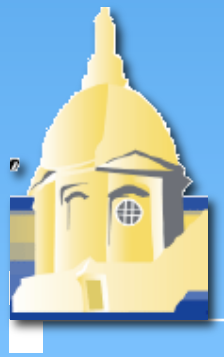
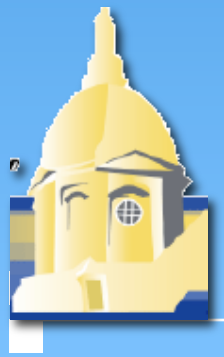
Media server and QoS (so far)

- Quality of service to quantify user experience
  - Admission and enforcement mechanisms to ensure QoS
- Media servers:
  - Different classes – goal is to service media to users
    - Servers, cloud services, simple devices (DVR)
    - Server based or Peer-to-peer
      - YouTube, Hulu, Google video, Vimeo etc.
      - PPLive, Joost, TVAnt, UUSee etc.
      - IPTV



Playback requests

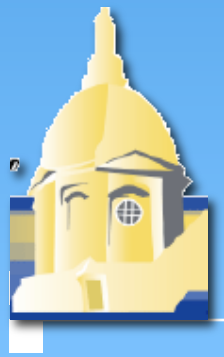
- Single Stream Playback
  - Possible approach – buffer the whole stream
    - Problem:??
  - Possible approach – prefetch just short video part
    - Problem:
      - Prevent starvation
      - Minimize buffer space requirement
      - Minimize initiation latency
- Multiple Streams Playback
  - Possible approach – dedicate a disk to each stream
    - Problem: ??
  - Possible approach – multiple streams per disk
    - Problems: ??



Slides courtesy Prof. Nahrstedt

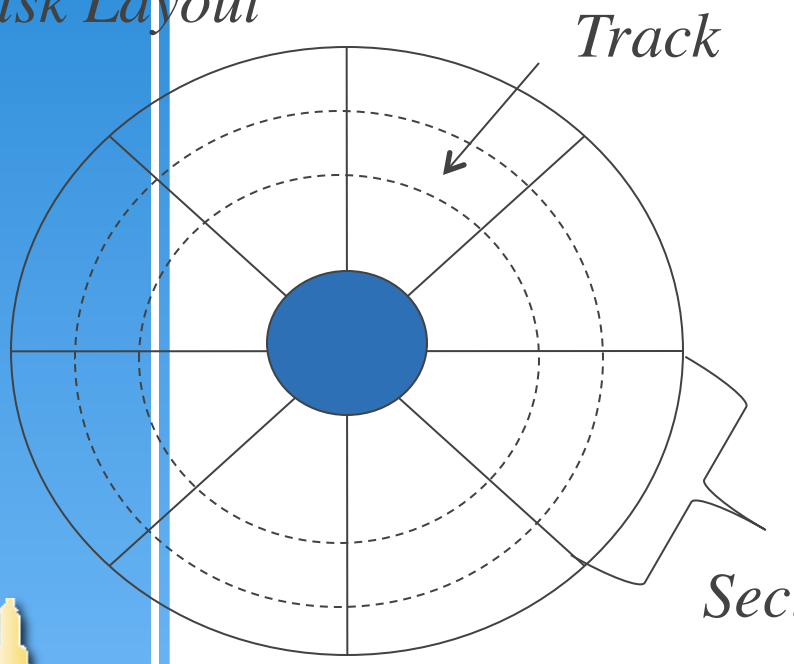
Support for Continuous Media

- Proper management of multimedia disk storage
  - Optimal placement of data blocks on disk
  - Usage of multiple disks
  - Role of tertiary storage
- Admission control
- Special disk scheduling algorithms and sufficient buffers to avoid jitter



Disk Layout

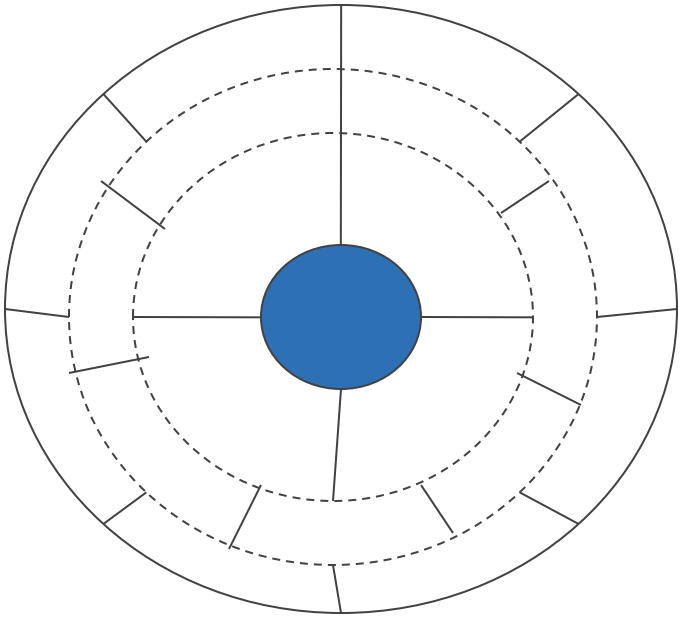
Traditional Random Access Disk Layout



Advantage: Easy mapping of location Information to head movement and disk rotation

Problem: loss of storage space

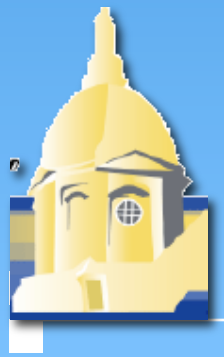
Zoned Disk (ZBR – Zone Bit Recording)



Advantage: Sector size same Rotation speed constant; efficient Usage of space

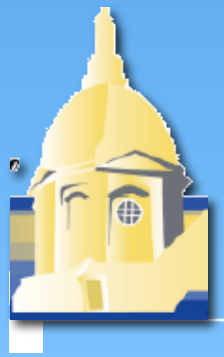
Storage Management

- Storage access time to read/write disk block is determined by 3 components
  - Seek Time
    - Time required for the movement of read/write head
  - Rotational Time (Latency Time)
    - Time during which transfer cannot proceed until the right block or sector rotates under read/write head
  - Data Transfer Time
    - Time needed for data to copy from disk into main memory

