Next Generation Session Announcements:

Internet Media Guides (IMGs)

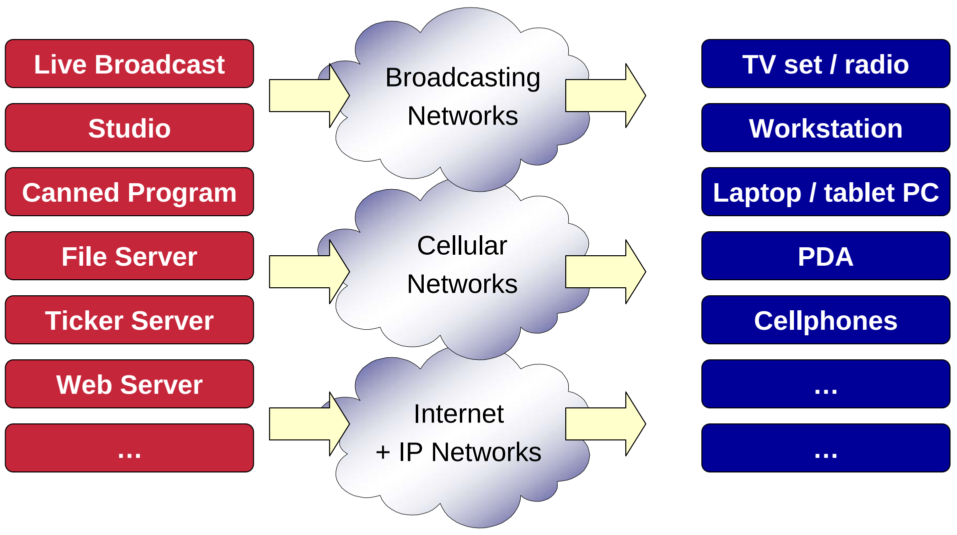
Observations

- SAP/SDP tied to IP-Multicast-based session model
- Only one distribution scheme: announcement
- Only one type of service: convey multimedia session information

- (Global) IP-Multicast has not prevailed as a distribution platform
- SAP rather experimental
- Was often used for debugging Mbone connectivity

- Summary
  - SAP/SDP too limited
  - Not appropriate as a general solution for distributing session information
  - Traditionally linked to IP-only (and Multicast-only)

Background: Ubiquitous Information Access



“Classic” Broadcasting & Internet Multimedia

- Broadcasting has been a different world
  (including customer expectations, philosophy)
  - Encodings
    - Audio/Video largely compatible (but different quality expectations)
    - Image/text formats/HTML vs. Videotex, MHP, specific markups, tables
  - Data transmission
    - IP + UDP/TCP + RTP/… vs. MPEG multiplex (or even analog)
  - Addressing
    - IP addresses + ports vs. frequency/channel, PID, satellite position, pol., …
  - Interaction & control
    - RTSP, HTTP, SIP, … vs. MHP
- But there is a migration towards IP in various areas
  - Content providers, transmission technologies, consumer equipment

Platform/Network-Independent Content Provision

- The same content shall be available via different networks
  - Preferably without repeated authoring
- "Content" used in a broad sense
  - Original media: Audio / video broadcasts, web pages, files, news feeds, …
  - Supplementary information: background, statistics, subtitles, ads, …
- Content needs to be globally (or regionally) identifiable
- Content needs to be found
  - Descriptive metadata
  - Availability (scheduling) metadata
- Alternate access methods must be possible
  - Network + network-specific address

Internet Media Guides (IMG)

Definition of an IMG (from MMUSIC Charter)

Content:

- A **collection of multimedia session descriptions**
- Expressed using SDP, SDPng or other metadata formats
- It is used to describe a collection of multimedia sessions (e.g. television programme schedules).

Distribution:

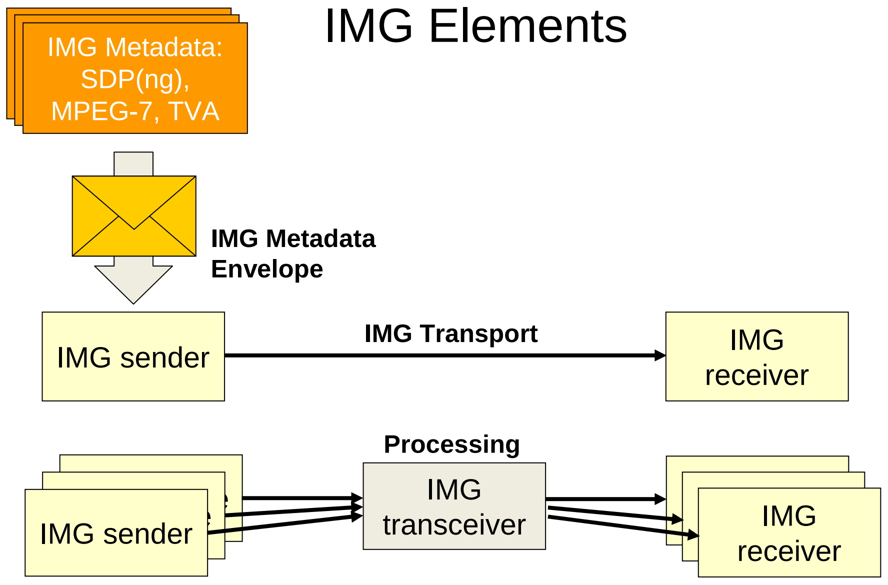
- The IMG must be **delivered to a potentially large audience (push or pull)**, who use it to join a subset of the sessions described, and who may need to be **notified of changes** to the IMG.

IMG ≈ EPG

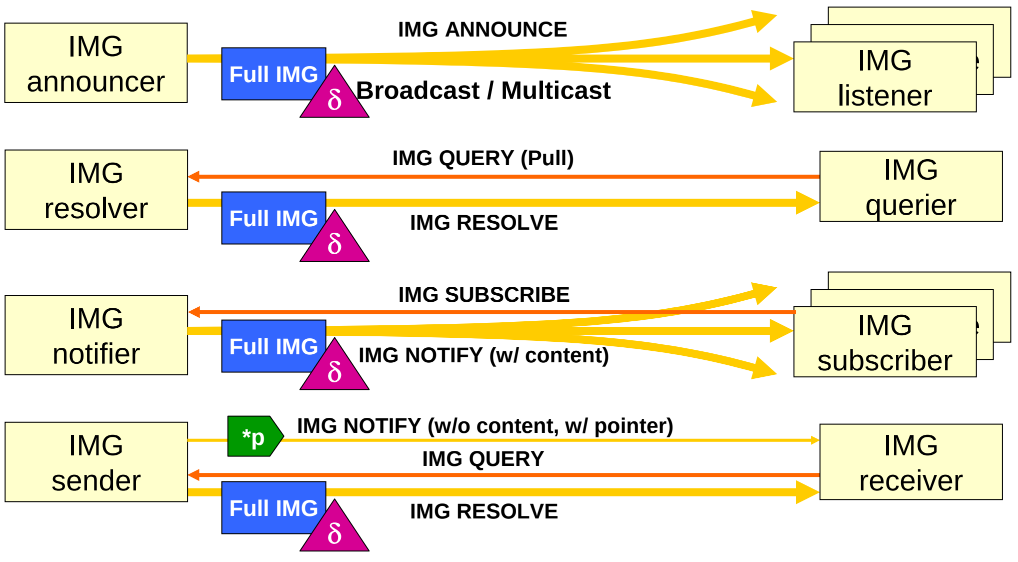
- Generalized for arbitrary...
  - Types of media
  - Types of sessions and interactions: services!
  - Classes of devices
- Plurality of access methods
  - Physical delivery
  - (Reliable) Broadcast / multicast (push)
  - Interactive retrieval (pull)
  - Provision of full IMGs and of deltas
  - Notification about changes
- Network-independent
  - For the delivery of IMGs
  - For the (request and) transmission of actual media in sessions

The same IMGs should be usable everywhere.

