# Lecture 6: Internet Streaming Media

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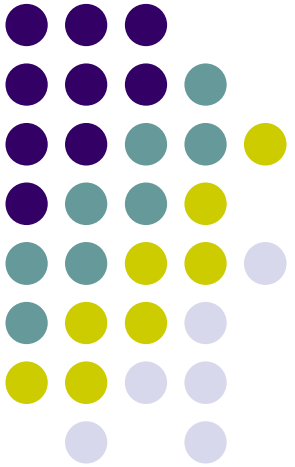
COMP9519 Multimedia Systems
S2 2009



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# Introduction

## The story so far ….

- Video Coding – MPEG-4
- Audio Coding – u-Law, AMR

- Packetization and Transport of media – RTP
- Transport Control / QoS Feedback - RTCP

## Lecture Outline

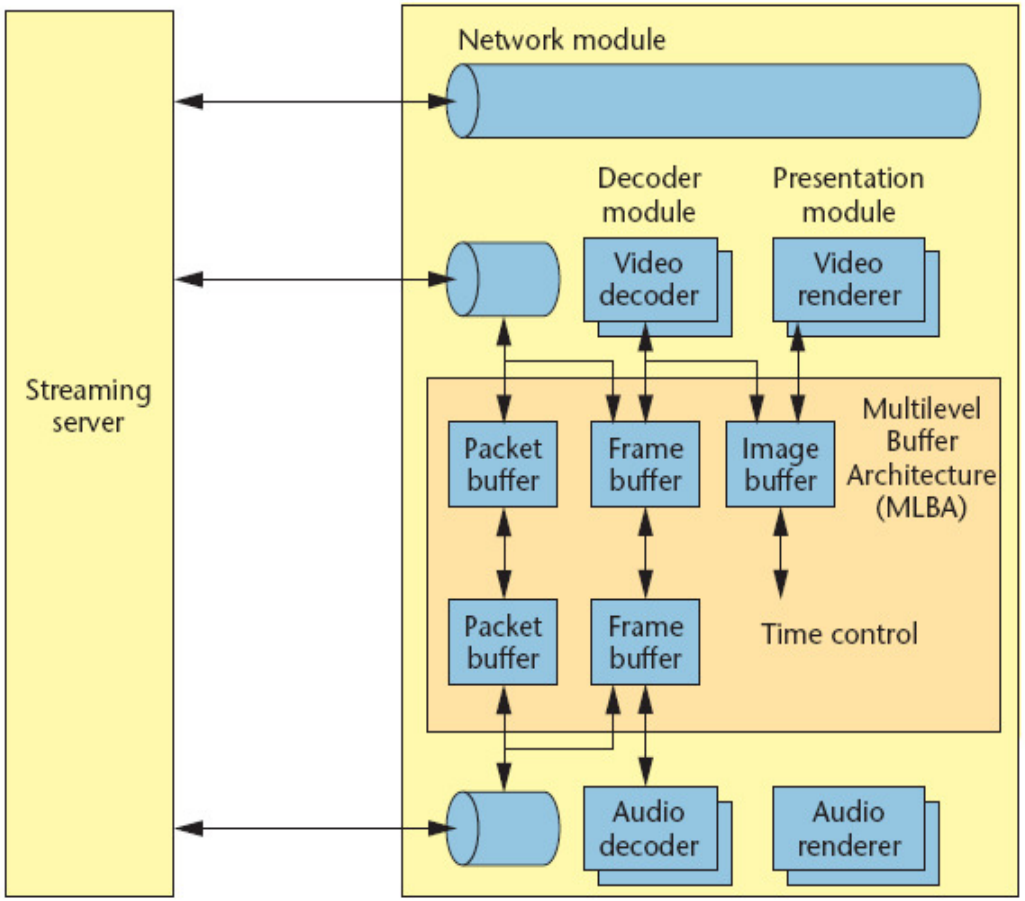
- Literature Review
  - Client Architecture : An Example

- Next
  - Further Protocols Enabling Streaming
  - SDP - Description
  - RTSP – Signaling
  - SIP

# Client Architecture : An Example

- Reference
  - "Client architecture for MPEG-4 streaming",
    Haifeng Xu  Diamand, J.  Luthra, A.
    IEEE Multimedia, April-June 2004, Vol 11, Issue: 2,
    pages 16-23
  - Review of
    - Streaming Video, RTP, MPEG-4
  - Client Architecture for streaming MPEG-4 video
    - Multilevel buffer system

# Client Architecture : An Example



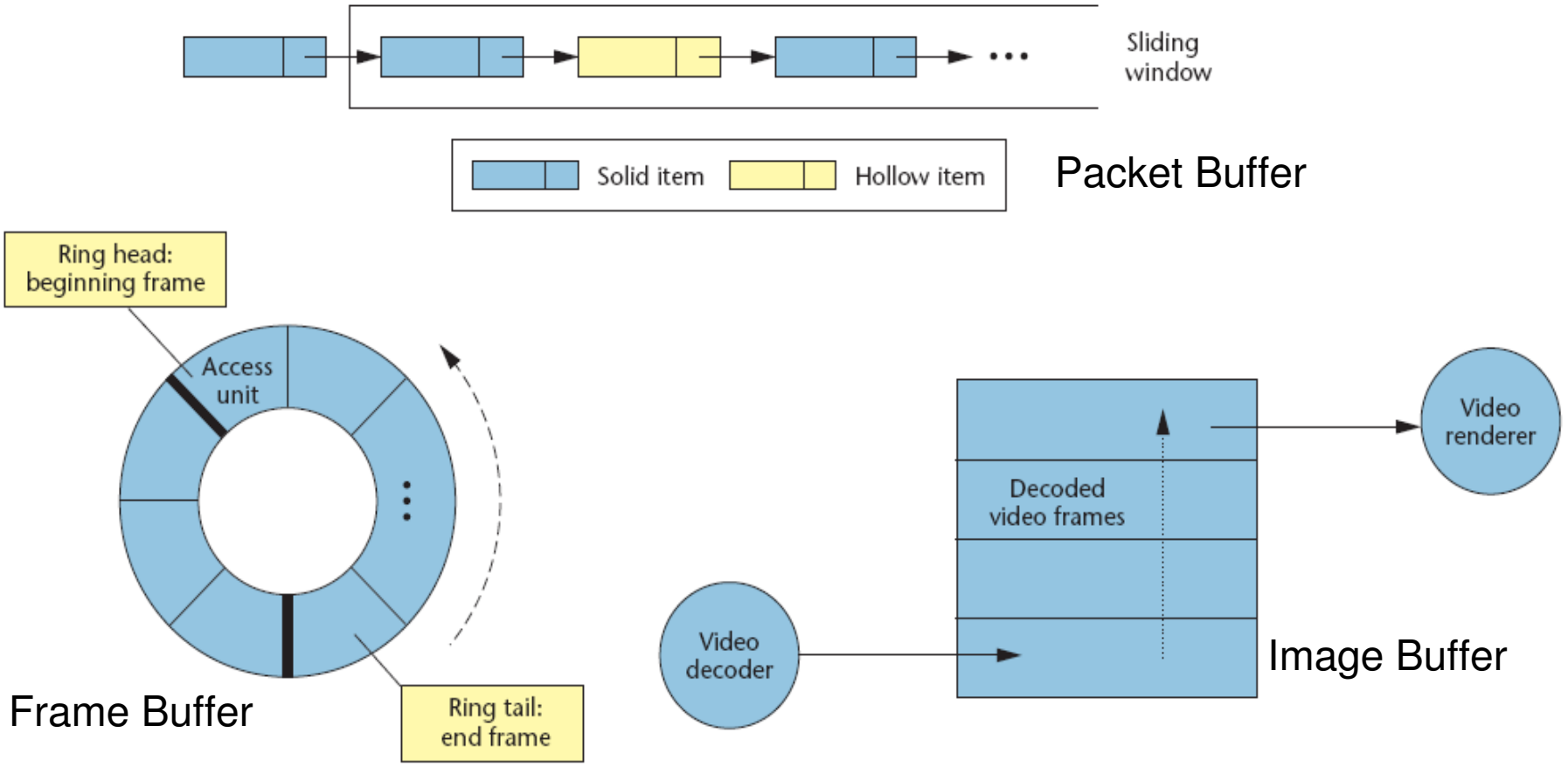

Multiple buffer architecture
to allow efficient control of media processing and presentation.

Three Modules

- Network Module : Packet buffer
- Codec Module : Frame Buffer
- Presentation Module : Image Buffer

"Client architecture for MPEG-4 streaming", Haifeng Xu Diamand, J. Luthra, A.
IEEE Multimedia, April-June 2004, Vol 11, Issue: 2, pages 16-23

# Client Architecture : Multiple Buffers

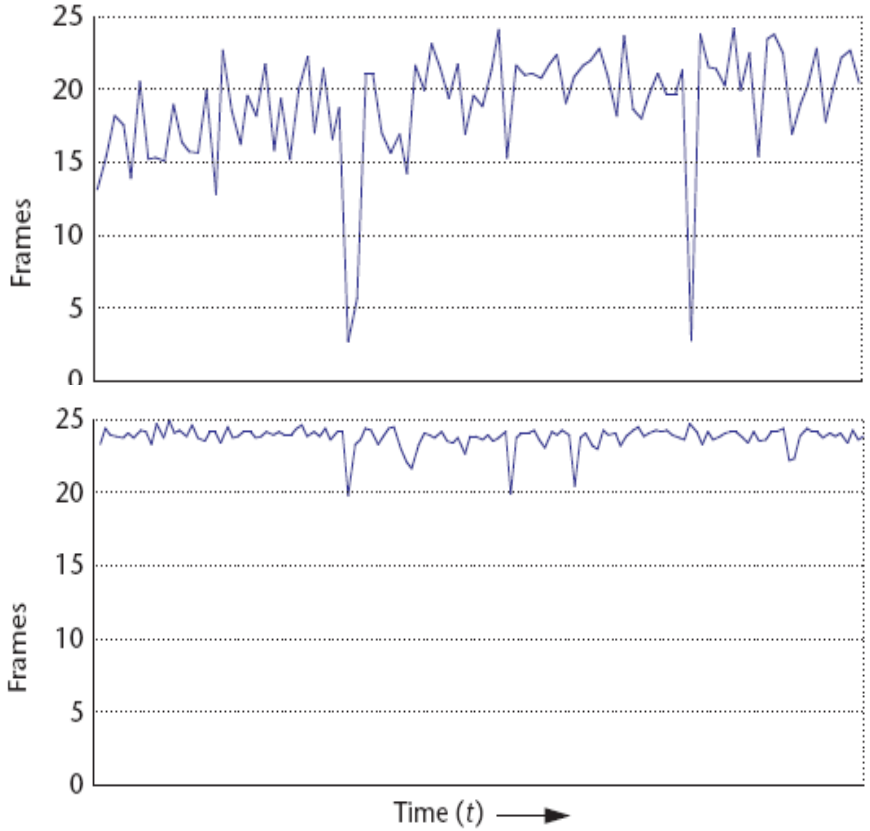



"Client architecture for MPEG-4 streaming", Haifeng Xu Diamand, J. Luthra, A.
IEEE Multimedia, April-June 2004, Vol 11, Issue: 2, pages 16-23