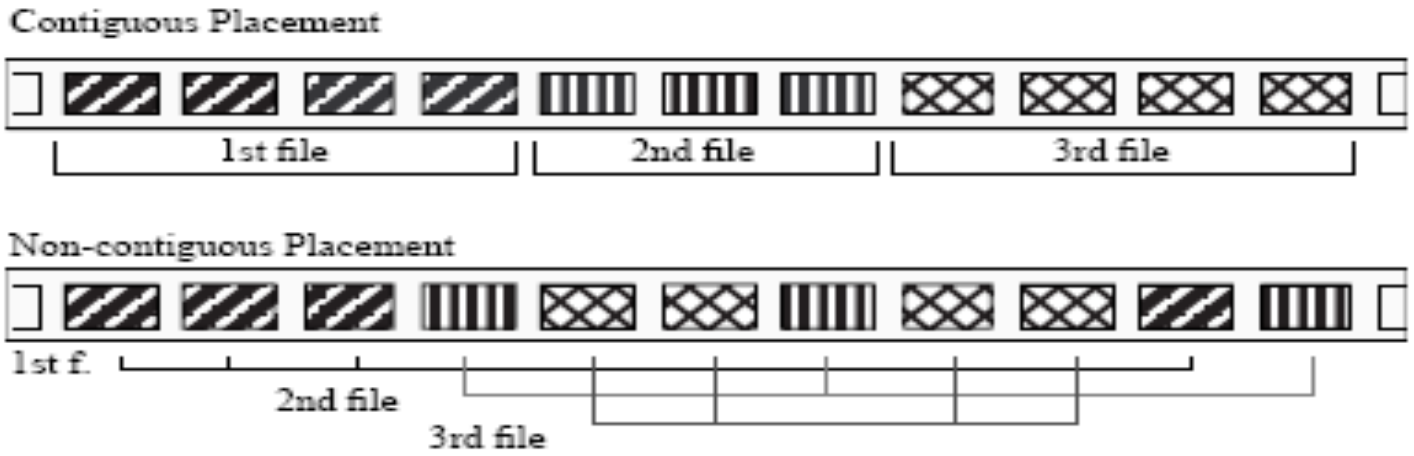


Placement is important

- Disk Layout and Number of disks play important role for media servers
- Data block placement and file placement are crucial for real-time retrieval on media servers



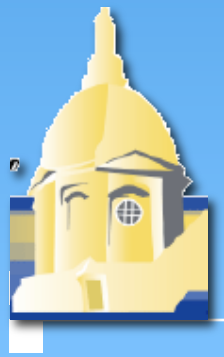
Placement of MM Data Blocks on Single Disk



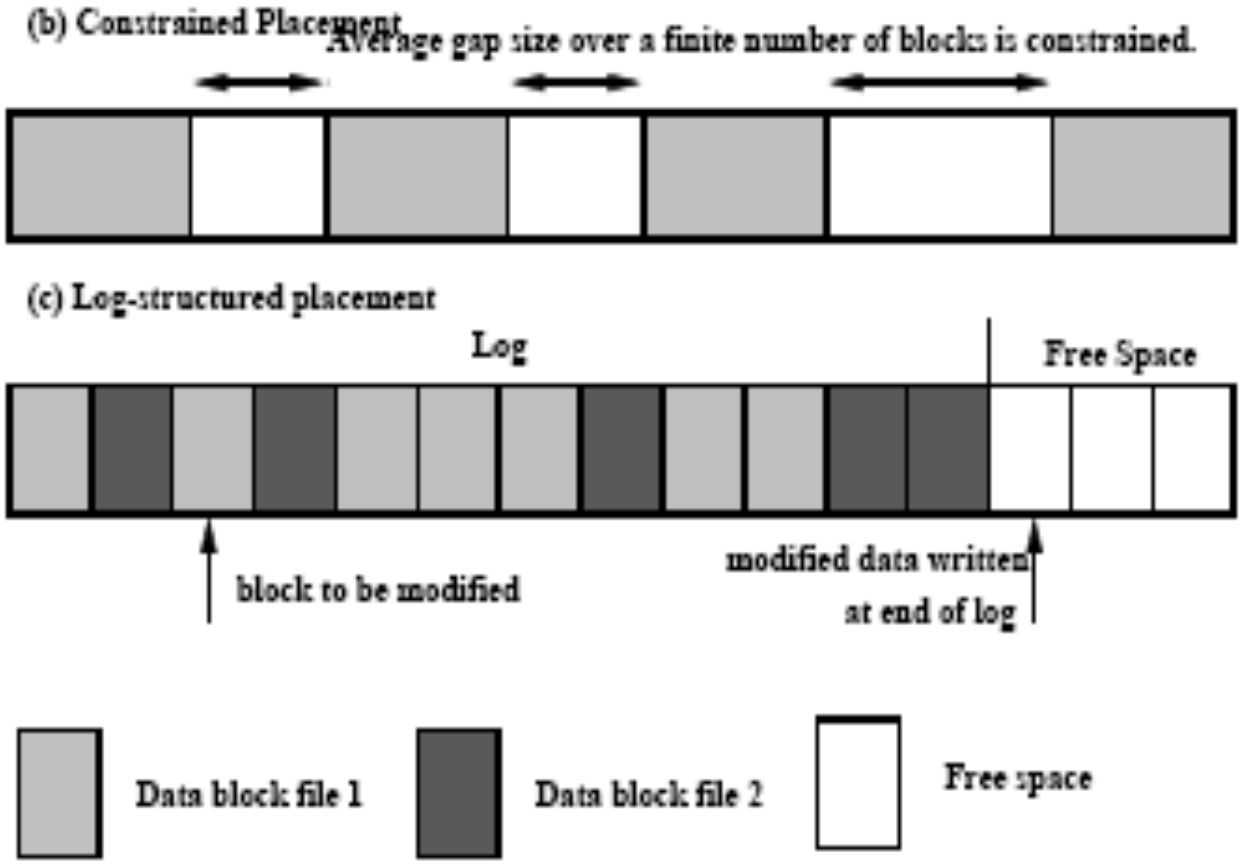
Continuous Placement	Scattered Placement
Simple to implement, but subject to fragmentation	Avoids fragmentation
Enormous copying overhead during insert/delete to maintain continuity	Avoid copying overhead
When reading file, only one seek required to position the disk head at the start of data	When reading file, seek operation incurs for each block , hence **intrafile seek**

Intra-file Seek Time

- Intra-file seek – can be avoided in scattered layout if the amount read from a stream always evenly divides block
- Solution: select sufficient large block and read one block in each round
  - If more than one block is required to prevent starvation prior to next read, deal with intra-file seek
- Solution: constrained placement or log-structure placement

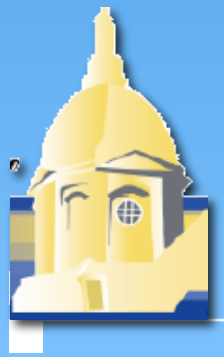


Scattered Non-continuous Placement



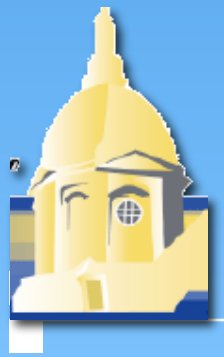
Constrained Placement

- Approach: separation between successive file blocks is bounded
  - Bound on separation – not enforced for each pair of successive blocks, but only on average over finite sequence of blocks
  - Attractive for small block sizes
  - Implementation – expensive
- For constrained latency to yield full benefit, scheduling algorithm must retrieve immediately all blocks for a given stream before switching to another stream