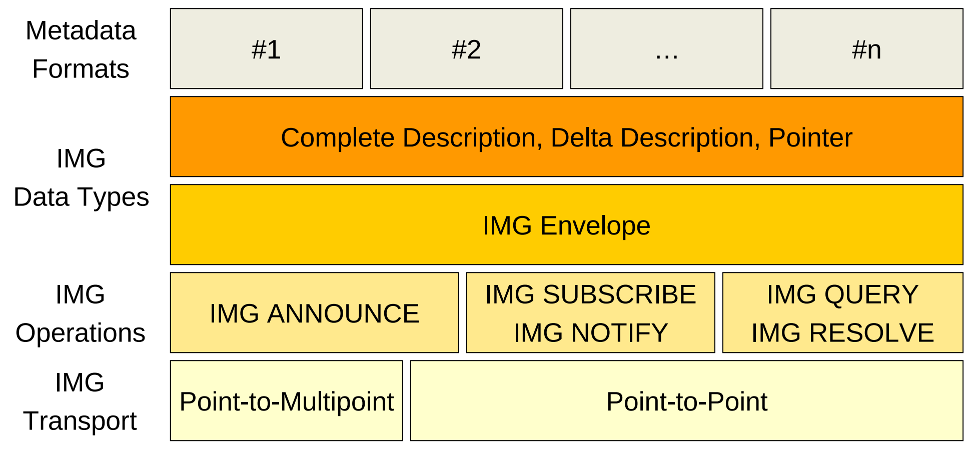
IMG Elements



IMG Delivery Models / Operations



IMG Architecture



IMG Envelope: Security Requirements

- Authentication + Integrity validation of contained metadata
  - Must work for complete and delta information
  - Must work across IMG transceivers
    - Aggregation, splitting, filtering of pieces of metadata
- Privacy
  - Must be able to protect (parts of) contained metadata
    - User protection + access control
  - Enable (limited) IMG transceiver functionality
- Interdependency with metadata formats
  - What to expect from metadata?
  - Granularity of embedded metadata objects
  - DRM? ➔ metadata formats

IMG Envelope

- Container for metadata
  - Complete, delta, pointers
  - Independent of metadata
  - Likely to become some kind of wrapper mechanism
  - Metadata itself defined by other bodies
- Generic management information
  - Identification + version + validity information
  - Content-Type: to identify metadata format
  - Support for security?
    - authentication + integrity information
    - Privacy of content

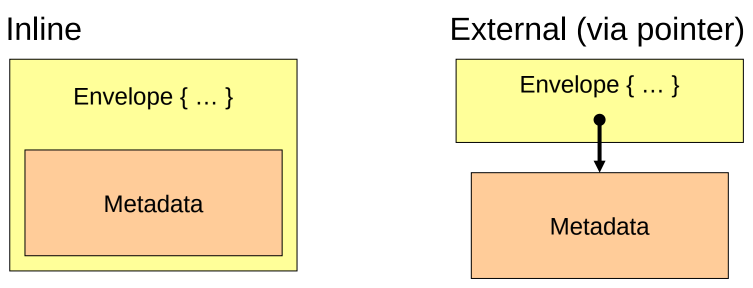
MIME vs. XML

Envelope Features (1)

- Container for metadata (independent of these)
  - Complete, delta, pointers
  - Metadata itself defined by other bodies
- Version number
  - Determine the most recent (i.e., valid) copy
  - Referenced as basis for delta encoding
- Validity time
  - Period: from, to
- Metadata URI
  - Identifies the metadata element contained in the envelope
  - Helps to deal with fragments
- Content-Type
  - Defines the type of metadata contents

Envelope Features (2)

- Support for digital signatures (on parts of the envelope)
- Support for encryption
  - Only partly specified so far
  - May use S/MIME
- Metadata contents:



Envelope Encoding: XML vs. MIME

- **Present focus: XML (also used by 3GPP MBMS)**
- **Example (with SDP as metadata)**

```
<?xml version="1.0" encoding="UTF-8"?>
       <metadataEnvelope
         xmlns:xsi="http://www.w3.org/2001/XMLSchema-instance"
         xsi:noNamespaceSchemaLocation="envelope.xsd"
         metadataURI="http/www.example.com/img001/session001.sdp"
         version="1"
         validFrom="2003-12-17T09:30:47-05:00"
         validUntil="2003-12-17T09:30:47-05:00"
         contentType="application/sdp">
         <metadataFragment>
           v=0
           o=jo 2890844526 2890842807 IN IP4 10.33.57.27
           s=SDP Seminar
           c=IN IP4 224.2.17.12/127
           t=2873397496 2873404696
           a=recvonly
           m=audio 49170 RTP/AVP 0
           m=video 51372 RTP/AVP 31
         </metadataFragment>
       </metadataEnvelope>
```

IMG Metadata

- Past focus on traditional contents
  - Conveying plain TV-schedules
  - Streaming in 3GPP Release 6
- Broadening the scope
  - Cover services in a more general fashion
  - Provide region/location information
  - Support personalized inquiries
  - Address issues of cost
    - Make offers automatically comparable
- Technical level: enable service discovery (and location)
- Business level: support adequate service selection

IMG URN

- IMGs need to be identified globally
  - In particular, across different networks and providers
- Motivates the use of IMG URNs
- Format

  urn:img: ProviderId : DateId : IMGResourceId [: FragmentId]
  - ProviderId: domain name
  - DateId: Point in time when the domain name was owned by the entity
  - IMGResourceId: provider-selected string
  - FragmentId: some identifier for a piece of an IMG
- Examples
  - urn:img:example.org:20051021:my-img
  - urn:img:example.org:20051021:my-img:subset
- Mapping to URIs (e.g., HTTP, SIP) to be defined

IMG Transports

- Need to provide mechanisms for IMG Operations
- ANNOUNCE
  - Reliable multicast transport protocol: FLUTE + MUPPET
- SUBSCRIBE / NOTIFY
  - Session Initiation Protocol (SIP): Extensions for Subscription/Notification
- QUERY / RESOLVE
  - HTTP
- Identify IMGs properly across protocols: IMG URN (yet tbd.)
  - Mappings to individual protocols for actual processing

IMG ANNOUNCE: Reliable Multicast

- Layered Coding Transport (LCT)
  - Single sender multicast transport
  - Defines single or multi-object delivery across an LCT session
    - Provides identifiers for objects (TOI)
    - Provides session identification (TSI)
  - LCT session comprises a group of channels
    - Each identified by the respective (multicast) transport address
- Forward Error Correction (FEC)
  - General container for various FEC schemes
  - Alows to identify payload + provides in-band signaling of FEC parameters
- Asynchronous Layered Coding (ALC)
  - Simple combination of LCT and FEC

IMG ANNOUNCE: FLUTE Basics

- File Delivery over Unidirectional Transport
- Uses ALC (= LCT + FEC)
  - Fixed parameter sets for the protocol instantiation
- Specifies semantics of objects
  - Files
  - File Delivery Table (FDT)
- FDT
  - XML-based format to carry file attributes (name, location, size, etc.)
    - Carried as Transport Object ID = 0
  - Transmitted in a carrousel style together with files

IMG ANNOUNCE: FLUTE FDT

- XML-based structured information
- Example

```
<FDT-Payload Expires="<date>" complete="true">
    <File
                Content-Location=
                TOI=
                Content-Length=
                Transfer-Length=
                Content-Type=
                Content-Encoding=
                Content-MD5=
                ... plus some FEC stuff ... >
    <File ...>
    ...
</FDT-Payload>
```

IMG ANNOUNCE: MUPPET

- Specific usage of FLUTE for carrying IMG envelopes
- Defines various lower layer parameters
- Defines usage of multiple layers

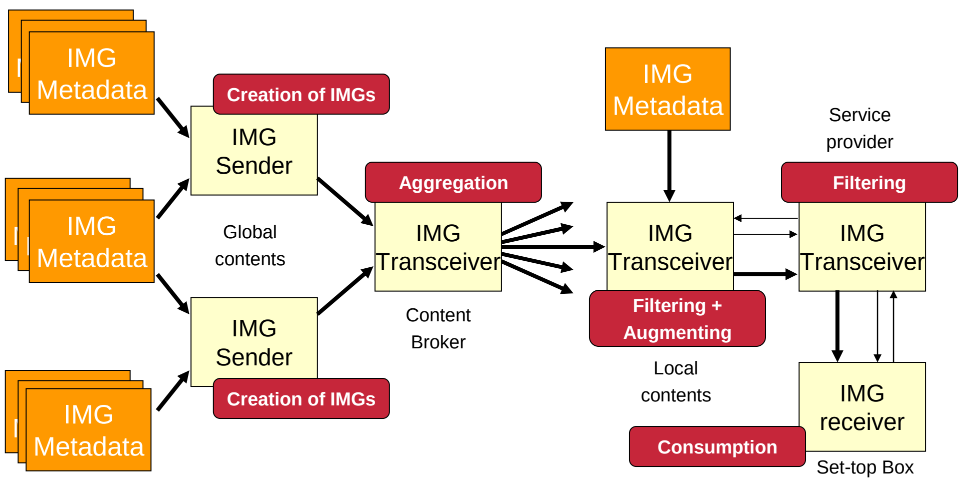
IMG QUERY / RESOLVE

- “Naturally” maps to HTTP GET + 200 OK
- HTTP URI: http://<hostname>/<resource>?param1&param2&...
  - Parameters identify IMG version
    - type: full or delta IMG, pointer
    - version requested
    - diffVersion: base for delta IMG
- Querier response format selection
  - Accept: application/img-envelope+xml
    - Provide IMG in envelope format
  - Accept: text/plain, text/html
    - Provide a human-readable description of an IMG as optional fallback
  - Allow for directly returning the plain metadata without envelope?
- 200 OK carries response in body
- HTTP headers used accordingly