# Client Architecture : Multiple Buffers

- Packet Buffer
  - Reorder packets
  - Identify missing packets (allow for easy insertion)
  - Ignores delayed packets (outside moving window)
- Frame Buffer
  - Stores video packets (smoothing out network jitter)
  - Allows dropping of frame (when lacking CPU resources)
  - Identify frames to be dropped (B, P)
- Image Buffer
  - Stores decoded frames for rendering
  - Smoothing decoders speed

# Client Architecture : Rendering




Rendered frames rates with and without the image buffer

"Client architecture for MPEG-4 streaming", Haifeng Xu Diamand, J. Luthra, A.
IEEE Multimedia, April-June 2004, Vol 11, Issue: 2, pages 16-23

# Client Architecture : Conclusion

- The MPEG-4 MLBA subsystem facilitates three player-related activities:
  - precise A/V synchronization,
  - client-based QoS management, and
  - improved rendering performance through an image buffer.

"Client architecture for MPEG-4 streaming", Haifeng Xu Diamand, J. Luthra, A.
IEEE Multimedia, April-June 2004, Vol 11, Issue: 2, pages 16-23

# Lecture Outline

- Session Description Protocol
  - How to describe a multimedia session ?
  - SDP example
- RTSP – Internet VCR controls
  - Stop, Pause, Play, Fast Forward over the internet
  - RTSP Methods
  - Signal Timing Diagram
  - Protocol stack for a total streaming system
- SIP – Quick Overview
- MPEG-4 File Format
  - What's so good about MP4?
  - File Format and Structure
  - Hinting

# Introduction

- Example : An existing live multicast session
  - Video and Audio streams
  - Transport - RTP/UDP/IP, Control – RTCP/UDP/IP
- A new client wanting to join the multicast session
  - Needs to know
    - multicast IP address and port
    - Media streams in a session (e.g. video only or audio + video)
    - Payload format (e.g. MPEG-4 video, AMR audio)
    - Initialization data for video and audio decoders
    - Transport protocol used
    - Other information ….
- Need a way to describe a multimedia session
  - To enable new clients to easily join the session

# SDP

- Session Description Protocol (SDP)
  - IETF – RFC2327
    - www.ietf.org/rfc/rfc2327.txt
  - For describing multimedia sessions
    - To communicate the existence of a session
    - To convey sufficient information to join a session
  - Simple text format
  - Defined to be general purpose
    - Can be used for a wide range of network environments
    - And applications

# SDP

- SDP includes
  - Session name and purpose
  - Time the session is active
  - The media comprising the session
  - Information to receive media (addresses, ports, formats)
  - Information about bandwidth to be used
  - Contact information of a person responsible for the session
- SDP is used by other signaling / initiation protocols
  - SIP : Session Initiation Protocol
  - RTSP : Real-time Streaming Protocol

# SDP

session level description

v= (protocol version)
o= (owner and session identifier)
s= (session name)
i=* (session information)
u=* (URI of description)
e=* (email address)
p=* (phone number)
c=* (connection information)
b=* (bandwidth information)
z=* (time zone adjustments)
k=* (encryption key)
a=* (zero or more session attribute)
t= (time the session is active)
r=* (zero or more repeat times)

SDP session description consists of a number of lines of text of the form

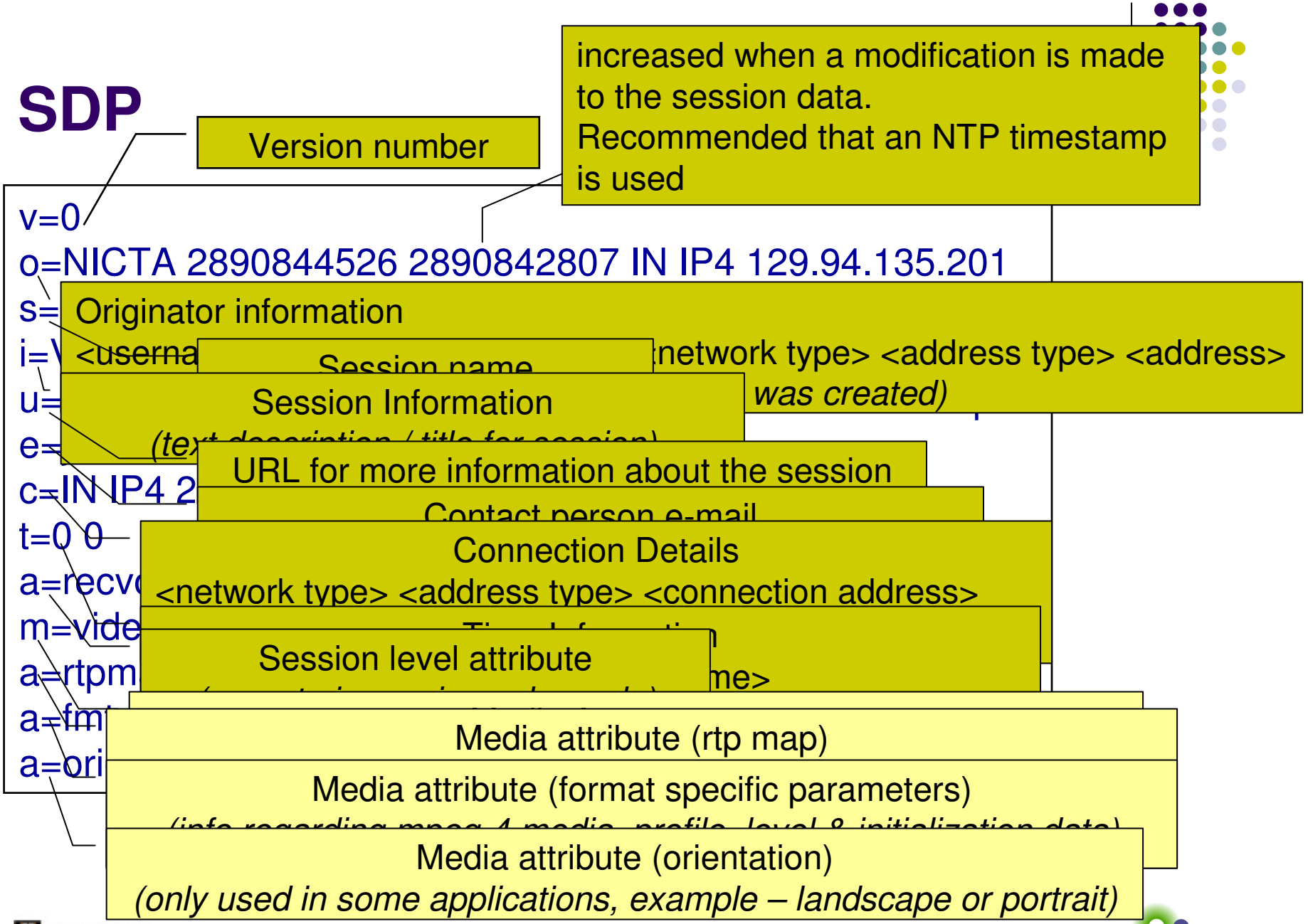
<type>=<value>

<type> is always exactly one character and is case-significant.

media level description

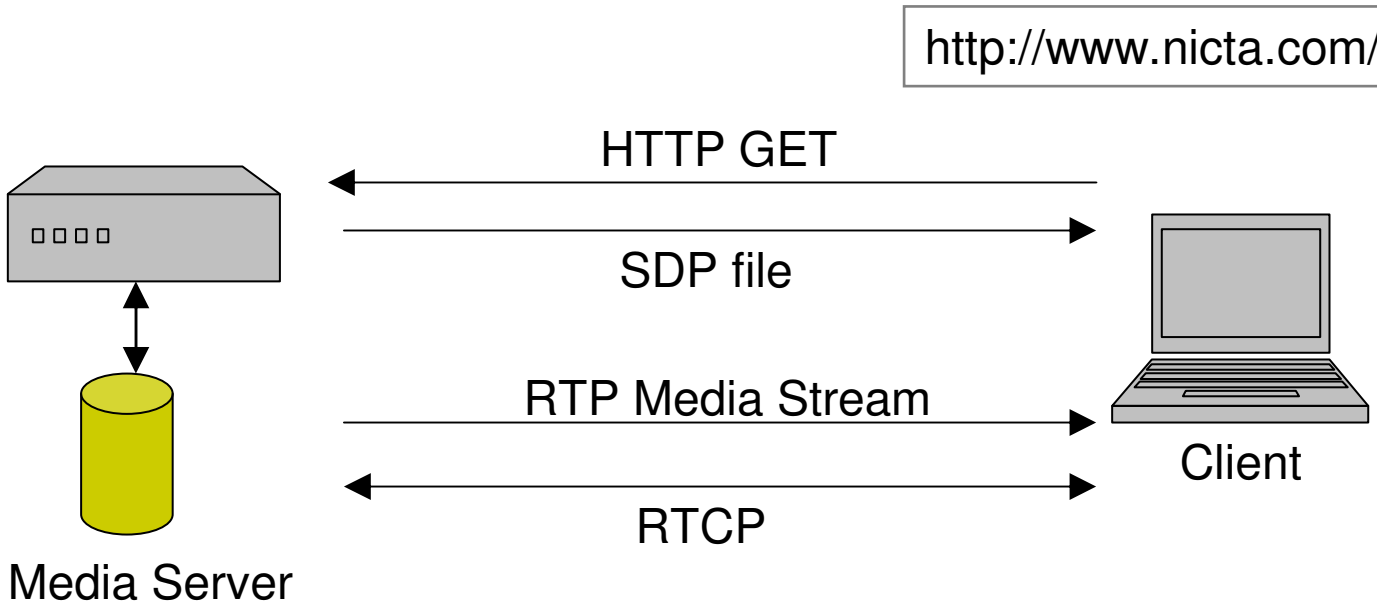
m= (media & transport address)
i=* (media title)
c=* (connection information)
b=* (bandwidth information)
k=* (encryption key)
a=* (zero or more media attribute)