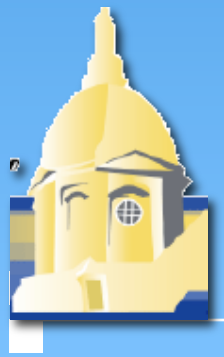
Log-Structure Placement

- This approach writes modified blocks sequentially in a large contiguous space, instead of requiring seek for each block in stream when writing (recording)
  - Reduction of disk seeks
  - Large performance improvements during recording, editing video and audio
- Problem: bad performance during playback
- Implementation: complex



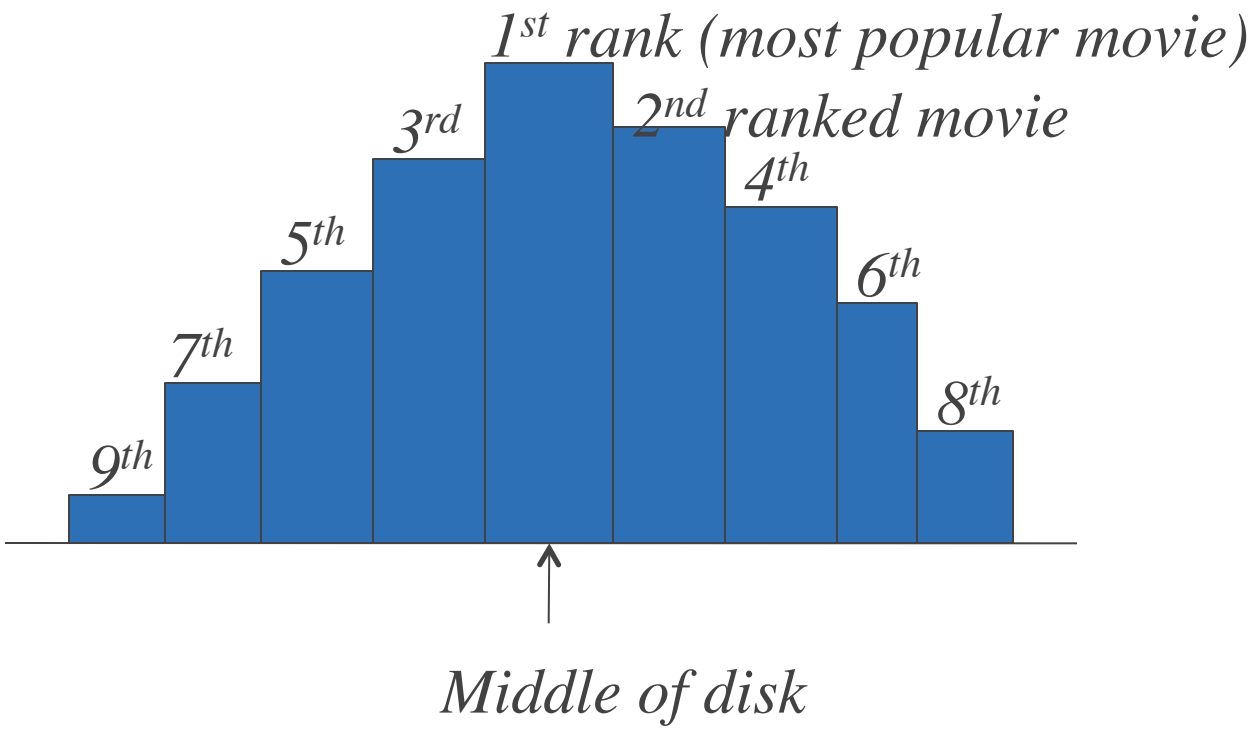
Placement of Multiple MM Files on Single Disk

- Popularity concept among multimedia content - very important
- Take popularity into account when placing movies on disk
- Model of popularity distribution – Zipf's Law
  - Movies are kth ranked
    - if their probability of customer usage is C/k,
      - C = normalization factor
    - Condition holds: C/1 + C/2 + … C/N = 1,
      - N is number of customers

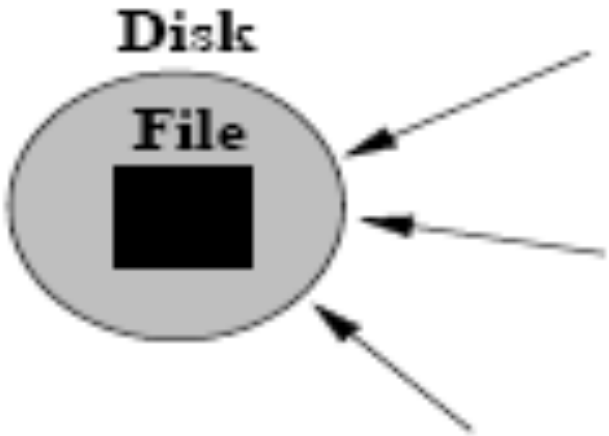


Placement Algorithm for Multiple Files on Single Disk

- Organ-Pipe Algorithms (Grossman and Silverman 1973)

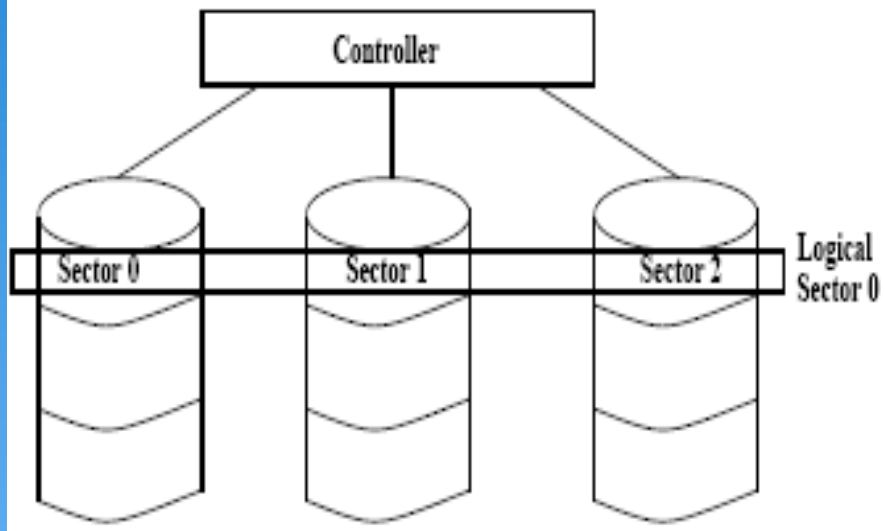


Need for Multiple Disks Solutions for Media Server



- Limitation of Single Disk: Disk Throughput
- Approach: 1 Maintain multiple copies of the same file on different disks
  - Very expensive
- Approach 2: Scatter multimedia file across multiple disks