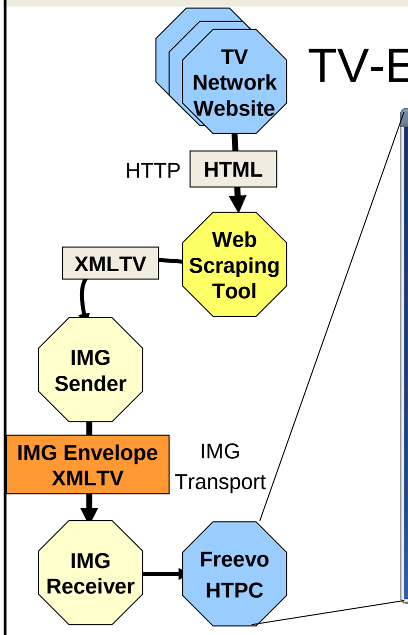
IMG SUBSCRIBE / NOTIFY

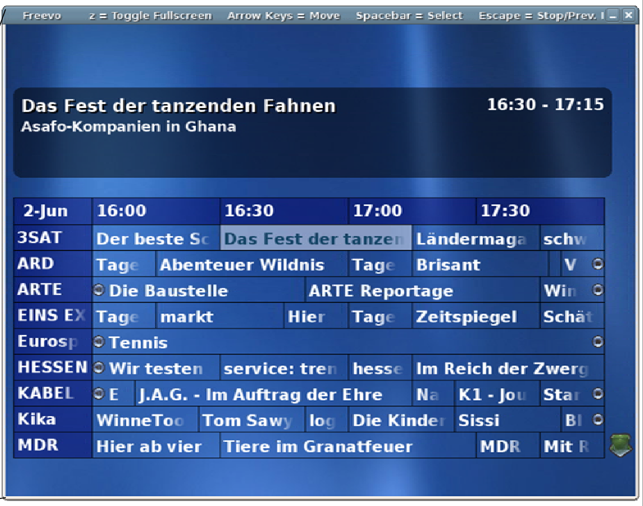
- Based upon the Session Initiation Protocol (SIP)
  - Particularly its SUBSCRIBE / NOTIFY mechanism
  - Details to be discussed
- SUBSCRIBE / NOTIFY
  - Register interest in (part of) an IMG
  - Receive an immediate response and updates upon changes
  - Soft-state based: subscription times out and needs refreshing
- IMG usage of SIP SUBSCRIBE / NOTIFY
  - Define SIP event package: img
  - Presently suggests a MIME-based IMG envelope
    - Natural choice for SIP
  - Content-Type:, Content-Location:
  - Content-ID: major.minor, Expires: valid-until

Regionalization & Personalization with IMGs



TV-EPG Distribution




Freevo z = Toggle Fullscreen Arrow Keys = Move Spacebar = Select Escape = Stop/Prev. I

Das Fest der tanzenden Fahnen 16:30 - 17:15
Asafo-Kompanien in Ghana

2-Jun	16:00	16:30	17:00	17:30	
3SAT	Der beste Sc	Das Fest der tanzen	Ländermaga	schw	
ARD	Tage	Abenteuer Wildnis	Tage	Brisant	V
ARTE	Die Baustelle	ARTE Reportage	Win		
EINS EX	Tage	markt	Hier	Tage	Zeitspiegel	Schät
Eurosp	Tennis				
HESSEN	Wir testen	service: tren	hesse	Im Reich der Zwerg	
KABEL	E	J.A.G. - Im Auftrag der Ehre	Na	K1 - Jou	Star
Kika	WinneToo	Tom Sawy	log	Die Kinder	Sissi	Bl
MDR	Hier ab vier	Tiere im Granatfeuer	MDR	Mit R	

IMGs: “Final” Remarks

- Content formats: various
  - Simple tables in DVB/MPEG (backwards compatibility)
  - XML-based data sets for IMGs
- IMGs in use in 3GPP MBMS
- Stalled in the IETF (further work abandoned)
- TV industry going various other ways
  - Specific EPGs in DVB
  - TV Anytime forum
  - Web/RSS-based program pages of TV magazines and broadcasters
  - Open source platforms use yet other formats
  - XMLTV

Media Streaming in the Internet

- Introduction to Media Streaming
- Real-time Streaming Protocol (RTSP)
- HTTP-based Streaming

Real-time Media Streaming

Retrieving content from a source where

- the content is continuous in nature (e.g. audio, video),
- the content is (potentially) presented to the user before it has been downloaded entirely, and
- there is no human-to-human interaction involved (i.e. latencies are acceptable to a certain degree),
- yet there may be a need for interactive streaming controls (possibly realized in a distributed fashion across sender and receiver)

Contrast: interactive, interpersonal communications

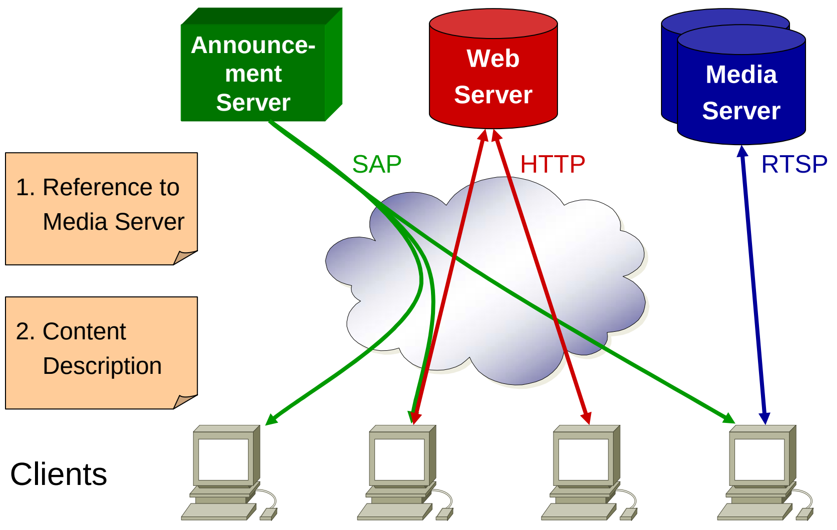
Two Types of Streaming

- Broadcast streaming (non-interactive)
  - Sender transmits media stream according to its own schedule
  - Receivers “tune into a media stream” of interested
  - Receivers have no means to influence the transmission
  - Suitable for multicast / broadcast networks
- Interactive streaming
  - Sender provides media stream to receivers “on demand”
  - Receivers may start / stop transmission
  - Receivers may invoke further operations
    - Fast forward, search, play offset, …
  - Suitable for P2P sessions or coordinated small groups

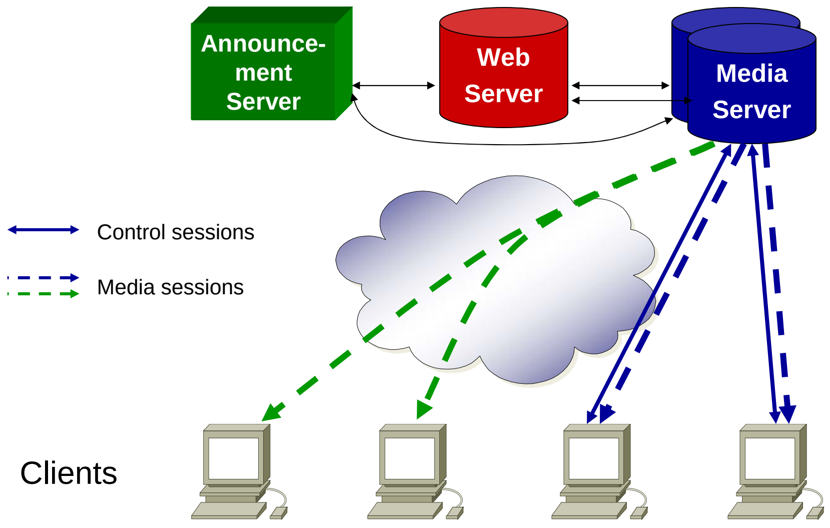
Architectural Components

- Content Description
  - Describe type of content, format, access methods, ...
  - SDP, SDPng, IMGs, MPEG tables, proprietary formats, ...
- Content Description Delivery / Access Protocol
  - Delivers Content Description
  - HTTP, SMTP, NNTP, SAP, proprietary protocols, ...
- Content Access (= Media Streaming) Protocol
  - Initiates, controls, and terminates media streams
  - RTSP, proprietary protocols, ...
- Content Delivery (= Media Transport) Protocol
  - Carries the actual content
  - RTP/RTCP, HTTP, proprietary protocols, ...

Conceptual Overview



Conceptual Overview



Variants of Media Streaming

From a service provider
- Via a broadcast network
  - Broadcasting
  - Advanced multicast-based video-on-demand
- Specific support for the last mile
  - TV-over-DSL (and other Internet access links)
- Video-on-Demand
  - Integrated with the web
  - Using dedicated network links

In a private household
- From a server to one or more home devices

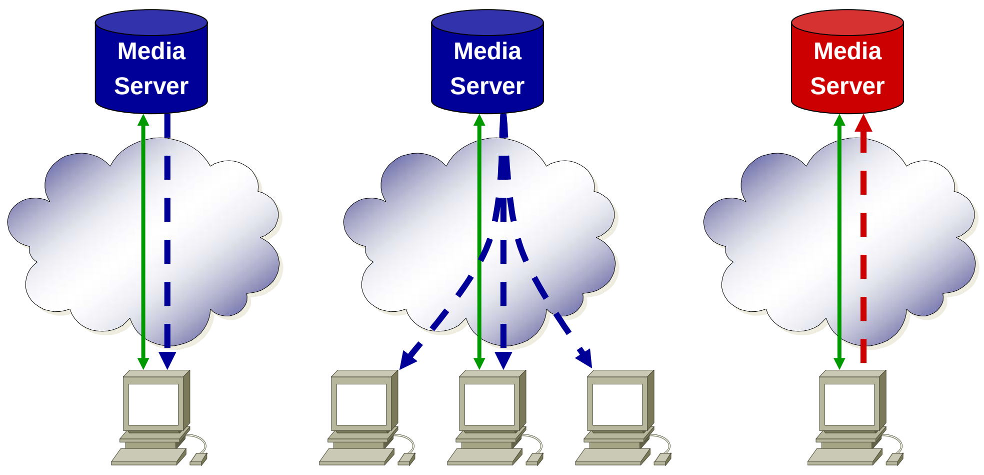
Community-based: Peer-to-peer
- Via the Internet between consumers
- Assisting service providers

Real-Time Streaming Protocol (RTSP)

- RFC 2326 (“buggy”, “underspecified”)
- draft-ietf-mmusic-rfc2326bis-15.txt

- Interactive streaming control in the Internet
  - Media servers provide media streams to users on demand
  - Content described by presentation descriptions
- “Network Remote Control” of a media server
  - PLAY [and RECORD]
  - Numerous options for media control
    - PAUSE, faster / slower playback, selection of ranges from a stream, ...