# SDP


Version number
increased when a modification is made to the session data. Recommended that an NTP timestamp is used
v=0
o=NICTA 2890844526 2890842807 IN IP4 129.94.135.201
s=
i=
u=
e=
c=IN IP4 2
t=0 0
a=recv
m=vide
a=rtpm
a=fm
a=ori
Originator information
<userna
network type> <address type> <address>
was created)
Session name
Session Information
(tex
URL for more information about the session
Contact person e-mail
Connection Details
<network type> <address type> <connection address>
Session level attribute
me>
Media attribute (rtp map)
Media attribute (format specific parameters)
Media attribute (orientation)
(only used in some applications, example – landscape or portrait)

# System Overview

- Example – Using SDP to join a multicast session
  - Request SDP file via HTTP
  - Retrieve information from downloaded SDP file
  - Receive RTP streams on SDP specifed address & port
  - Decode and display specified media



# System Overview

- Example – Traffic Monitoring
  - Continuous multicast streaming of video
  - A client can receive the stream
    - by downloading SDP via http (web browser)
    - Provide SDP file to QuickTime player
    - Player initializes and waits for stream data
    - Easily support multiple client
  - Demo Link

# Lecture Outline

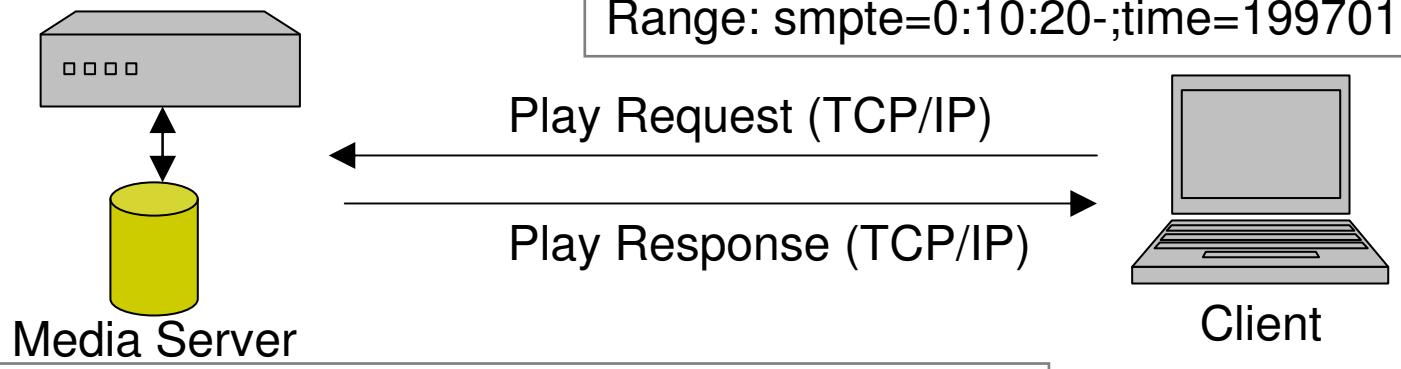
- Session Description Protocol
  - How to describe a multimedia session ?
  - SDP example
- RTSP – Internet “Remote” VCR controls
  - Stop, Pause, Play, Fast Forward over the internet
  - RTSP Methods
  - Signal Timing Diagram
  - Protocol stack for a total streaming system
- SIP – Quick Overview
- MPEG-4 File Format
  - What’s so good about MP4?
  - File Format and Structure
  - Hinting

# RTSP

- Now we can describe and transport media streams
- But how to control these streams
  - Start, Stop, Pause, Fast Forward, Rewind
  - “internet VCR”
- Solution – RTSP
  - Real Time Streaming Protocol
  - Establishes and controls one or more continuous media streams - such as audio and video
  - Similar in syntax and operation to HTTP/1.1
    - Client –Server protocol
    - Text based
  - IETF RFC 2326

# RTSP

- More Info
  - www.ietf.org/rfc/rfc2326.txt
  - www.rtsp.org
- Example



# RTSP

- Protocol Properties
  - Media Transport Independent
    - RTSP does not depend on the transport mechanism used to carry the continuous media
    - Media transport can be via RTP or some other mechanism
  - Transport Layer Independent:
    - RTSP may use either an unreliable datagram protocol (UDP) or a reliable stream protocol such as TCP
  - Control of recording devices:
    - Can control both recording only and playback only devices,
    - As well as devices that can alternate between the two modes

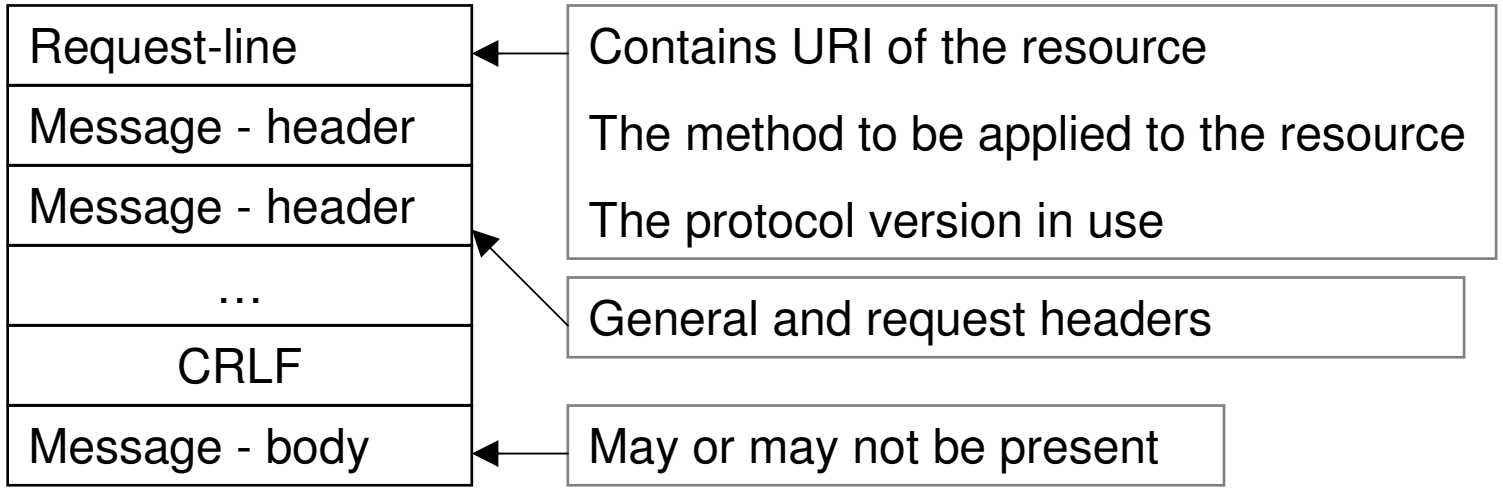
# RTSP

- Protocol Properties
  - Extendable:
    - New methods and parameters can be easily added to RTSP.
  - Easy to parse
  - Multi-server capable:
    - Each media stream within a presentation can reside on a different server.
  - HTTP-friendly:
    - RTSP reuses HTTP concepts, so that the existing infrastructure can be reused.

# RTSP

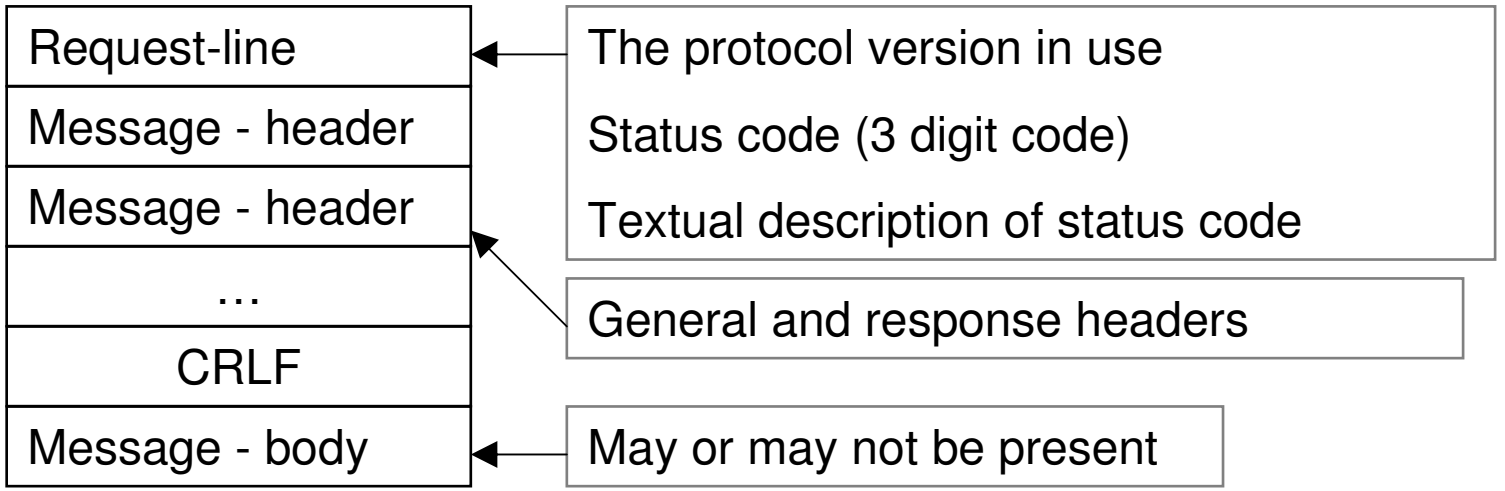
- Protocol Operation
  - Text based messages between client and server
  - Messages can be :
    - Requests
    - Responses