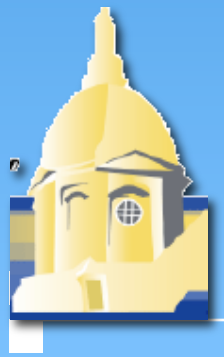
Approach: Data Striping



- RAID (Redundant Arrays of Inexpensive Disks)
  - Addresses both performance and security
  - (0-6) RAID levels – different approach at combining performance enhancements with security/fault-tolerance enhancements
- Disks spindle synchronously
  - Operate in lock-step parallel mode
- Striping improves BW, but does not improve seek or rotational delay

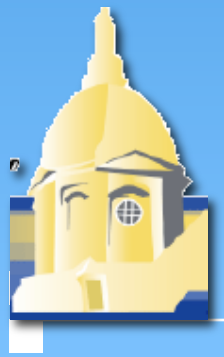
Storage/Disk Management

- Disk access – slow and costly
- Reduce disk access
  - Use block caches (anticipate future reads or writes)
  - Reduce disk arm motion
    - Blocks accesses in sequence (continuously) , place together on one cylinder
    - Interleaved vs non-interleaved storage



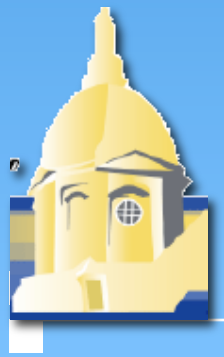
Disk Scheduling Policies

- Goal of Scheduling in Traditional Disk Management
  - Reduce cost of seek time
  - Achieve high throughput
  - Provide fair disk access
- Goal of Scheduling in Multimedia Disk Management
  - Meet deadline of all time-critical tasks
  - Keep necessary buffer requirements low
  - Serve many streams concurrently
  - Find balance between time constraints and efficiency



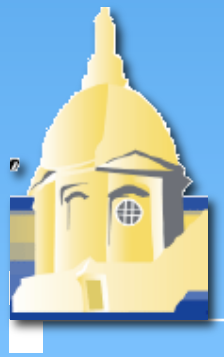
EDF (Earliest Deadline First) Disk Scheduling

- Each disk block request is tagged with deadline
- Policy:
  - Schedule disk block request with earliest deadline
  - Excessive seek time – high overhead
  - Pure EDF must be adapted or combined with file system strategies



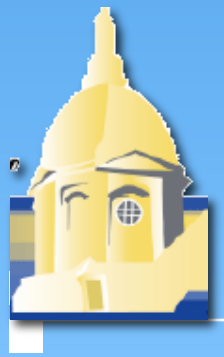
SCAN-EDF Scheduling Algorithm

- Combination of SCAN and EDF algorithms
- Each disk block request tagged with augmented deadline
  - Add to each deadline perturbation
- Policy:
  - SCAN-EDF chooses the earliest deadline
  - If requests with same deadline, then choose request according to scan direction



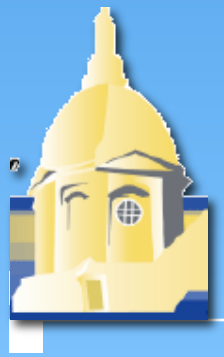
Service Requirements for Real-time Flows (Voice/Video) in the network

- Sequencing
- Intra-media synchronization
- Inter-media synchronization
- Payload identification
- Frame indication



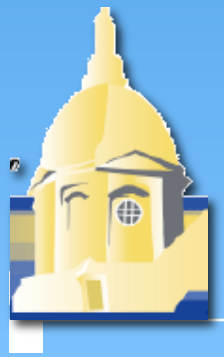
Popular protocols

- Network transmission control
  - RTP – Realtime Transmission Protocol
    - RTCP – Realtime Transmission Control Protocol
- Session control
  - Real-Time Streaming Protocol (RTSP)
  - Session Description Protocol (SDP) – textual representation of sesion
- VOIP – SIP – Session Initiation Protocol
  - Signaling for IP Telephony
- SAP – Session announcement protocol for multicast sessions



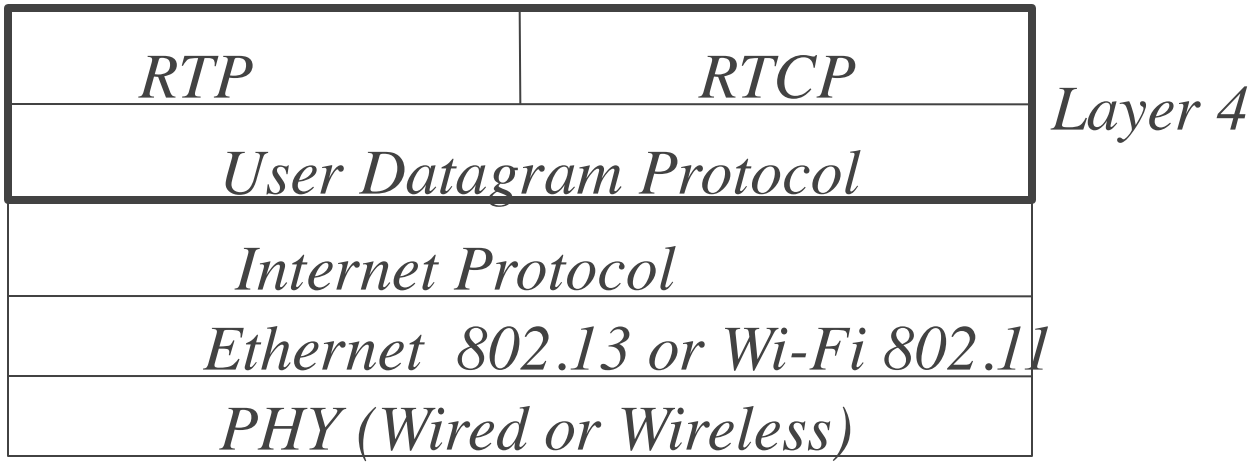
RTP and RTSP

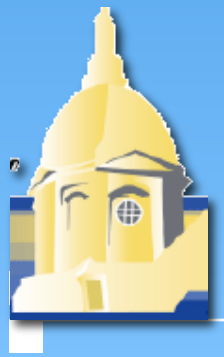
- RTP usage – in several application audio and video tools (vat, vic)
- RTP follows the principle of application level framing and integrated layer processing
- RTP/UDP/IP is being used by the current streaming session protocols such as RTSP
- Session protocols are actually negotiation/session establishment protocols that assist multimedia applications
- Multimedia applications such as QuickTime, Real Player and others use them