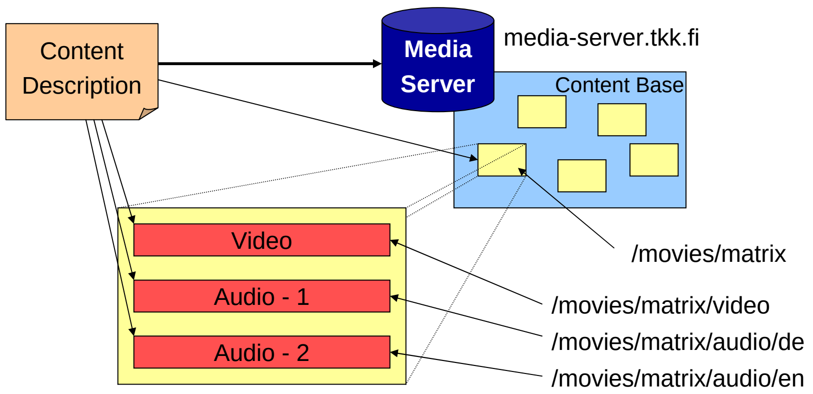
RTSP Scenarios



Protocol Characteristics

- Borrows heavily from HTTP
  - Syntax, quite a bit of semantics, parts of the architecture
- Important differences
  - Servers may issue requests, too!
    - Symmetric communication
  - Servers are stateful
  - Different methods
  - Different headers
    - But many HTTP headers re-used
  - Entities (=request/response bodies) only describe content
  - Content itself (=media) is carried out of band
    - e.g. in RTP; also support for interleaving of media with RTSP connection
- Transport: TCP [or UDP]
  - Reliability handled at the RTSP level

RTSP Components



rtsp://media-server.tkk.fi/movies/matrix/audio/en

RTSP URIs

- Schemes:

rtsp:	reliable, connection-oriented (TCP)
rtspu:	potentially unreliable, connectionless (UDP)
rtsps:	secure, reliable, connection-oriented (TLS)

- General scheme:
  - rtsp:// host / local identifier
- Host
  - Should be DNS name
  - Support for IPv4; IPv6 now being added
- Local Identifier
  - Opaque; may be used for aggregate / non-aggregate control

Time in RTSP

- SMPTE Timestamps
    - SMPTE = Society of Motion Picture Television Engineers
  - Measured in hours, minutes, seconds, frames, fractions (subframes)
    - 29.97 or 25 frames per second (default: 29.97)
  - Human readable HHH:MM:SS:FF.ff 3:47:09:10.25
- Normal Play Time (NPT ≠ NTP)
  - Relative to beginning of stream

In seconds:	SS.fff	10.74
In human readable time:	HHH:MM:SS.fff	3:47:09.314159

- Absolute Time
  - Using ISO 8601 format
  - 20021211T101435.89Z
- (RTP Media Time)
  - Media-specific clock for the RTP timestamp
  - Synchronized with absolute time via RTCP

RTSP Sessions

- Shared state between RTSP client and server
- Establish by SETUP message
- Removed by TEARDOWN
  - Or due to some timeout
- Independent of underlying TCP connections
  - TCP connections may be closed and re-opened during a single RTSP session
- Typically bound to a single presentation
  - in case of SDP, valid for one SDP session (description)
- May contain several RTP sessions
  - e.g. one per media stream

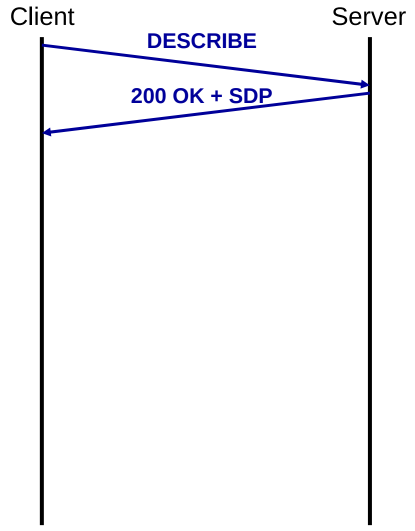
RTSP Request Message

```
SETUP rtsp://ms.tkk.fi/movies/matrix RTSP/1.0
CSeq: 302
Date: 10 Dec 2002 15:35:06 GMT
Session: 47112344
Transport: RTP/AVP;unicast;
   client_port=4588-4589
<CRLF>
[Optional Message Body]
```

RTSP Response Message

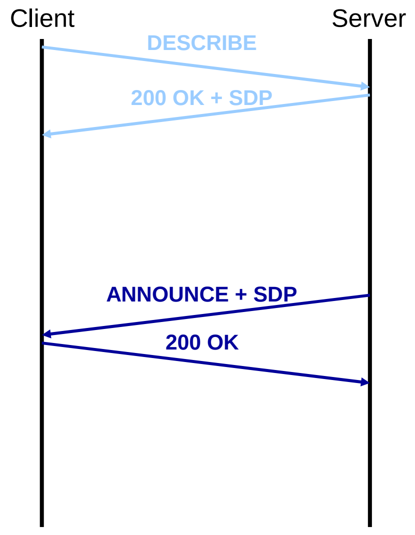
RTSP/1.0 200 OK
CSeq: 302
Date: 10 Dec 2002 15:35:07 GMT
Server: Matrix-Server 0.4.2
Session: 47112344
Transport: RTP/AVP;unicast;
  client_port=4588-4589;server_port=6256-6257
<CRLF>
[Optional Message Body]

RTSP Protocol Operation: DESCRIBE



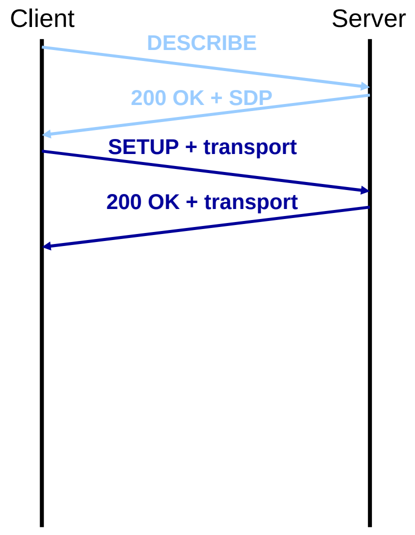
- Obtain presentation description from server
  - e.g. SDP
- Media initialization
  - Contains information about all embbeded media streams
  - Support for aggregate / non-aggregate control
  - Allows a client to determine suitability of content
  - Choose encoding if possible
- Optional: description may be obtained out-of-band

RTSP Protocol Operation: ANNOUNCE



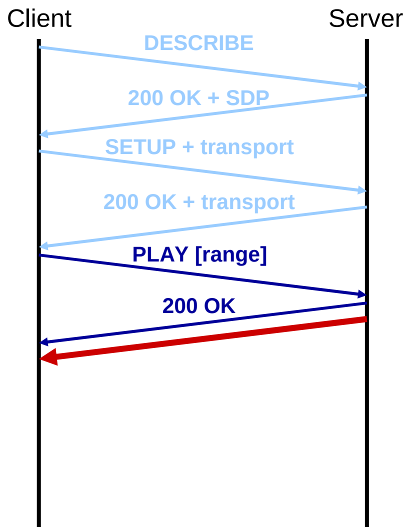
- Updates the presentation description actively from the server
  - e.g. add or remove media streams
- May be issued at any time

RTSP Protocol Operation: SETUP



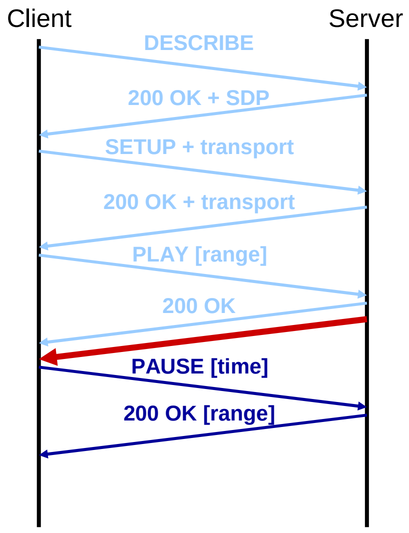
- Initiate an RTSP session
- Reserve resources at the server
  - Server may redirect to other servers (e.g. if busy)
- Convey transport parameters for media sessions
  - Negotiate transport protocol
  - e.g. RTP/UDP vs. tunneling
  - Enable firewalls to open holes