  - Request Messages



# RTSP

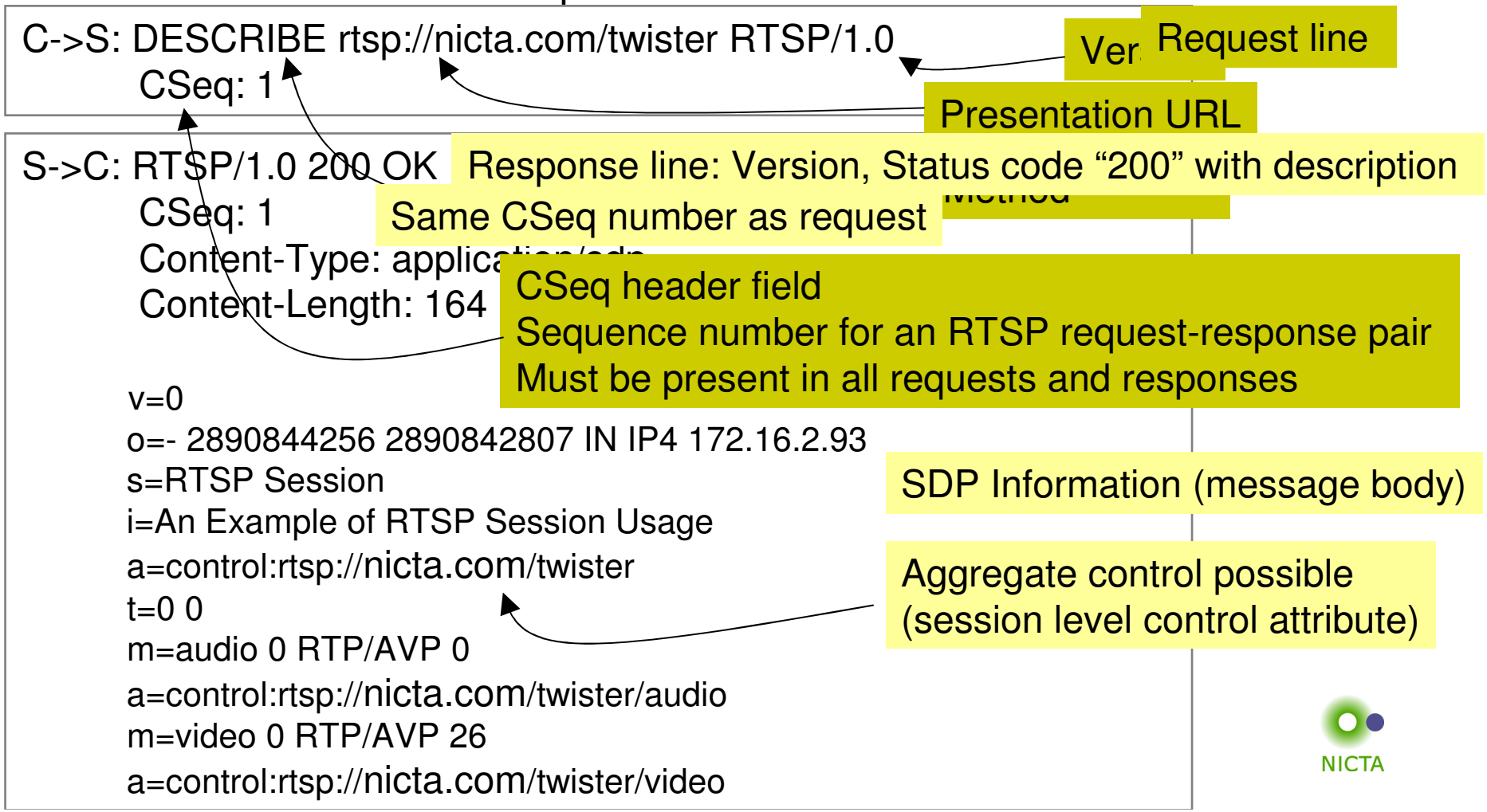
- Protocol Operation
  - Response Messages




  - Next : examples of Request and Response messages
    - Corresponding to five important request methods
    - Methods : Describe, Setup, Play, Pause, Teardown
    - Unicast example

# RTSP : Describe Method

- Retrieves the description of a presentation, identified by the request URL, from a server. The DESCRIBE reply-response pair constitutes the media initialization phase of RTSP.

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# RTSP : Setup Method

- Specifies the transport mechanism to be used for the streamed media

C->S: SETUP rtsp://nicta.com/twister/audio RTSP/1.0
CSeq: 2
Transport: RTP/AVP;unicast;client_port=8000-8001

unicast RTP/RTCP port pair on which the client has chosen to receive media data and control information

S->C: RTSP/1.0 200 OK
CSeq: 2
Transport: RTP/AVP;unicast;client_port=8000-8001; server_port=9000-9001
Session: 12345678

RTSP session ID

unicast RTP/RTCP port pair on which the server has chosen to send media data and control information

C->S: SETUP rtsp://nicta.com/twister/video RTSP/1.0
CSeq: 3
Transport: RTP/AVP;unicast;client_port=8002-8003
Session: 12345678

Setup operates on each stream separately

Same session ID used

S->C: RTSP/1.0 200 OK
CSeq: 3
Transport: RTP/AVP;unicast;client_port=8002-8003; server_port=9004-9005
Session: 12345678

# RTSP : Play Method

- Tells the server to start sending data via the mechanism specified in SETUP request/response messages

```
C->S: PLAY rtsp://nicta.com/twister RTSP/1.0
        CSeq: 4
        Range: npt=0-
        Session: 12345678
```

```
S->C: RTSP/1.0 200 OK
        CSeq: 4
        Session: 12345678
        RTP-Info: url=rtsp://foo/twister/video;
                  seq=9810092;rtptime=3450012
```

Aggregate control of all media streams in the presentation.
The PLAY request starts streaming both audio and video streams.

Range header used to specify time ranges (start / stop) for playback

Normal play time (NPT) indicates the stream absolute position relative to the beginning of the presentation.

# RTSP : Pause Method

- Causes the stream delivery to be interrupted (halted) temporarily.

```
C->S: PAUSE rtsp://nicta.com/twister RTSP/1.0
        CSeq: 5
        Session: 12345678
```

```
S->C: RTSP/1.0 200 OK
        CSeq: 5
        Session: 12345678
```

Aggregate control of all media streams in the presentation.
The PAUSE request halts the streaming of both audio and video streams.

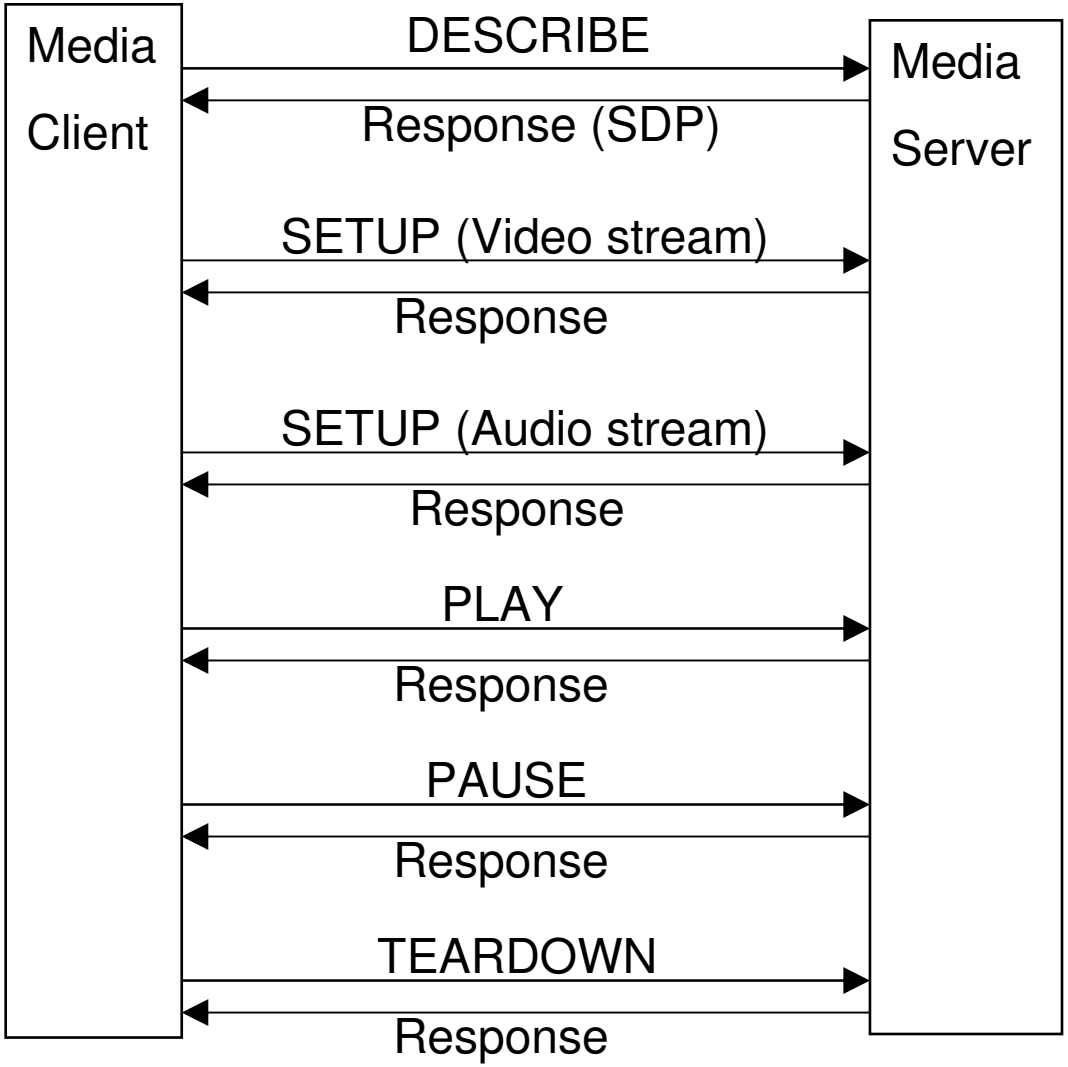
# RTSP : Teardown Method

- Stops the stream delivery for the given URI, freeing the resources associated with it

```
C->S: TEARDOWN rtsp://nicta.com/twister RTSP/1.0
      CSeq: 892
      Session: 12345678
```

```
S->C: RTSP/1.0 200 OK
      CSeq: 892
```