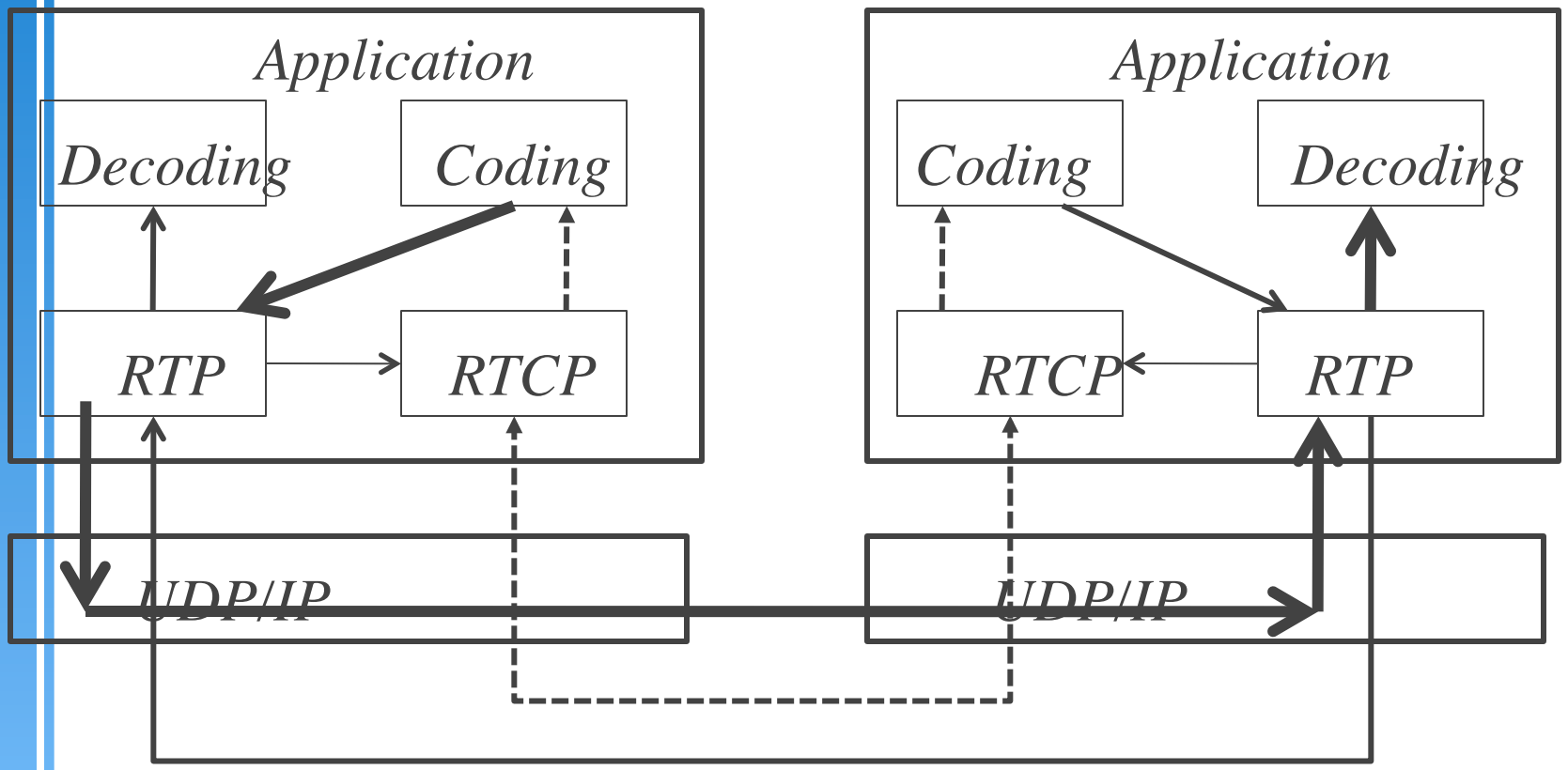
Real-time Transmission Protocol (RTP)

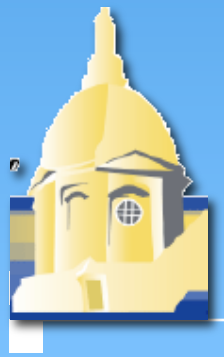
- RTP provides end-to-end transport functions suitable for real-time audio/video applications over multicast and unicast network services
- RTP companion protocol – Real-time Transport Control Protocol (RTCP)





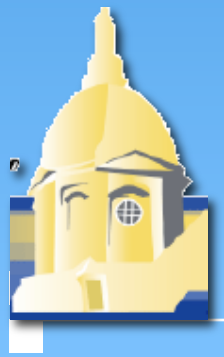
Relation between RTP and RTCP





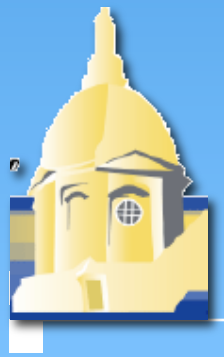
RTCP: Control and Management

- Out-of-band control information for RTP flow.
  - Monitors QoS for RTP in the delivery and packaging of multimedia data
  - Used periodically to transmit control packets to participants in a streaming multimedia session.
  - Provides feedback on the quality of service being provided by RTP.
  - Gathers statistics on media connection
    - Bytes sent, packets sent, lost packets, jitter, feedback and round trip delay.
    - Application may use this information to increase the quality of service, perhaps by limiting flow or using a different codec.



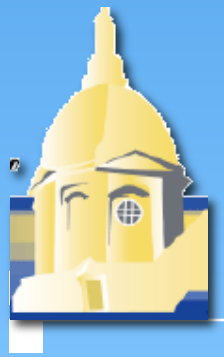
RTCP Functions

- There are several type of RTCP packets:
  - Sender report packet,
  - Receiver report packet,
  - Source Description RTCP Packet,
  - Goodbye RTCP Packet and
  - Application Specific RTCP packets.
- RTCP itself does not provide any flow encryption or authentication means. SRTCP protocol can be used for that purpose.



