectPreset	R	
• Get/Set		
• Brigthness	O	Video playback options
• Contrast	O	
• Sharpness	O	
• VideoGains(blue,red,green)	O	
• Blacklevel(blue,red,green)	O	
• ColorTemperature	O	
• Mute	O	
• Volume	O	Audio playback options
• VolumeDB	O	
• Loudness	O	
• StateVariables	O	

Use Get/Set actions only when you are controlling the output device….
•Video options should be implemented on a device with a screen
•Audio options should be implemented on a device with a Amplifier

3 Box Model Play

Server

DMS

Play

Client

DMR

Browse

User finds nice content

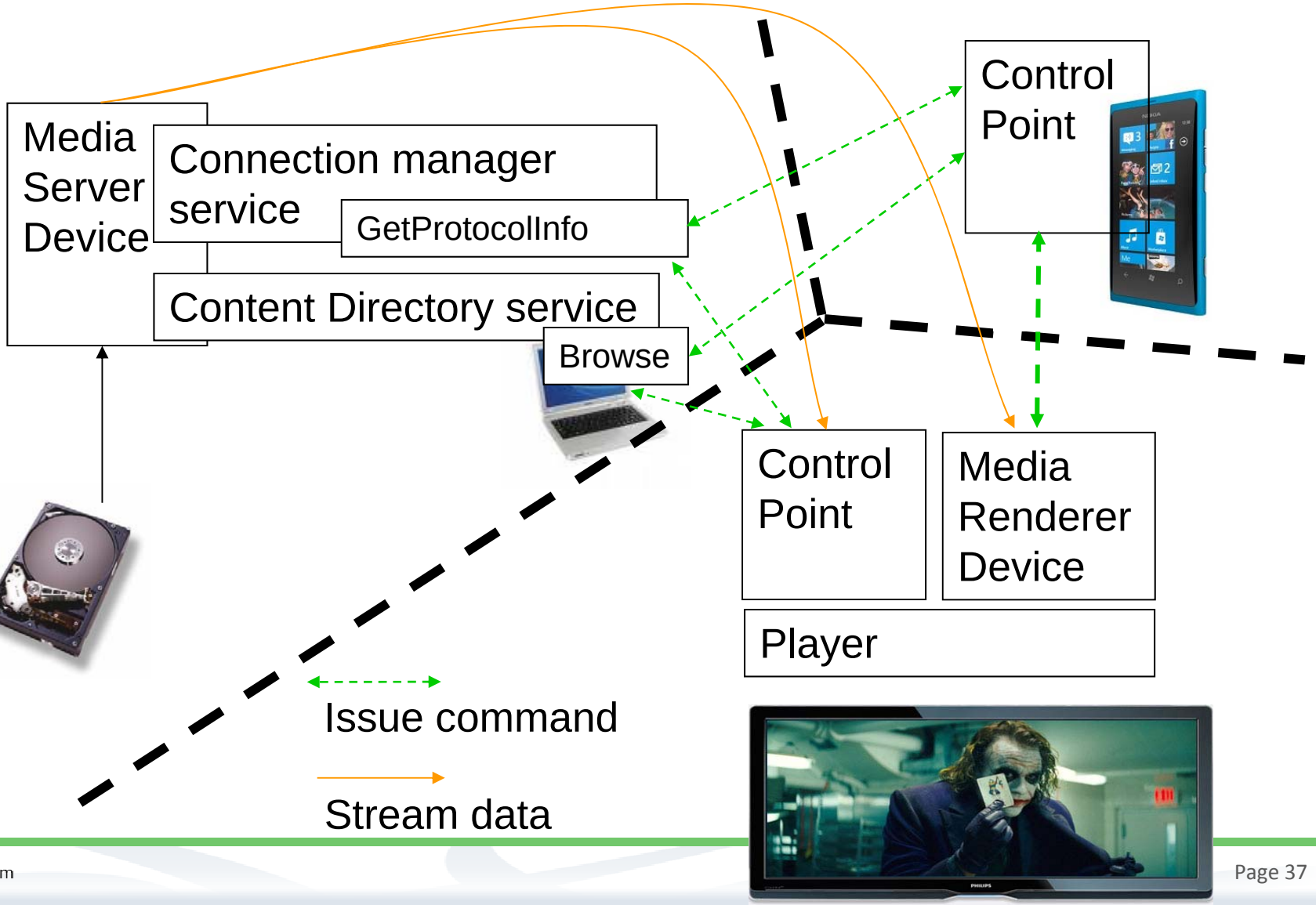
URL

Instruct Client to start playing URL

Client

Control Point

2-3 box interactions



AV versioning

- Currently 4 sets of AV specifications exist.
- Each new version is fully backward compatible with a previous version
  - No changes, only additions and clarifications are made
- 5th version in progress

version	Service	Addition
AV2	SRS	Scheduled Recording Service
AV3	CDS	Tracking Changes Option
		Foreign Meta data
		FreeFormQuery (XML based Search)
AV4	CDS	Richer Content Description (ResExt)
		Enriched Content Navigation (Content Segmentation)
		Content Privacy (depends on DeviceProtection)
		Resource management (depends on DeviceProtection)
		Exclusive ownership
		Time Shift Support (of recordings)
	RCS	Renderer Side Content Transforms
	AVT	Playback Synchronization (precision timed)
		Enhanced Playback Support
	CMS	Renderer Content Matching (with DRM)