RTSP Protocol Operation: PLAY



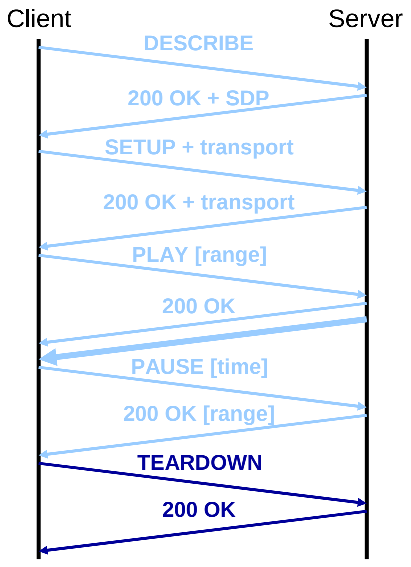
- Start streaming
- Allows to specify a variety of streaming operations
  - Range(s) to play
    - = seek operation
    - E.g. 10-20s; 30-45s; 60s-
  - Forward / backward
  - Speed
    - +3.0
    - - 2.5

RTSP Protocol Operation: PAUSE



- Interrupt streaming
  - But keep resources allocated
- May take effect
  - Immediately or
  - At a specified point in time
- PLAY may be used to resume streaming

RTSP Protocol Operation: TEARDOWN



- Stop streaming
- Terminate RTSP session
  - Free resources
- Takes effect immediately

RTSP Methods

- OPTIONS
- DESCRIBE, ANNOUNCE
- SETUP, TEARDOWN
- PLAY, PAUSE
- REDIRECT
  - May be used by a server to refer a client to a different location
- GET_PARAMETER
  - Retrieve parameter value specified in the header (in the Session: context)
    - Returned in 200 OK response body as “Name: value” pairs
  - May be used for keep-alive purposes
- SET_PARAMETER
  - Set value of parameter(s) per response body (“Name: value” pairs)
- [RECORD]
  - Record a media stream at a server
  - Underspecified, not really suppored, now removed from base spec

RTSP General Header Fields

(For reference only)

- Cache-Control:
- Connection:
- CSeq:
- Date:
- Timestamp:
- Via:

RTSP Request Header Fields

(For reference only)

- Accept:, Accept-Encoding:, Accept-Language:
- Authorization:
- Bandwidth:
- Blocksize:
- From:
- If-Modified-Since:
- Require:, Proxy-Require:, Supported:
- Referer:
- Scale:, Speed:, Range:
- Session:
- Transport:
- User-Agent:

Some Response Status Codes

- 100 Continue
- 200 OK / 201 Created
- 300 Multiple Choices
- 301 Moved Permanently / 302 Moved Temporarily
- 304 Not Modified
- 305 Use Proxy
- 400 Bad Request
- 401 Unauthorized / 407 Proxy Authentication Required
- 403 Forbidden
- 404 Not Found
- 405 Method Not Allowed / 406 Not Acceptable / 408 Request Timeout
- 451 Parameter Not Understood
- 454 Session Not Found
- 455 Method vot valid in this State / 457 Invalid Range
- 461 Unsupported Transport
- 500 Internal Server Error / 501 Not Implemented / 551 Option not Supported

Response Header Fields

(For reference only)

- Accept-Ranges:
- Proxy-Authenticate: / WWW-Authenticate:
- Public:
- Location:
- Range: / Scale: / Speed:
- Retry-After:
- RTP-Info:
- Transport:
- Unsupported:
- Vary:
- Session:

Entities

- Entities contained in RTSP messages are typically presentation descriptions
  - e.g. an SDP message
    (Content-Type: application/sdp)
  - Should always fully specify the media stream(s)
- Header fields:
  - Content-Length:, Content-Type:, Content-Encoding:,
    Content-Base:, Content-Location:, Content-Language:
  - Allow:
  - Last-Modified:, Expires:

Interleaving

- RTSP should use RTP/UDP for media streaming
  - Not always feasible (e.g. firewall, see next slide)
- Interleaving of RTSP and media data
  - Escape binary data (“$”)
  - Define multiple “channels”
  - Specify packet length in binary
  - Yields a four byte header:
    - Interleaved with RTSP messages
    - Starts right after previous message
    - Length used to determine how many bytes to skip / pass

$	**ch**	**length**

RTSP 2.0

- Presently under development (well advanced)
- draft-ietf-mmusic-rfc2326bis-15.txt
- Tons of editorial changes (readability, coherence, …!)
- Better state machine descriptions
- Updated (more coherent) semantics for various header fields
  - Significant alignment with SIP based upon experience gained there
- RECORD disappeared from base spec
  - Was underspecified anyway
- Support for NAT traversal upcoming
  - draft-ietf-mmusic-rtsp-nat-05.txt

Firewall Friendliness

- Several means to support RTSP across firewalls
  - Interleaving support
  - Transport: header indicates port numbers, IP addresses, …
    - Firewall logic does not need to parse SDP format
  - SOCKS support
- Still may be insufficient
  - Firewalls may block RTSP in the first place
  - “Last resort”: HTTP tunneling
    - Really bad (dubious!)
    - Boils down to a competition between firewall vendors and application developers
    - Defeats the purpose of a firewall in the first place
  - Nevertheless: widely deployed (“HTTP streaming”)
    - Apple, Microsoft, …

RTSP: Implications for Session Descriptions

- Session Announcements (SAP)
  - Session Descriptions (SDP) specifies fixed parameter set
  - May be updated by the server later on
- HTTP-based retrieval of session information
  - SDP specifies fixed parameter set or alternatives
  - Client gets to choose one of these
- RTSP-based session initiation
  - SDP from server describes set of alternatives
  - Clients may choose which one to use
  - Both sides may update their offering / choice later
- Need for negotiating session parameters
  - Both side may provide suggestions, make choices, and update these
  - Particularly relevant for interactive communications
- Generalized Offer/Answer model for SDP

“HTTP Streaming”

- Tunneling media and control in an HTTP connection
- Simplest case
  - Start replay before download is complete
  - No extensions needed
  - Mainly client-side operation
  - But: server needs to use appropriate media file format
- Alternative: add additional headers (MS)
  - Preserve packetization of media within a TCP connection

Old(?) MS HTTP Streaming Format

```
     0 1 2 3 4 5 6 7 0 1 2 3 4 5 6 7 0 1 2 3 4 5 6 7 0 1 2 3 4 5 6 7
    +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
+00 |             Type              |         Chunk Length          |
    +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
+04 |                        Sequence Number                        |
    +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
+08 |      Flags (Unknown)          |     Chunk Length (again?)     |
    +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
+12 |                                                               |
    :                        Chunk Data Block                       :
    |                                                               |
    +                                                               +
    |                                                               |
    +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
```

Sample Request Header (1/2)

```
GET test.asf HTTP/1.0
Accept: */*
User-Agent: NSPlayer/4.1.0.3856“
Host: media_host
Pragma: no-cache,rate=1.000000,stream-time=0,stream-offset=0:0,
             request-context=1,max-duration=0
Pragma: xClientGUID={c77e7400-738a-11d2-9add-0020af0a3278}
Connection: Close
```

Sample Request Header (2/2)

```
GET test.asf HTTP/1.0
Accept: */*
User-Agent: NSPlayer/4.1.0.3856
Host: media_host
Pragma: no-cache,rate=1.000000,stream-time=0,
        stream-offset=0:0,request-context=2,max-duration=40“
Pragma: xPlayStrm=1
Pragma: xClientGUID={c77e7400-738a-11d2-9add-0020af0a3278}
Pragma: stream-switch-count=1
Pragma: stream-switch-entry=ffff:1:0
Connection: Close
```

Sample Response Header

```
HTTP/1.1 200 OK
Content-Type: application/octet-stream
Server: Cougar 4.1.0.3920
Cache-Control: no-cache
Pragma: no-cache
Pragma: features=“broadcast"
```

Another Example: HTTP GET

```
GET /media/Videos/200710/200710A0/29102007002.mp4 HTTP/1.1
Content-length: 0
User-Agent: Java/1.5.0_10
Host: 192.168.1.100:50 004
Accept: video/mp4, text/html, image/gif, image/jpeg, *; q=.2, */*; q=. 2
Connection: keep-alive
```