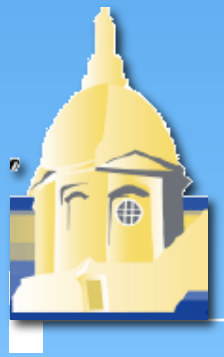
RTP Services

- Payload Type Identification
  - Determination of media coding
  - Source identification
  - RTP works with Profiles
    - Profile defines a set of payload type codes and their mappings to payload formats
- Sequence numbering
  - Error detection
- Time-stamping
  - Time monitoring, synchronization, jitter calculation
- Delivery monitoring



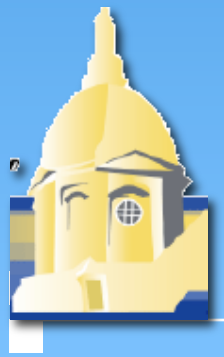
RTP Services – Support of Heterogeneity

- Mixer service
  - Allows for resynchronization of incoming audio packets
  - Reconstructs constant 20 ms spacing generated by sender
  - Mixes reconstructed audio streams into single stream
  - Translated audio encoding to lower bandwidth
  - Forwards lower bandwidth packet streams
- Translator service
  - Allows for translation between IP and other high speed protocols
  - May change encoding data



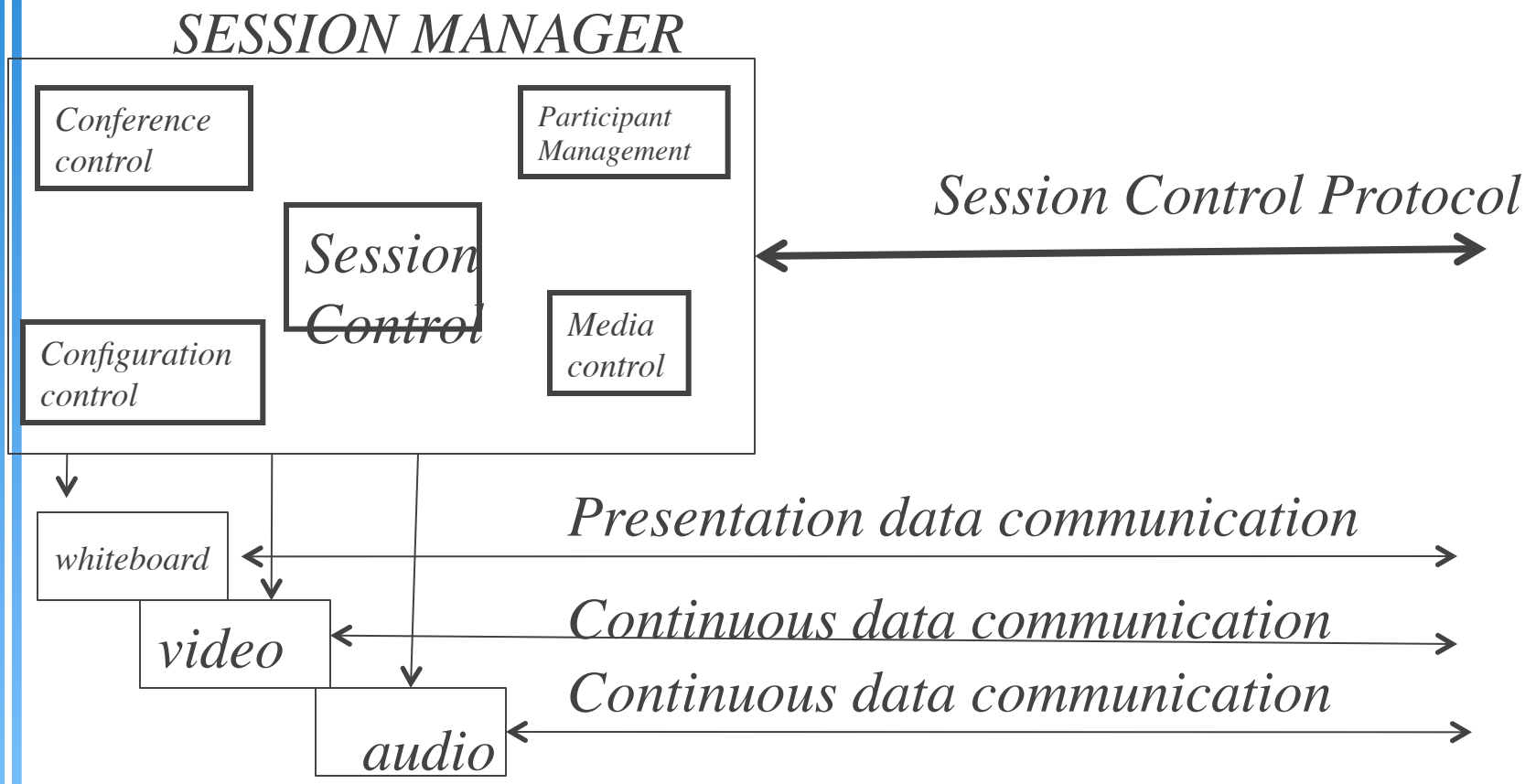
Payload Formats

- Static Payload formats
  - Established in RTP Profile
  - Payload type 0 := μ-law audio codec
- Dynamic Payload formats
  - Applications agree per session on payload format
  - H.263, JPEG, MPEG



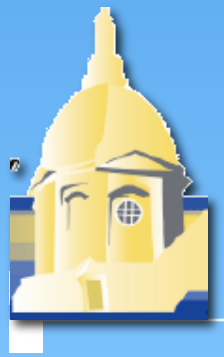
Session Management (Layer 5)

- Important part of multimedia communication
- Separates control aspects from transport aspects



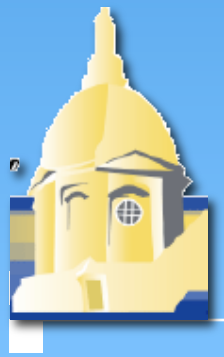
Session Manager

- Tasks:
  - Membership control
  - Monitoring of shared workspace
  - Coordination of Media control management
  - Exchange of QoS parameters
  - Conference control management – establishment, modification, termination



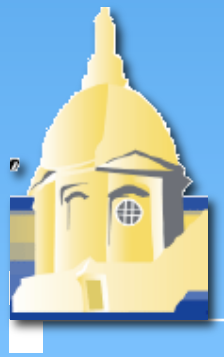
Session Control

- Session Described by
  - Session state
    - Name of session, start, valid policies
- Session management – two steps for state processing
  - Establishment of session
  - Modification of session



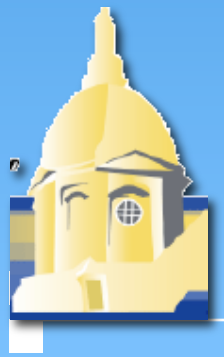
Session Control

- Conference Control
  - Centralized or distributed approach
- Media Control
  - Synchronization
- Configuration Control
  - Negotiation of QoS parameters, admission control and reservation/allocation of resources
- Membership Control
  - Invitation of users; registration of users, change of membership