# RTSP : Signal Timing Diagram

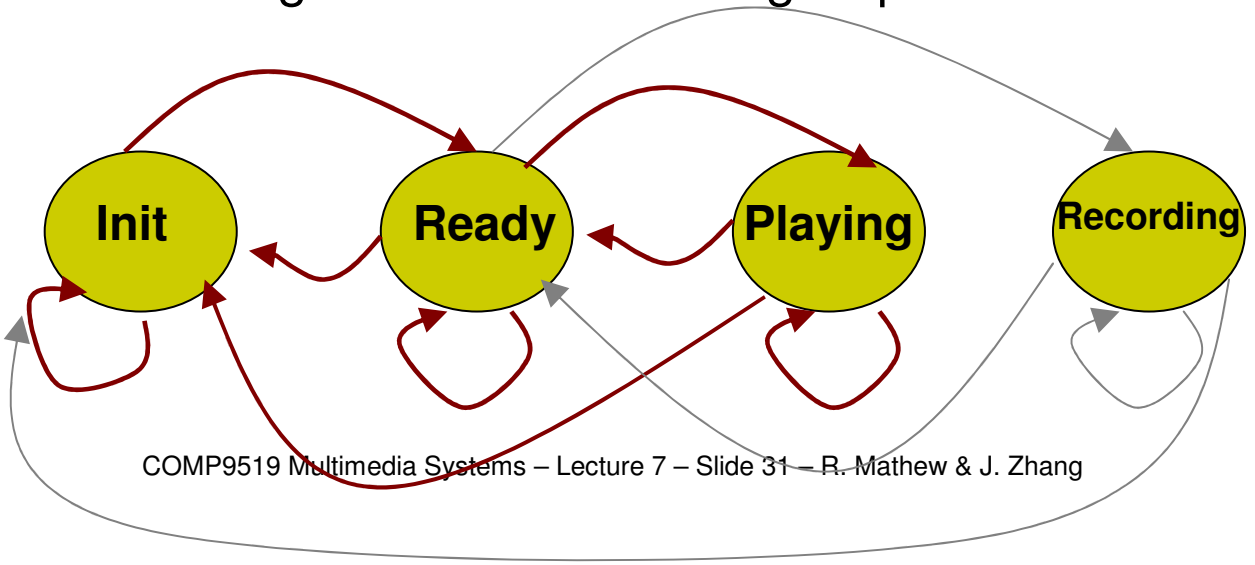


# Summary of RTSP Methods

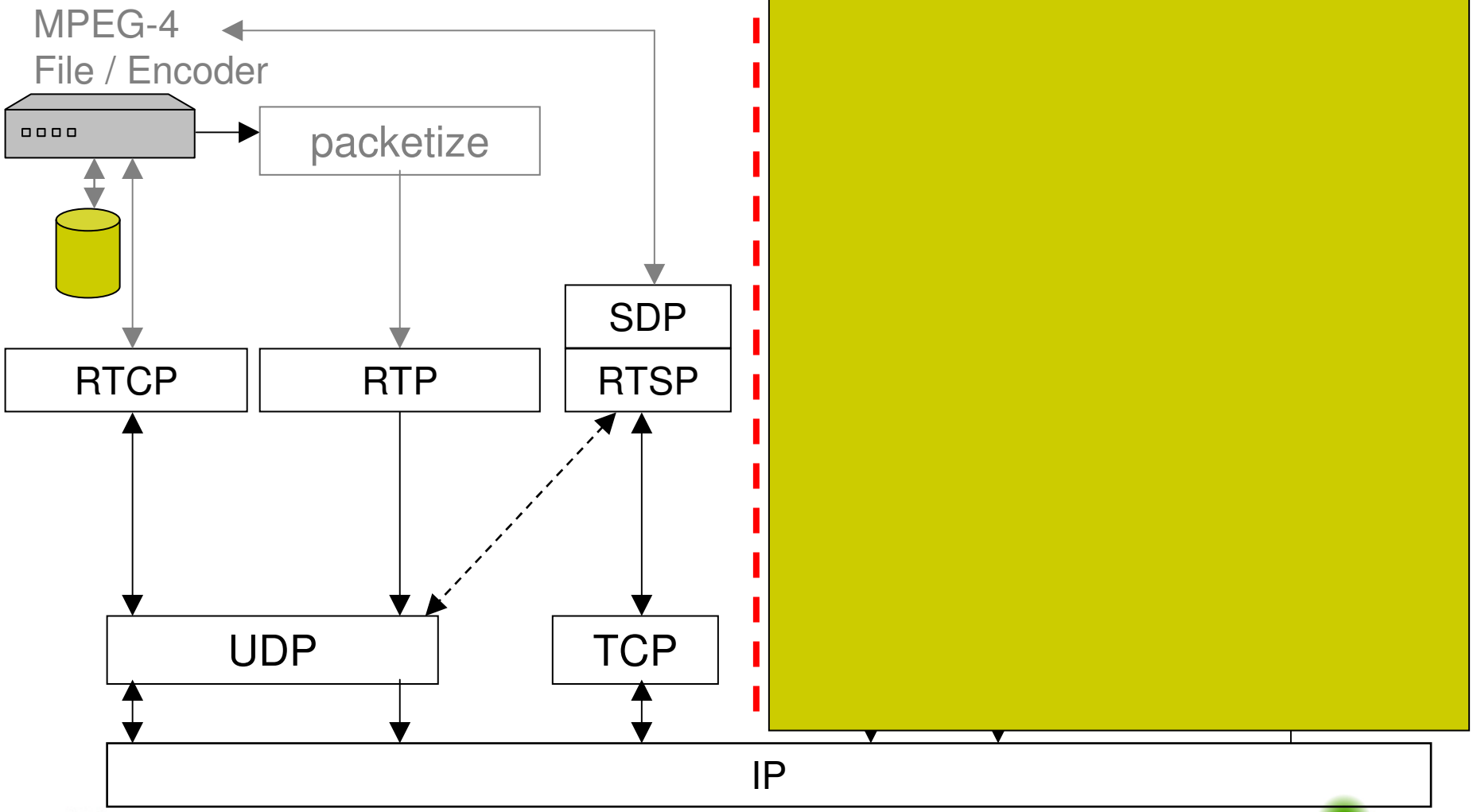
- OPTIONS : get available methods
- SETUP : establish transport
- ANNOUNCE : change description of media object
- DESCRIBE : get description of media
- PLAY : start playback, reposition
- RECORD : start recording
- REDIRECT : redirect client to new server
- PAUSE : pause delivery, while keeping state
- SET PARAMETER : device or encoding control
- TEARDOWN : remove state / close

# RTSP : Comparison with HTTP

- Similar to HTTP, but some important differences for RTSP are :
  - Data delivery takes place out-of-band in a different protocol
    - e.g. RTP
  - Both the media client and media server can issue requests
    - Client > Server : SETUP, PLAY, ….
    - Server > Client : ANNOUNCE, REDIRECT, ….
  - Requests are not stateless : client & server state machines
    - client changes state on receipt of replies to requests
    - server changes state on receiving requests



# Protocol Stack



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  - What's so good about MP4?
  - File Format and Structure
  - Hinting

# SIP

- Session Initiation Protocol (SIP)
  - Another session control protocol – diff SDP and RTSP??
  - IETF RFC 3261 www.ietf.org/rfc/rfc3261.txt

  - Protocol that can establish, modify and terminate multimedia sessions.
  - Applications – IP telephony, multimedia conferences

  - SIP, like RTSP,
    - Uses text-based request/response transaction model
      - Requests contain Methods and Header fields
      - Responses include 3 digit status codes (eg “200 OK”)

    - Is Transport layer independent
    - Uses other protocols for media delivery (eg RTP).