Another Example: 200 OK

```
HTTP/1.1 200 OK
CONTENT-TYPE: video/mp4
CONTENT-LENGTH: 7667062

0040    0d 0a 0d 0a 00 00 00 1c 66 74 79 70 6d 70 34  ........ftypmp4
0050 32 00 00 00 00 6d 70 34 32 33 67 70 34 69 73 6f 2....mp423gp4iso
0060 6d 00 74 b2 13 6d 64 61 74 00 00 18 83 f2 1b fb m.t..mdat.......
0070 04 29 69 69 69 69 69 69 69 69 69 69 69 69 69 69 .)iiiiiiiiiiiiii
0080 69 69 69 69 69 69 69 69 69 69 69 69 69 69 69 69 iiiiiiiiiiiiiiii
0090 69 69 69 69 69 69 69 69 69 69 69 69 69 69 69 69 iiiiiiiiiiiiiiii
00a0 69 69 69 69 69 69 69 69 69 69 69 69 69 69 69 69 iiiiiiiiiiiiiiii
00b0 69 69 69 69 69 69 69 69 69 69 69 69 69 69 69 69 iiiiiiiiiiiiiiii
00c0 69 69 69 69 69 69 69 69 69 69 69 69 69 69 69 69 iiiiiiiiiiiiiiii
00d0 69 69 69 69 69 69 69 69 69 69 69 69 69 69 69 69 iiiiiiiiiiiiiiii
00e0 69 69 69 69 69 69 69 69 69 69 69 69 69 69 69 69 iiiiiiiiiiiiiiii
00f0 69 69 69 69 69 69 69 69 69 69 69 69 69 69 69 69 iiiiiiiiiiiiiiii
0100 69 69 69 69 69 69 69 69 69 69 69 69 69 69 69 69 iiiiiiiiiiiiiiii
```

Home Media Streaming Architectures

- No single coherent solution at this point
  - Different camps follow different approaches
  - Apple vs. other industry consortia vs. (operator) standardization bodies vs. …
- But architectural similarities
  - Devices need to support zero/autoconfiguration
    - No need for any kind of setup interaction ("plug and play")
  - Devices need to be able to find one another
  - Devices need to determine each others' capabilities
    - Self-descriptions
  - Devices need to discover resources available on/from another devices
  - Devices need to engage in communications and deliver media streams
- Example: DLNA: Digital Living Network Alliance
  - Design for small scale and closed deployments (home networks)
  - Uses Universal Plug and Play (UPnP) and UPnP AV

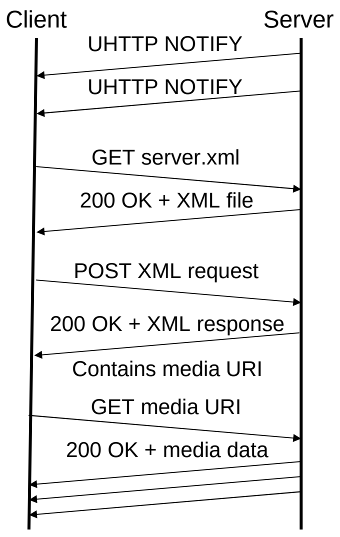
Example: DLNA

- Autoconfiguration
  - DHCP (if a DHCP server is present)
  - Zero configuration: IPv4 link local address configuration (RFC 3927)
- Device discovery: UPnP
  - Based upon something called "UHTTP": HTTP syntax over UDP packets
  - Sent in regular intervals (no scaling as with RTCP or SAP!)

```
NOTIFY * HTTP/1.1
LOCATION: http://192.168.1.100:50004/MediaServer1/MediaServer1.xml
HOST: 239.255.255.250:1900
SERVER: Symbian/9.2 UPnP/1.0 Nokia/N95
NTS: ssdp:alive
USN: uuid:d8c66d26-1b20-10e1-9c90-001CD45CCA96
CACHE-CONTROL: max-age=1800
NT: uuid:d8c66d26-1b20-10e1-9c90-001CD45CCA96
```

Example: DLNA

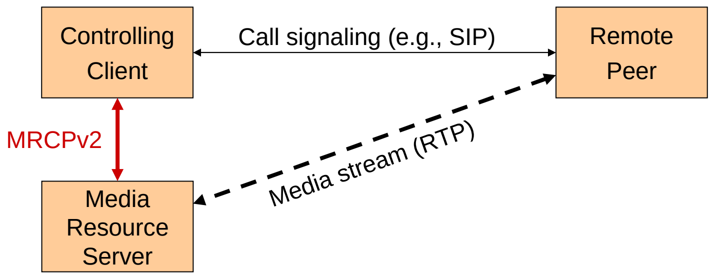
- Device capability assessment
  - HTTP-based (over TCP) query-response protocol
  - Simple Service Discovery Protocol (SSDP)
  - Retrieval of an XML-based service description
- Resource discovery
  - Based upon the device capabilities (e.g., media server profile)
  - Simple Object Access Protocol (SOAP) RPC
    - XML-encoded synchronous RPCs carried over HTTP
  - Example: get a "directory listing"
    - Using naming conventions for folders to locate contents
    - Yields URIs to access each individual media resource
- Media streaming
  - HTTP streaming: GET on the URI of the media resource



Third party media resource control

Media Resource Control Protocol (MRCPv2)

- Another protocol to control media resources
  - Based upon a proprietary version by Cisco et al. (MRCPv1, RFC 4443)
- Enable a client to task a third entity to perform on its behalf
  - Media stream generation (basic and advanced speech synthesis)
  - Media processing (recording, DTMF/speech recognition, speaker verification)



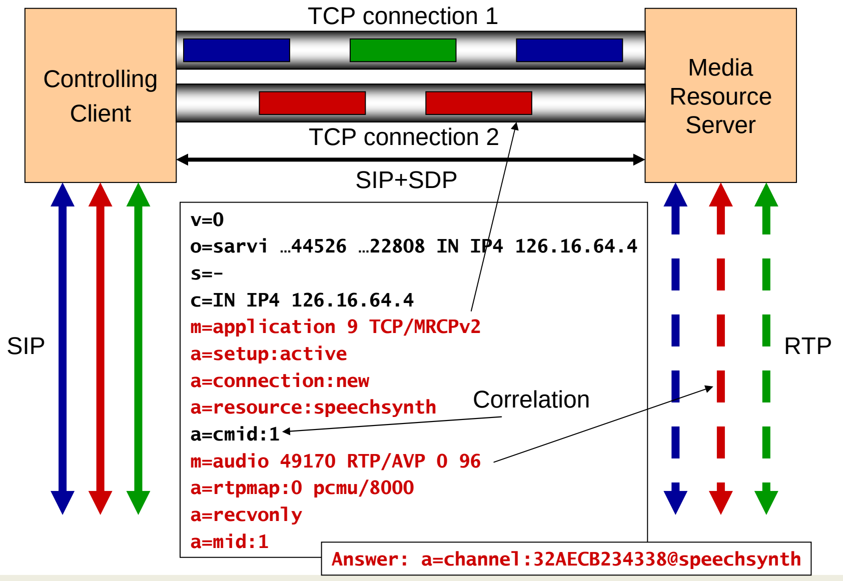
MRCPv2 Overview (1)

- MRCPv2 defines a common framework for rather different application classes
- Commonalities
  - Media stream consumption or generation by a media resource server
  - Control of the media stream generation or processing by the client
  - Report on media stream contents, characteristics, and resource server status
- Text-based protocol
  - Start line + headers + message body
  - Borrows heavily from HTTP and RTSP
  - Yet, subtle differences (later)
  - Message bodies identified by entity headers (using MIME types, etc.)
- Symmetric operation
  - Both peers can initiate actions: Methods (client->server), Events (server->client)
  - Headers + contents to parameterize operations or deliver results

MRCPv2 Overview (2)

- Uses TCP as underlying transport (+ optional TLS)
  - Reliability required; limited real-time interaction requirements only (true?)
    - Or do we assume sufficiently well interconnected clients and media resources
  - One of more TCP connections multiplexed
    - Concept of logical channels
- Uses RTP for media streams
  - Explicit correlation to TCP control channels in SDP using new grouping
- Relies on SDP offer/answer (using SIP) for session setup
  - Connection-oriented media (TCP, TLS) as well as RTP sessions

MRCP Overview (2)



```
v=0
o=sarvi …44526 …22808 IN IP4 126.16.64.4
s=-
c=IN IP4 126.16.64.4
m=application 9 TCP/MRCPv2
a=setup:active
a=connection:new
a=resource:speechsynth
a=cmid:1
m=audio 49170 RTP/AVP 0 96
a=rtpmap:0 pcmu/8000
a=recvonly
a=mid:1
```

```
Answer: a=channel:32AECB234338@speechsynth
```

MRCP Packages

- Different command sets defined for different packets
  - Building upon a small common subset of protocol elements
  - Otherwise largely independent of one another
  - Methods and events, response codes
  - Header fields
  - Content types (references to externally defined content formats)
- One package type per application
  - Speech Recognition
  - DTMF Recognition
  - Basic synthesis
  - Speech synthesis
  - Speaker verification
  - Recording
- Highly specialized for the specific application domain
  - You wonder why all this stuff goes into a single spec

Simple Example: Recording (1)

- Methods

• RECORD	— start recording
• STOP	— stop recording
• START-INPUT-TIMERS	— configuration

- Events

• START-OF-INPUT	— media stream recording has begun
• RECORD-COMPLETE	— recording done

- Some useful headers

• Sensitivity-Level	— for silence suppression
• Media-Type	— what to record
• Record-URI	— where to store recording
• Trim-Length	— limit length of recording
• Capture-on-Speech	— wait for speech

  - Various timeouts for input sensing, end of recording, …
- Message bodies
  - Captured recording (unless stored at a URI)