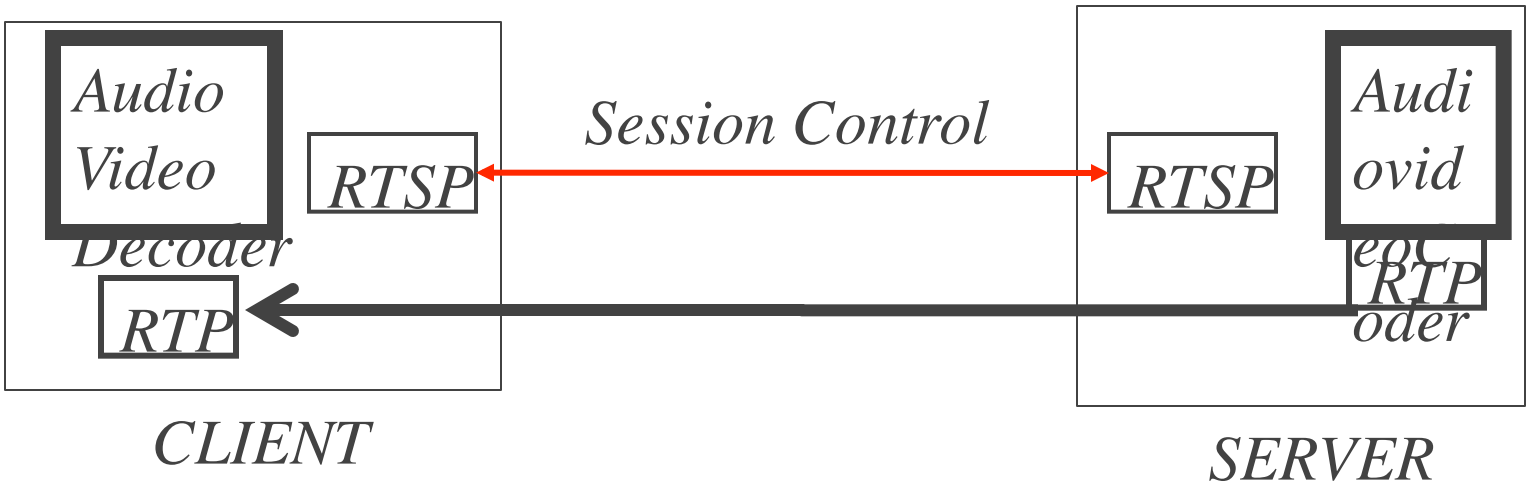
RTSP

- Enables controlled, on-demand delivery of real-time data such as audio and video
- Intends to control multiple data delivery sessions
- Provides means for choosing delivery channels
  - UDP
  - Multicast UDP,
  - TCP



Real-Time Streaming Protocol (RTSP)

- Application Protocol for Control of multimedia streams
- This is not an application data transmission protocol, just remote control protocol between client and server

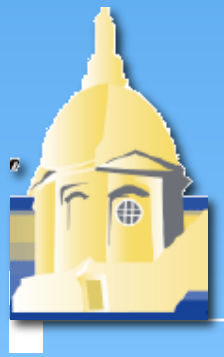


RTSP Methods

Request	Direction	Description
OPTIONS	S <-> C	Determine capabilities of server (S) or client (C)
DESCRIBE	C -> S	Get description of media stream
ANNOUNCE	S <-> C	Announce new session description
SETUP	C -> S	Create media session
RECORD	C -> S	Start media recording
PLAY	C -> S	Start media delivery
PAUSE	C -> S	Pause media delivery
REDIRECT	S -> C	Use other server
TEARDOWN	C -> S	Destroy media session
SET_PARAMETER	S <-> C	Set server or client parameter
GET_PARAMETER	S <-> C	Read server or client parameter

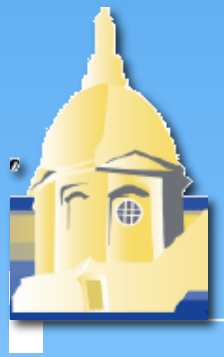
RTSP Extensions

- Timing
  - RTSP needs to hide latency variations
  - PLAY request may contain information about when request is to be executed
- Three types of timestamps
  - SMPTE (the same as in TV production)
    - Format: hours:minutes:seconds:frames
  - Normal play time
    - Measured relative to beginning of stream and expressed in ours, minutes, seconds and fractions of second
  - Absolute time
    - Wall clock



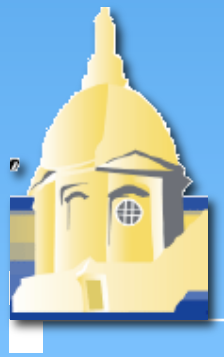
Session Description Protocol (SDP)

- Text format for describing multimedia sessions
- Not really a protocol (similar to markup language like HTML)
- Can be carried in any protocol, e.g., RTSP or SIP
- Describes unicast and multicast sessions



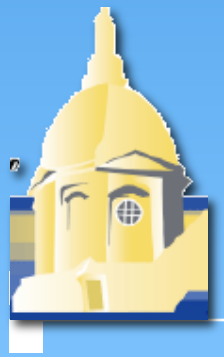
SDP

- There are five terms related to multimedia session description:
  - Conference: It is a set of two or more communicating users along with the software they are using.
  - Session : Session is the multimedia sender and receiver and the flowing stream of data.
  - Session Announcement: A session announcement is a mechanism by which a session description is conveyed to users in a proactive fashion, i.e., the session description was not explicitly requested by the user.
  - Session Advertisement : same as session announcement
  - Session Description : A well defined format for conveying sufficient information to discover and participate in a multimedia session.



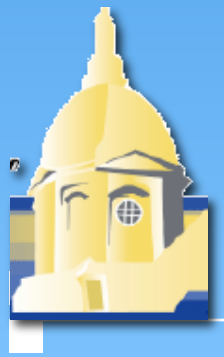
Sample SDP file

```
v=0
o=- 19 1077294547 IN IP4 127.0.0.0
s=QuickTime
t=0 0
a=range:npt=now-
a=control:rtsp://127.0.0.1/mystream.sdp
a=isma-compliance:2,2.0,2
m=audio 0 RTP/AVP 96
c=IN IP4 0.0.0.0
b=AS:8
a=rtpmap:96 mpeg4-generic/8000/1
a=fmtp:96 profile-level-id=15;mode=AAC-
    hbr;sizelength=13;indexlength=3;indexdeltalength=3;config=1588
a=mpeg4-esid:101
m=video 0 RTP/AVP 97
c=IN IP4 0.0.0.0
b=AS:30
a=rtpmap:97 H264/90000
a=fmtp:97 packetization-mode=1;profile-level-id=4D400A;sprop-parameter-
    sets=J01ACqkYUI/LgDUGAQa2wrXvfAQ=,KN4JF6A=
a=mpeg4-esid:201
a=cliprect:0,0,120,160
a=framesize:97 160-120
```