# SIP

- SIP Methods
  - INVITE, ACK, CANCEL : for setting up sessions
  - BYE : for terminating sessions
  - REGISTER : for registering contact information
  - OPTIONS : for querying servers about capabilities

- INVITE
  - User agent client initiates a session with INVITE
  - Invitation can be accepted by a user agent server
  - SIP invitations convey session descriptions that allow participants to agree on a set of compatible media types
  - Offer/answer model
- ACK
  - Response confirmation to INVITE

# SIP

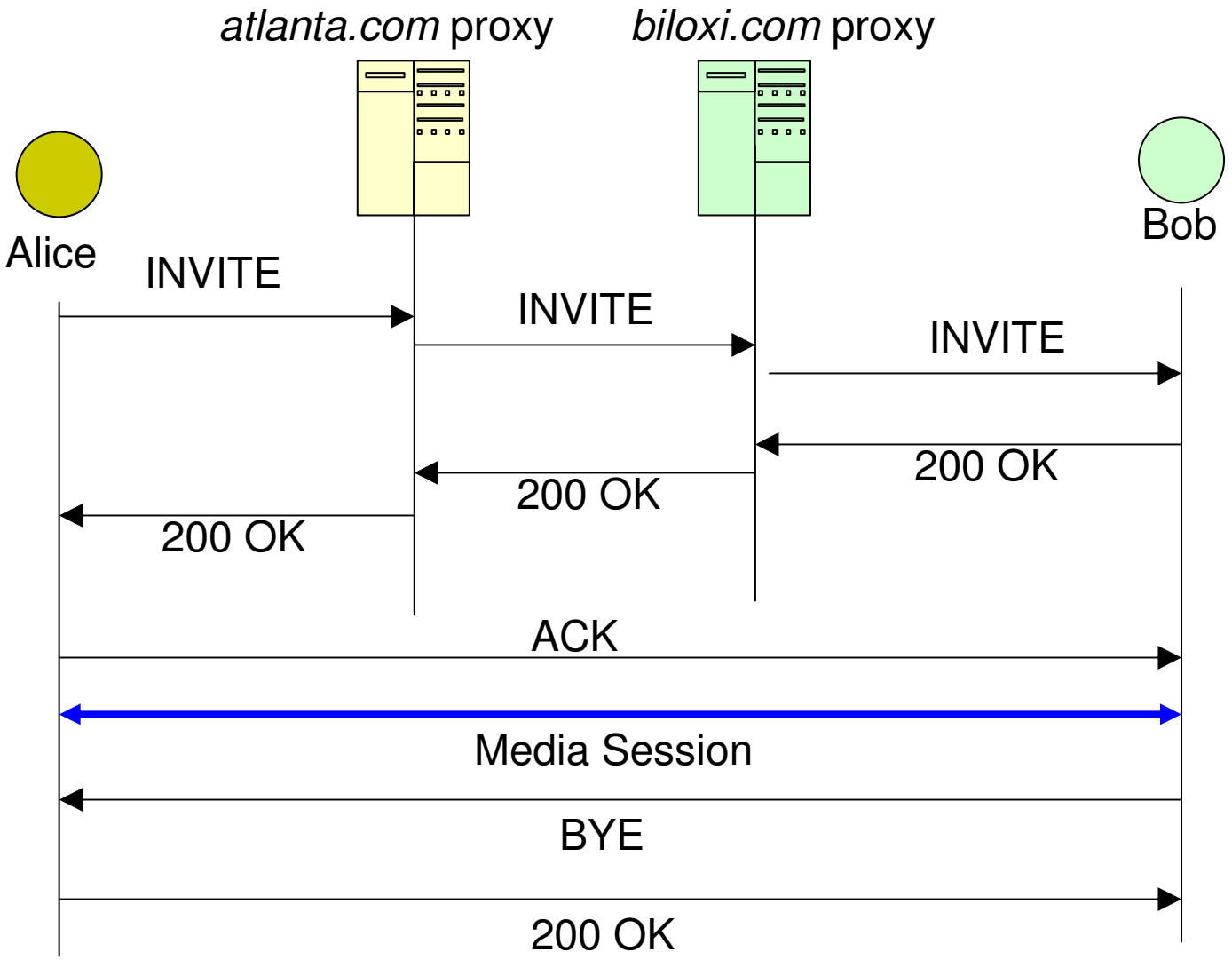
- INVITE Example

```
INVITE sip:bob@biloxi.com SIP/2.0
Via:SIP/2.0/UDPpc33.atlanta.com;branch=z9hG4bK776asdhds
Max-Forwards: 70
To: Bob <sip:bob@biloxi.com>
From: Alice <sip:alice@atlanta.com>;tag=1928301774
Call-ID: a84b4c76e66710@pc33.atlanta.com
CSeq: 314159 INVITE
Contact: <sip:alice@pc33.atlanta.com>
Content-Type: application/sdp
Content-Length: 142
(Alice's SDP not shown)
```

# SIP

- SIP supports user mobility
  - With proxy servers to help route requests to user's current location
  - Registration function allowing users to upload current locations for use by proxy servers

# SIP


atlanta.com proxy
biloxi.com proxy
Alice
Bob
INVITE
INVITE
INVITE
200 OK
200 OK
200 OK
ACK
Media Session
BYE
200 OK

# SIP

## Response Example

SIP/2.0 200 OK

Via: SIP/2.0/UDP server10.biloxi.com
;branch=z9hG4bKnashds8;received=192.0.2.3

Via: SIP/2.0/UDP bigbox3.site3.atlanta.com
;branch=z9hG4bK77ef4c2312983.1;received=192.0.2.2

Via: SIP/2.0/UDP pc33.atlanta.com
;branch=z9hG4bK776asdhds ;received=192.0.2.1

To: Bob <sip:bob@biloxi.com>;tag=a6c85cf

From: Alice <sip:alice@atlanta.com>;tag=1928301774

Call-ID: a84b4c76e66710@pc33.atlanta.com

CSeq: 314159 INVITE

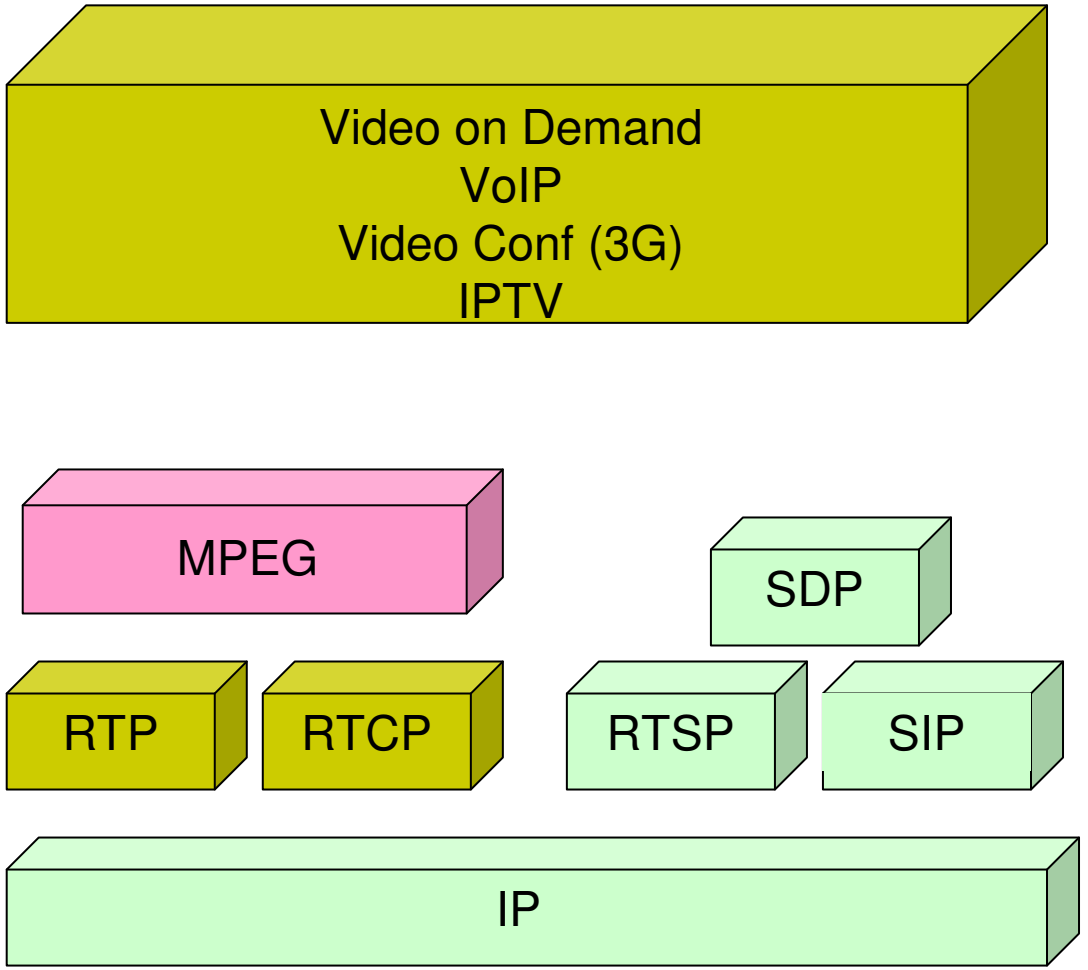
Contact: <sip:bob@192.0.2.4>

Content-Type: application/sdp

Content-Length: 131

(Bob's SDP not shown)

# Streaming Applications



# Streaming Media Players

- Qucik Time Player
- Real Player
- Microsoft Media player
- Packet Video

- Players for various platforms
  - PC
  - Pocket PC
  - 3G Phones

# Lecture Outline

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- MPEG-4 File Format
  - What's so good about MP4?
  - File Format and Structure
  - Hinting

# File Format

- Now we can code and stream video and audio
- Next we look at file formats for exchanging multimedia
- MPEG-1 & MPEG-2 content typically exchanged as files that represent a stream ready to be delivered
  - Embedded absolute time stamps
  - Fragmentation of media for some preferred transport
  - Random Access could be difficult
- Need a new file format that can be used when
  - Storing captured media
  - Editing stored media
  - Combining multiple files
  - Delivering as File Download or Streaming
  - A “life-cycle” file format

# File Format

- MPEG-4 file format : MP4
  - "life-cycle" file format defined as part of MPEG-4
  - Based on Apple's QuickTime format ("mov files")
  - Due to MP4's flexibility and extensibility
    - Industry acceptance for exchange of MPEG-4 video and audio
    - Basis for Motion JPEG 2000 file format
    - Basis for 3GPP file format used in MMS
      - Multimedia Messaging Service

# MP4 : Main File Format Concepts

- The Media data is stored separately from Meta data
  - Media data : Audio, Video samples
  - Metadata : Data describing the media
    Examples : timing info,
    number of bytes required for a frame
- Timing information specified by relative numbers (durations) rather than absolute numbers
  - Allows editing to be easier – eg insertion of a new frame
- Able to store media data distributed over several files
  - Use URLs to point to media data stored at various locations