UPnP AV - summary

UPnP Audio Video Architecture defines:

- Media Servers; that are discoverable on the network, and expose multi-media content by providing meta-data about the content.
- Media Renderers; that are discoverable on the network, and expose API to play content.
- Control Points which can be used to find other devices, send commands. For example, browsing the content hierarchy of a media server for selecting a song for playback.

DLNA

DLNA

- DLNA: builds on UPnP to specify the interoperability of devices that share Images, Audio, and AV content on the home network.
- Refers to other existing specifications
- Focuses on system usages (use cases)

System Usages Overview

- 2-Box Pull System Usage
- 2-Box Push System Usage
- 3-Box System Usage
- 2-Box Printing System Usage
- 3-Box Printing System Usage
- Download System Usage
- Upload System Usage
- Download Synchronization System Usage
- Upload synchronization System Usage
- 2-Box RUI Pull System Usage
- 3-Box RUI System Usage
- Recording and EGP System Usage

DLNA: Interoperability at All Layers

Narrowing the plethora of standards to a mandatory small set

Link Protection	DTCP-IP	How commercial content is protected on the Home Network
Media Formats	MPEG2, AVC/H.264, LPCM, MP3, AAC LC, JPEG, XHTML-Print + optional formats	How media content is encoded and identified for interoperability
Media Transport	HTTP Quality of Service	How media content is transferred
Media Management	UPnP AV 1.0 UPnP Print Enhanced 1.0	How media content is identified, managed, and distributed
Discovery & Control	UPnP Device Architecture 1.0	How devices discover and control each other
IP Networking	IPv4 Protocol Suite	How wired and wireless devices physically connect and communicate
Connectivity	Wired: Ethernet 802.3, MoCA Wireless: Wi-Fi 802.11, Wi-Fi Protected Setup	

Technical Additions on top of UPnP

- DLNA signaling in Device description
- DLNA protocolInfo extensions
- DLNA defined actions
- DLNA defined state variable values

DLNA signaling in Device description

- Extra signaling in the device description that UPnP devices has an Supported DLNA profile:
  <dlna:X_DLNADOC xmlns:dlna="urn:schemas-dlna-org:device-1-0">DMS-1.50</dlna:X_DLNADOC>

- Extra signaling in the device description that UPnP devices has an Supported features:
  <dlna:X_DLNACAP xmlns:dlna="urn:schemas-dlna-org:device-1-0">av-upload,image-upload,audio-upload</dlna:X_DLNACAP></device>
  having the upload capabilities signaled means that you have to accept HTTP-POST as upload commands.

DLNA protocolInfo extensions

Extra DLNA information in the protocolInfo 4th field

- More specific mimetype definition: DLNA.ORG_PN
  - More than 100 definitions already defined
  - Most important: Split up of Mpeg Transport and Program stream
- Extra transport settings: DLNA.ORG_OP
  - Time range capable
  - Byte range capable
- Server side trick modes: DLNA.ORG_PS=1,2
  - Play speed normal, double, done on the SERVER side
    The player plays back at normal speed…
- FLAGS
  - Binary transport settings flags

- Example
  “http-get:*:video/mpeg:DLNA.ORG_PN=MPEG_PS_PAL_XAC3;DLNA.ORG_OP=01, DLNA.ORG_PS=1,2; DLNA.ORG_FLAGS=03100000000000000000000000000000 ”

DLNA defined actions

Media Server Extensions

- Upload extension:

  CDS:X_GetDLNAUploadProfiles()

  Function to indicate the DLNA media profiles that will be accepted by CDS:CreateObject()

- Synchronization extension:

  CDS:X_GetTakeOutGroupNames()

  Function identifies content tree to be synchronized.

Media Renderer Extensions

- Extensions for Byte Seek

  AVT:X_DLNA_GetBytePositionInfo()

  Function to indicate the current byte position in the stream

DLNA defined state variable values

Eventing of possible trick modes supported by a Digital Media Renderer

- AVT.CurrentTransportActions state variable:
  - X_DLNA_PS
  - X_DLNA_SeekTime

Signaling DLNA specific seek instructions

- AVT.Seek input arguments:
  - X_DLNA_REL_BYTE
  - X_DLNA_SeekTime
  - X_DLNA_SeekByte

For the interconnected lifestyle