Simple Example: Recording (2)

```
C->S:  MRCP/2.0 386 RECORD 543257
       Channel-Identifier:32AECB23433802@recorder
       Record-URI:<file://mediaserver/recordings/myfile.wav>
       Capture-On-Speech:true
       Final-Silence:300
       Max-Time:6000

 S->C: MRCP/2.0 48 456234 200 IN-PROGRESS
       Channel-Identifier:32AECB23433802@recorder

 S->C: MRCP/2/0 49 START-OF-INPUT 456234 IN-PROGRESS
       Channel-Identifier:32AECB23433802@recorder

 S->C: MRCP/2.0 54 RECORD-COMPLETE 456234 COMPLETE
       Channel-Identifier:32AECB23433802@recorder
       Completion-Cause:000 success-silence
       Record-URI:<file://mediaserver/recordings/myfile.wav>;
          size=242552;duration=25645
```

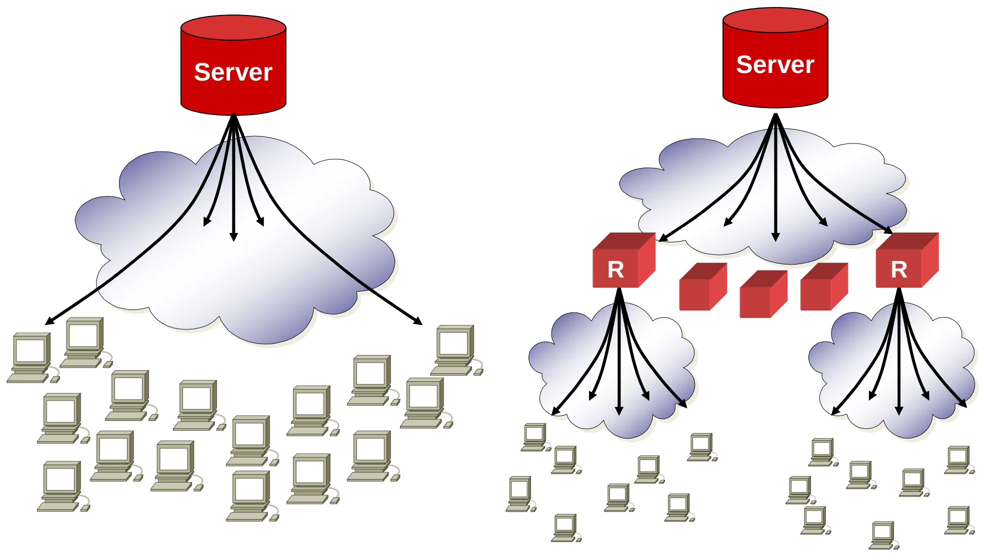
More Media Control

- Media Gateway Control Protocol (MEGACOP)
  - Configuring (PSTN) media gateways for IP telephony
  - Controlling media resource functions in 3GPP
- Media Server Control Markup Language and Protocol
  - Controlling conference servers
  - Controlling Interactive Voice Response (IVR) systems
- MEDIACTL WG in the IETF (newly created last week)
- Lots of non-IETF work (e.g., W3C)
- Gains importance in the context of service creation for interpersonal communications (using SIP)

Broadcast Streaming

From television broadcast to video-on-demand

Topologies



Media Stream Encapsulation

- Traditional DVB: MPEG Transport Streams (TS)
  - Uses 188 byte packets of which 184 bytes are payload (3 x 48 = 184)
    - Multiplexes different “channels”
  - Provides multiplex for different media streams on a single “channel”
    - Audio, video, data
    - Time synchronization, supplementary information, etc.
- MPEG-TS-over-RTP (RFC 2250)
  - Maintaining the per channel multiplex
  - Differentiating different “channels” via IP multicast addresses
- MPEG audio/video/… in separate RTP streams
  - Multiplexed via IP/UDP only
  - Independent RTP encapsulation
    - Video: RFC 3016, RFC 3984
    - Audio: RFC 3016, RFC 4184, RFC 4598
  - Binding channels together via, e.g., SDP descriptions

Broadcasting Schemes

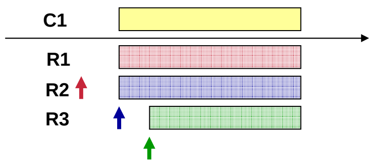
- Assuming no or little per receiver interaction
  - No control as in RTSP-based on-demand point-to-point streaming
  - Possibly indicating a desire to receive a particular stream
    - But no/little direct impact on scheduling
- Inherent tradeoff between
  - User satisfaction
    - measured in the waiting time until the stream starts from the beginning
    - Flexibility to decide what to see and not to miss anything
  - Server and link capacity (transmission bit rate R_t) required to provision the media streams to a large audience
- Further parameters
  - Receiver-side link (and hardware reception) capacity per media stream
  - Receiver-side memory required (= cost, feasibility), also complexity
  - Stream bit rate (for regular playback) R_s

Traditional Schemes

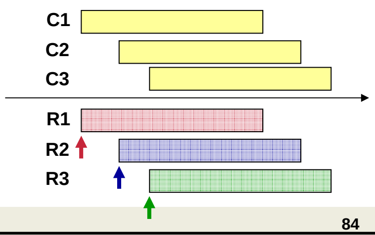
- Which are actually in use…
- File-based distribution
  - Movies are distributed using a reliable multicast protocol
    - Possibly involving some interactive repair schemes or just erasure coding/FEC
  - Selected genres (or specific movies) are stored on a user's receiver device
    - Possibly encrypted if they are pay-per-view
  - Usually requires a hard drive as mass storage
    - Plus some replacement policy to manage storage space
  - Viewed by the user whenever convenient
  - Drawbacks
    - Limited storage capacity
    - Limited flexibility and choice
    - Not really streaming
  - Some of the drawbacks mitigated by pull-based peer-to-peer file distribution
    - E.g., more choice
    - But users still need to decide in advance what they want to view

Simple Schemes: Two Extreme Points

- Simple television-style broadcast (proactive scheme)
  - Broadcast as per announced schedule
  - Receiver has to be aware or may miss the stream
  - Server load: O(1)
    - One stream for all
    - Streamed at the stream bit rate R_t = R_s
  - Client load: O(1)
    - Received at the stream bit rate R_r = R_s
    - Received and played back instantly (after dejittering)
    - No memory needed

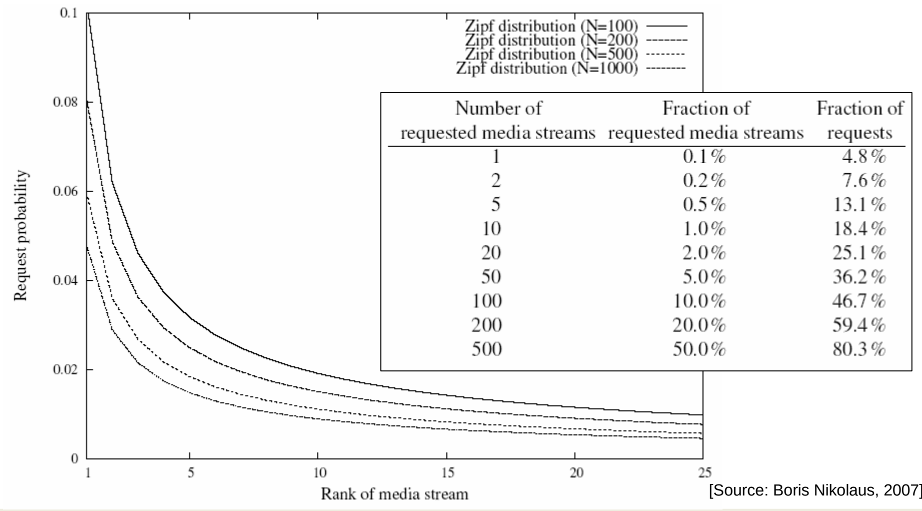


- Simple interactive video-on-demand (reactive scheme)
  - Unicast whenever requested by the user
  - Server load: O(n)
    - One stream per receiver, streamed at the stream bit rate
    - N independent streams for N receivers: R_t = N x R_s
  - Client load: O(1)
    - Received at the stream bit rate R_r = R_s
    - Received and played back instantly (after dejittering)
    - No memory needed



User Demand vs. Server Load

- Media stream demand follows a Zipf distribution (s=0.729)

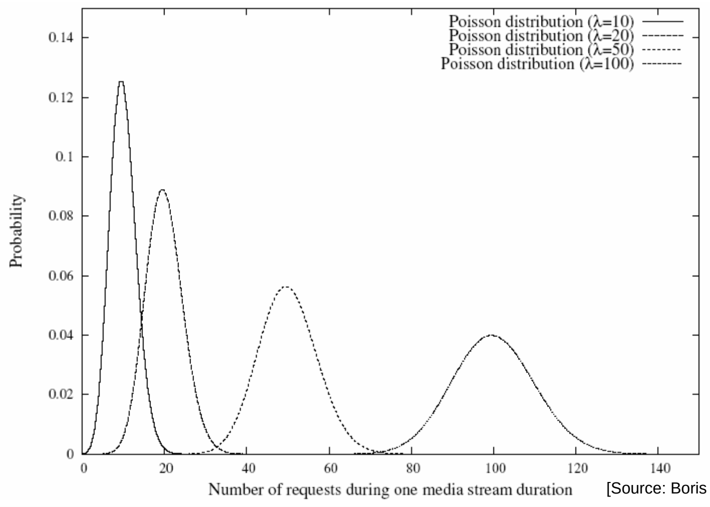


Number of requested media streams	Fraction of requested media streams	Fraction of requests
1	0.1 %	4.8 %
2	0.2 %	7.6 %
5	0.5 %	13.1 %
10	1.0 %	18.4 %
20	2.0 %	25.1 %
50	5.0 %	36.2 %
100	10.0 %	46.7 %
200	20.0 %	59.4 %
500	50.0 %	80.3 %