# MP4 : Main File Format Concepts

- The Media data is stored separately from Meta data
- Timing information specified by relative numbers (durations) rather than absolute numbers
- Able to store media data distributed over several files

- Locating media data by means of data offsets and length information
  - Metadata tables mapping media sample number to location in a file

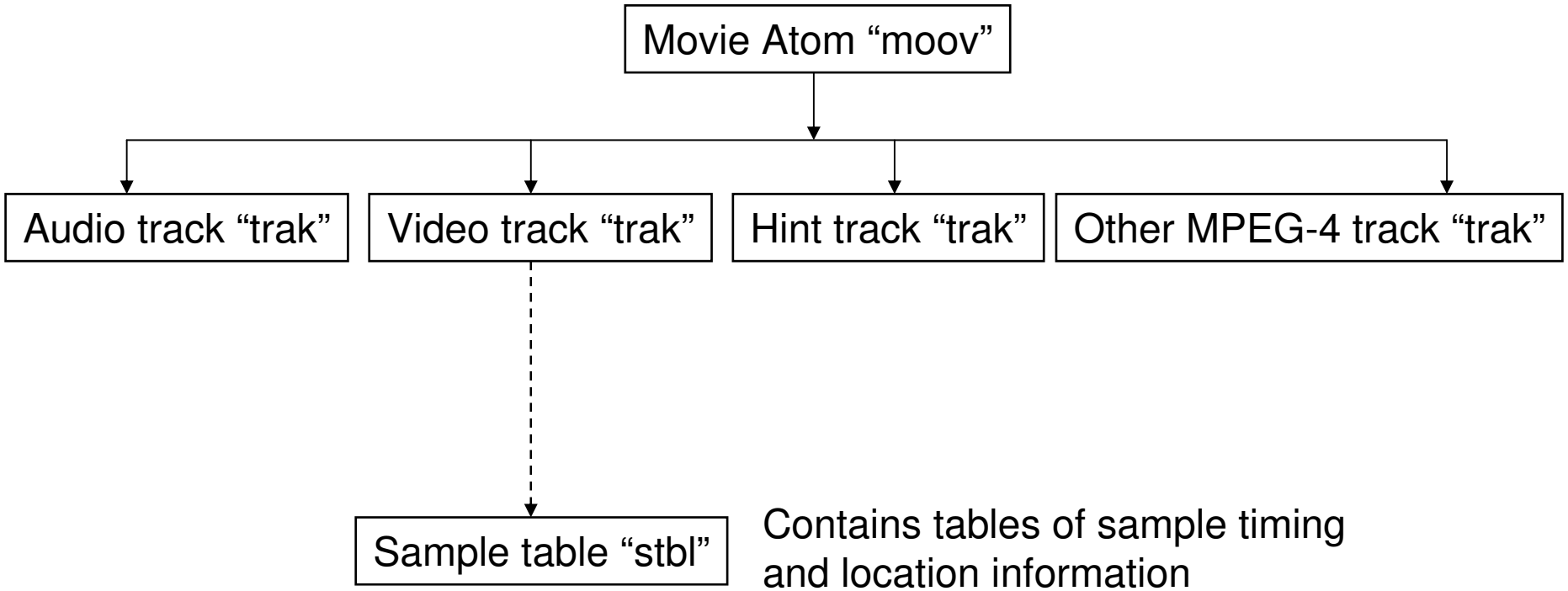
- Support streaming protocols through optional hint tracks
  - Metadata information for packetization and header data
  - Example – hints for RTP streaming stored as a separate track

# MP4: File Structure

- The MP4 file format is composed of object-oriented structures called ‘atoms’.
  - A unique tag and a length identify each atom.
- Metadata atoms :
  - A hierarchy of metadata giving information such as
    - index points, durations, and pointers to the media data.
  - This collection of atoms is contained in an atom called the ‘movie atom’.
- Media Data Atoms :
  - The media data is contained in one or more ‘mdat’ or media data atoms,
  - or could be located outside the MP4 file; referenced via URL’s.

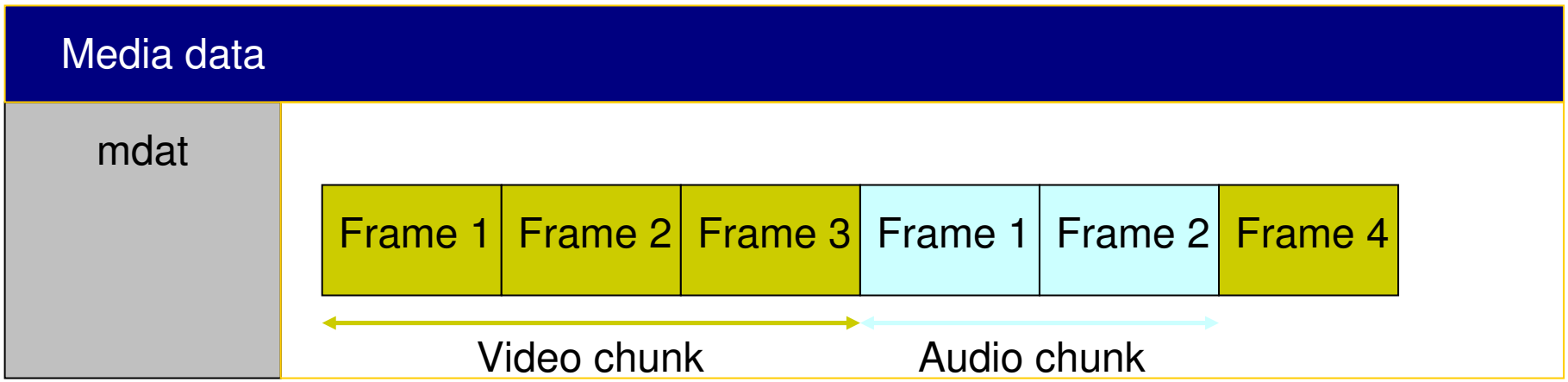
# MP4: File Structure

- Metadata Hierarchy [5]



# MP4: File Structure

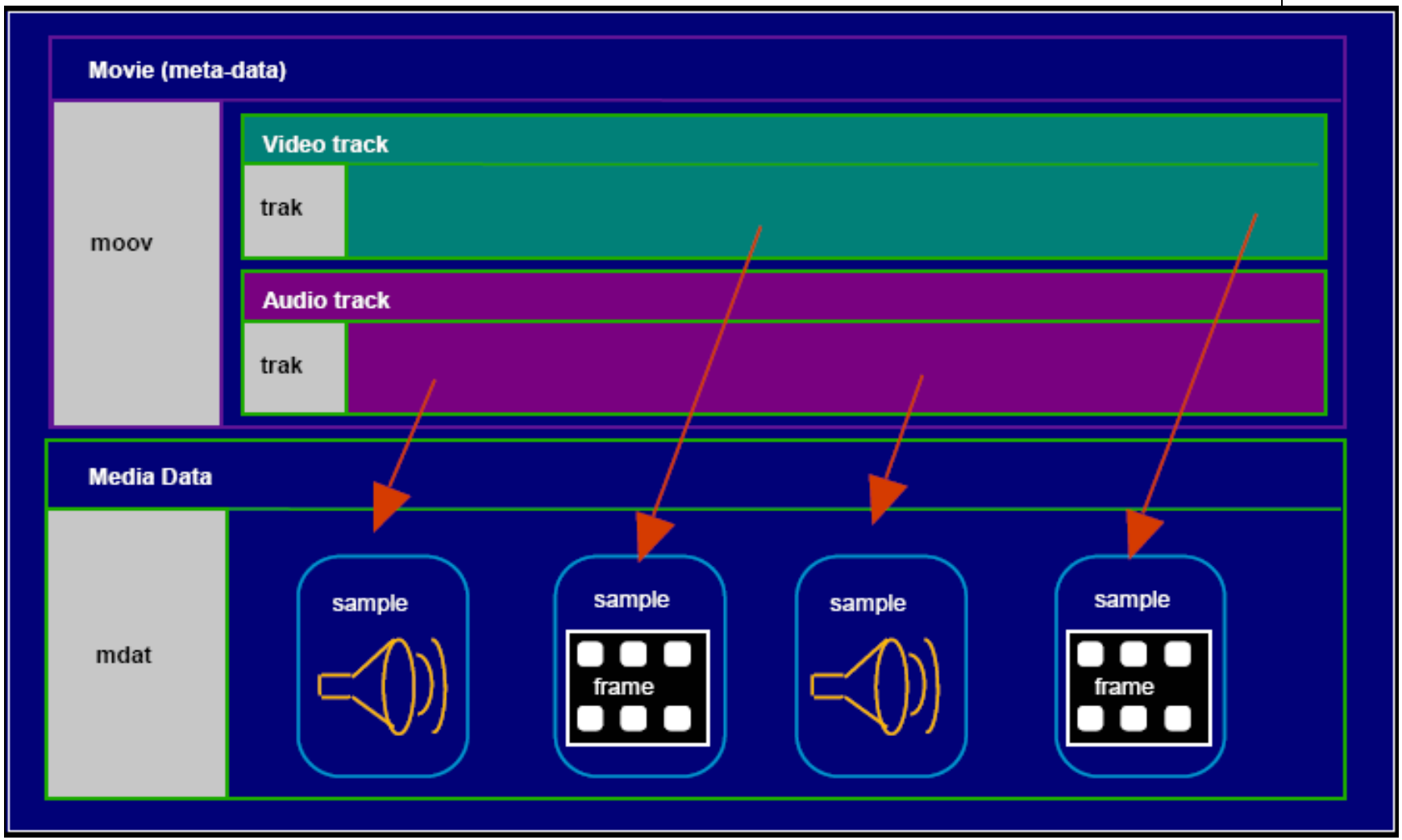
- Media data "*mdat*" Atom
  - Contains interleaved, time ordered video and audio samples referred to as Access Units (AU)
  - Several frames from the same track are often stored contiguously in "*chunks*".