[Source: Boris Nikolaus, 2007]

User Demand vs. Server Load (2)

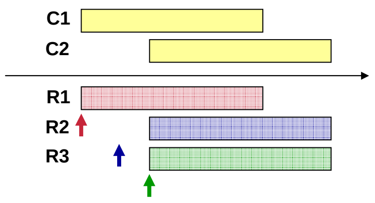
- Requests for a specific media stream follow a Poisson distribution



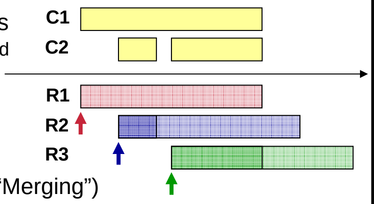
[Source: Boris Nikolaus, 2007]

Variations of Reactive Schemes

- Batching
  - Aggregate requests and start streaming delayed
  - After the number of requests exceeds a threshold
  - After a maximum waiting time passed
  - Various scheduling policies conceivable
    - FCFS, priorities, sort by request frequency, …
  - Fix the maximum number of transmission channels
  - Server load: depends on the batching granularity
  - Client load: O(1)

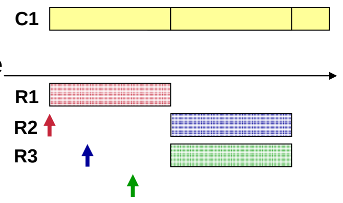


- Patching
  - Clients receive pieces of media streams for other clients
    - Implies that a broadcast/multicast transmission medium is used
  - Receivers buffer a fraction of the other media stream
    - Delays playout
  - Sender transmits the missing pieces in parallel
    - These pieces played out immediately
  - May be expanded across multiple streams (“Tapping”, “Merging”)
  - Virtual batching: exploits media stream exchange between receivers

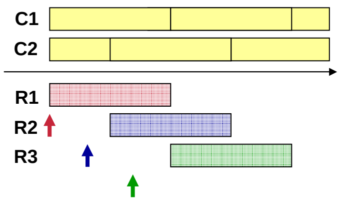


Pro-active Broadcasting Schemes

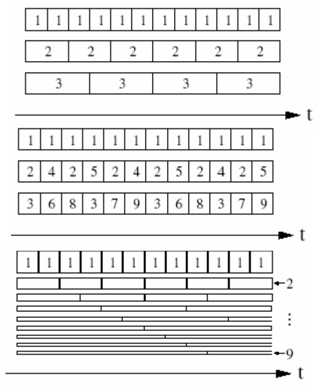
- Non-segmenting (keeps stream as a whole)
- Round-robin broadcasting
  - Server repeats broadcasts according to a schedule
    - Only repeats a single movie (e.g., every two hours)
    - Repeats a sequence of movies per channel
  - Receiver waits until the next scheduled time
  - Server load: O(1)
  - Client load: O(1)



- Staggered broadcasting
  - Server continuously broadcasts each stream
  - Uses multiple channels with interleaved start times
  - Server load: O(C) (C is the number of channels)
  - Client load: O(1)
  - Mean waiting time: Movie length / # channels



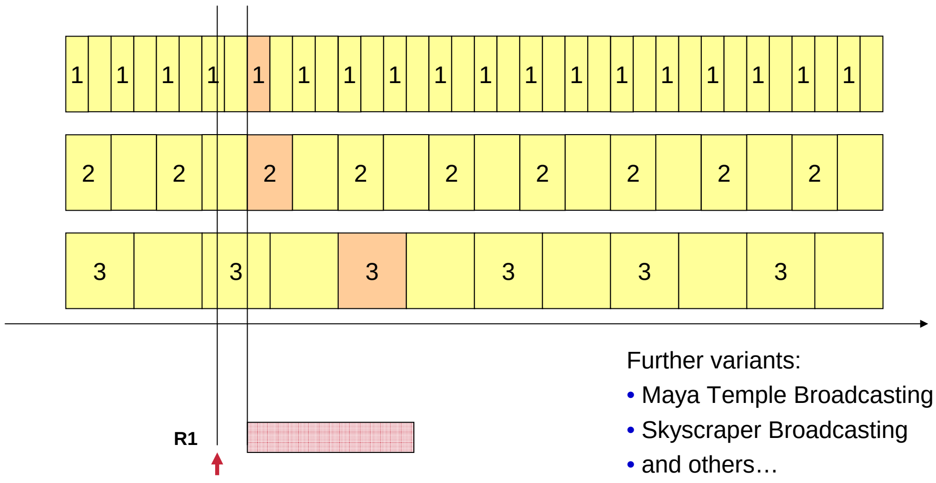
Pro-active Broadcasting Schemes (2)



[Source: Boris Nikolaus, 2007]

- Segmenting schemes
  - Subdivide the media stream into segments
    - Equal size
    - Different sizes
- Sender
  - Transmits the segments on one or more channels
    - With different frequencies
    - At different data rates
  - Segment transmission is ordered and
  - Segment assignment to channels according to a pre-defined schedule (determined via some algorithm)
  - Load: O(C_t) (C_t = number of transmission channels)
- Receiver
  - Joins the right channels at the right time (knowing the transmission scheme)
  - Receives from one or more channels at the same time
  - Buffers segments for later playout (unless they will be sent again prior to playout)
    - Maximum required buffer size is a limiting factor for client equipment
  - Load: O(C_r) (C_r = number of channels to be joined simultaneously)

Size-Based: Pyramid Broadcasting

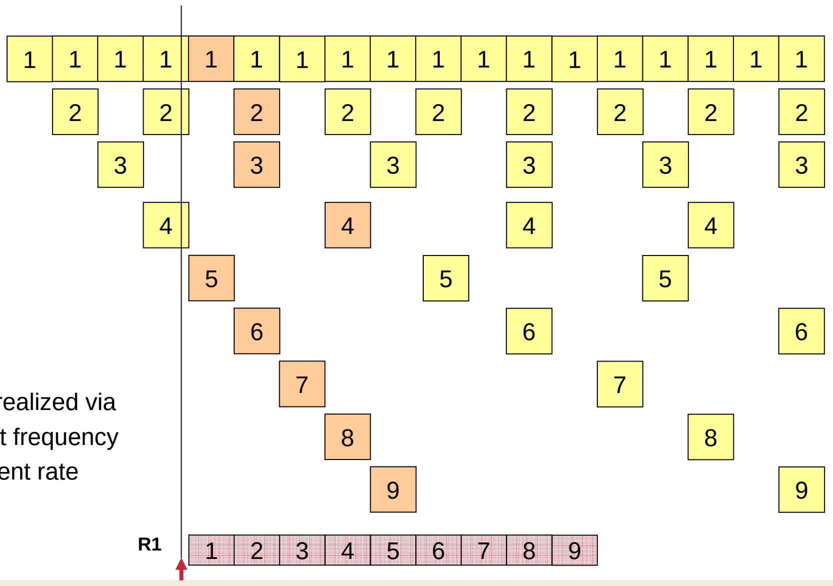


Further variants:
- Maya Temple Broadcasting
- Skyscraper Broadcasting
- and others…

Worst case delay: 2 x transmission duration of segment #1

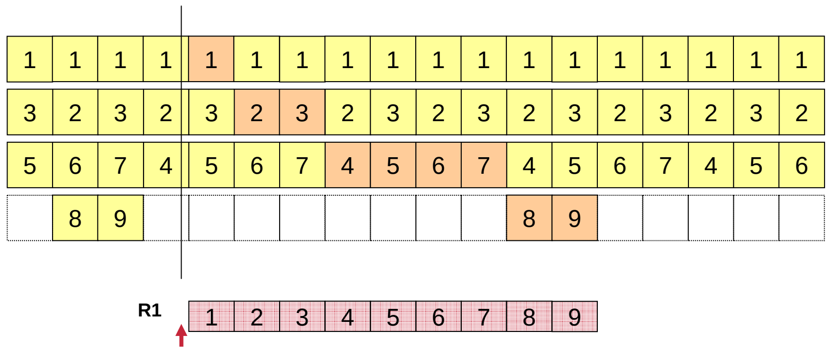
Channel bit rate C_t must be much higher than the stream bit rate C_s

Bit rate-based: Harmonic Broadcasting



Can be realized via
Segment frequency
or segment rate

Harmonic Broadcasting (variant)



Further schemes:

- Cautious harmonic broadcasting
- Quasi-harmonic broadcasting
- Polyharmonic broadcasting
- Staircase broadcasting (and related ones)
- Greedy broadcasting