# MP4: File Structure

- Basic structure of MP4 file
  - Metedata “moov” atom
    - Each stream has a track “trak” atom – which contain tables
    - Tables with info on AU’s
      - Timing, size, location (offsets), synchronization points
      - Tables used to point to AU in “mdat”
  - Media Data “mdat” atom
    - Contains AU of audio and video
  - Putting it together
    - See next slide

# MP4: File Structure [4]



# MP4: Hinting

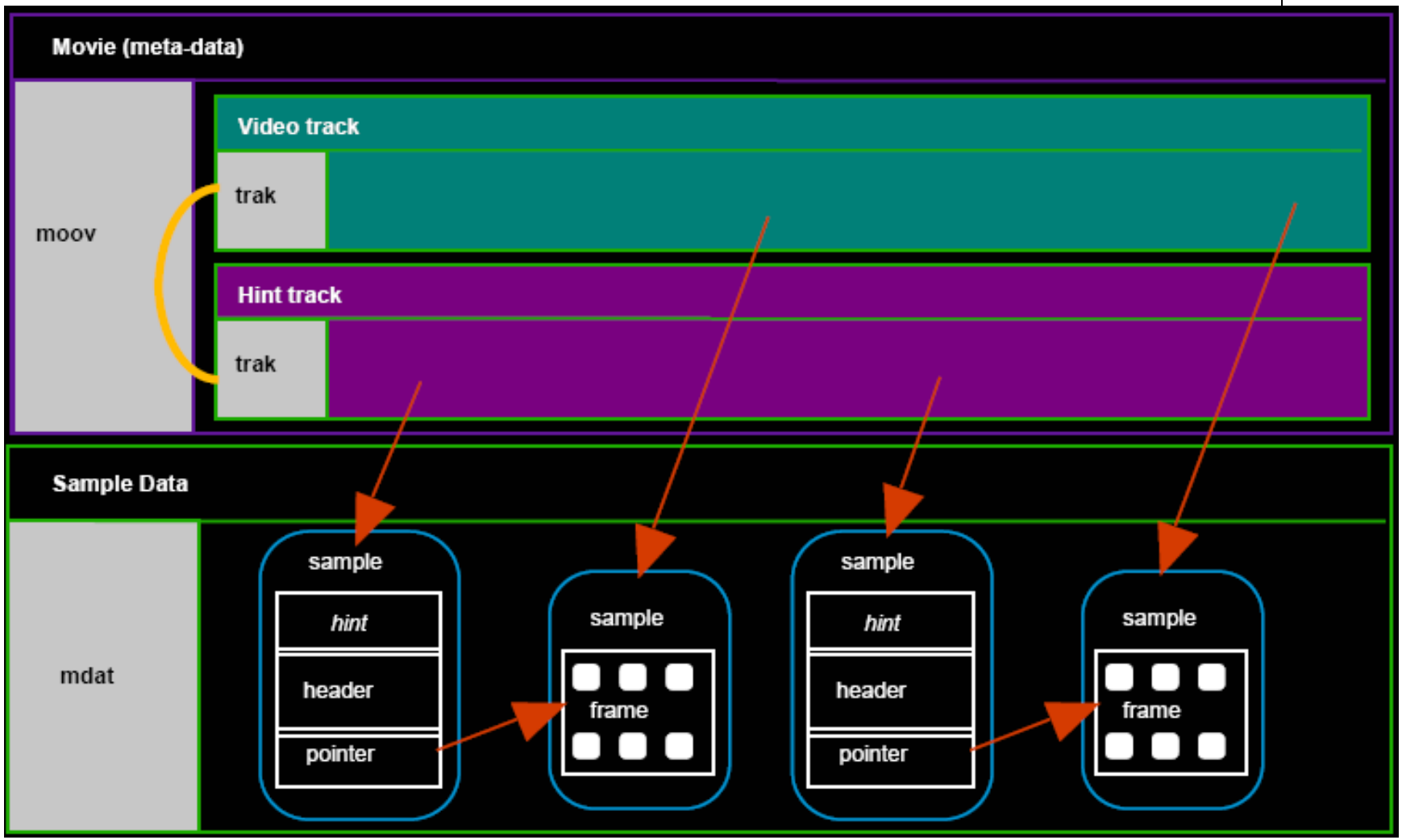
- MP4 file format is a streamable format, as opposed to a streaming format.
- The file format facilitates streaming without ever being streamed directly
  - File format does NOT define an on-the-wire protocol, and is never actually streamed over a transmission medium.
  - Metadata in the file known as ‘hint tracks’ provide instructions, telling a server application how to deliver the media data over a particular delivery protocol.
  - There can be multiple hint tracks for one presentation, describing how to deliver over various delivery protocols.

# MP4: Hinting

- Remember for streaming, need to format data into packets, with each packet containing a
  - Header, and
  - Samples or Media data
  - Example – RTP for MPEG-4

- Hint Track
  - Tables pointing to header information
    - The header information is stored in “mdat”
    - Example – RTP header information
  - Then points to appropriate fragment of sample data
    - Example – one video frame for an RTP packet
  - See next slide

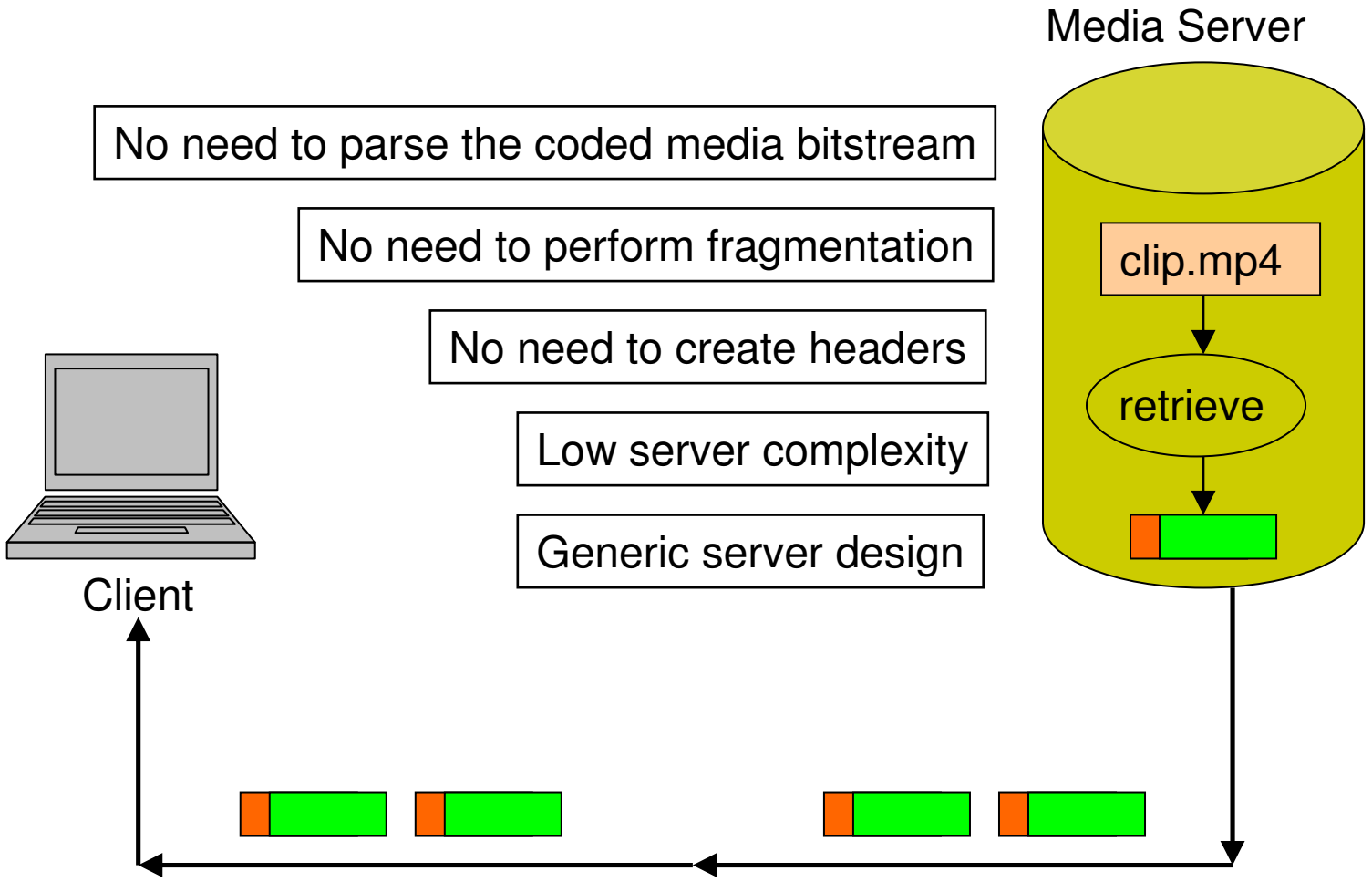
# MP4: Hinting [4]



# MP4: Hinting

- What to do to accommodate different transport protocols ?
  - Multiple hint tracks for one media
- Advantage to the media server ?
  - The server can be “dum”
  - No knowledge of transport protocol required
    - Header information already stored in the MP4 file
  - No need to do media fragmentation
    - Pointers to appropriate media fragments already created
    - No knowledge of media codec required

# MP4: Hinting


Media Server
No need to parse the coded media bitstream
No need to perform fragmentation
No need to create headers
Low server complexity
Generic server design
clip.mp4
retrieve
Client

# References and Further Reading


1. IETF RFC 2327 “SDP: Session Description Protocol”
2. IETF RFC 2326 “Real Time Streaming Protocol (RTSP)”
3. IETF RFC 3261 “SIP: Session Initiation Protocol”
4. David Singer, QuickTime Engineering “Quick Time etc. Introduction for UC Davis”, Feb 2004
5. MPEG-4 Overview, ISO/IEC JTC1/SC29/WG11 N4668 www.chiariglione.org/mpeg/standards/mpeg-4/mpeg-4.htm