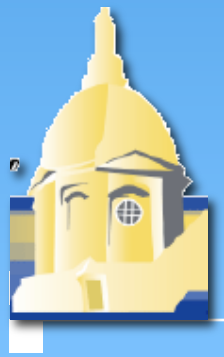
Signaling for IP Telephony

- Internet Telephone – needs ability of one party to signal to other party to initiate a new call
- Call – association between a number of participants
  - Note: there is no physical channel or network resources associated with the session layer connection, the connection exists only as signaling state at two end points



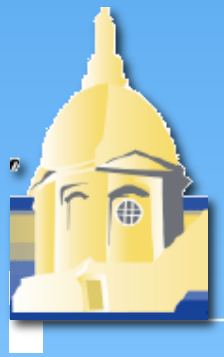
IP Telephony Signaling Protocol (Requirements)

- Name translations and user location
  - Mapping between names of different levels of abstraction
    - Email address to IP address of host
- Feature negotiation
  - Group of end systems must agree on what media to exchange ad their respective parameters
    - Different encodings, rates
- Call Participant Management
    - Invite participants to existing call, transfer call and hold other users



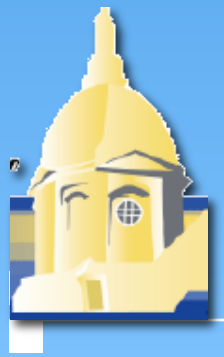
IP Telephony Signaling (Requirements)

- Feature change
  - Adjust composition of media sessions during the course of call
    - Add or reduce functionality
    - Impose or remove constraints due to addition or removal of participants
- Two signaling protocols:
  - **SIP** (IETF Standard)
  - **H.323** (ITU Standard)



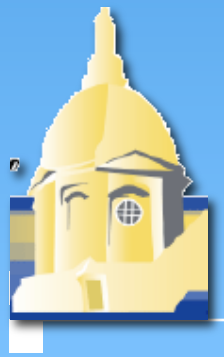
SIP (Session Initiation Protocol)

- SIP Goal: invite new participants to call
- Client-Server protocol at the application level
- Protocol:
  - User/Client creates requests and sends to server;
  - User agent server responds;
- SIP requests can traverse many proxy servers
- Server may act as redirect server
- Proxies or redirect servers cannot accept/reject requests, only user agent server can
- Requests/Responses are textual



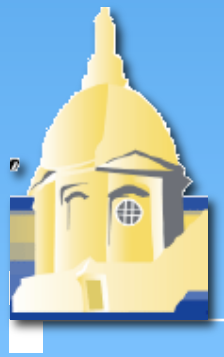
SIP - Message

- Calls in SIP – have unique call ID (carried in Call-ID header field of SIP message)
- Call identifier is created by the caller and used by all participants
- SIP messages have information
  - Logical connection source
  - Logical connection destination
  - Media destination
  - Media capabilities (use SDP)

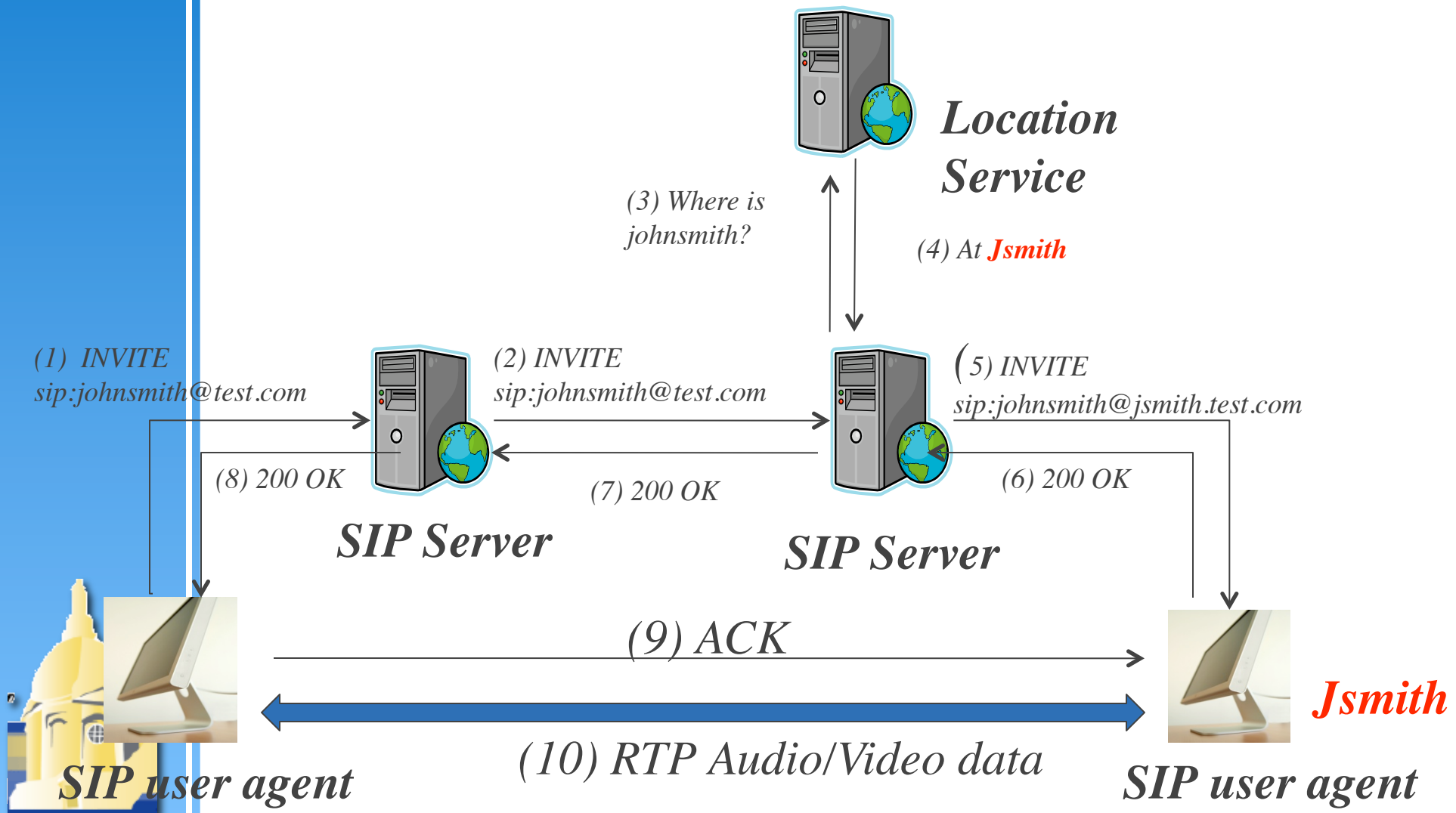


SIP – Addressing and Naming

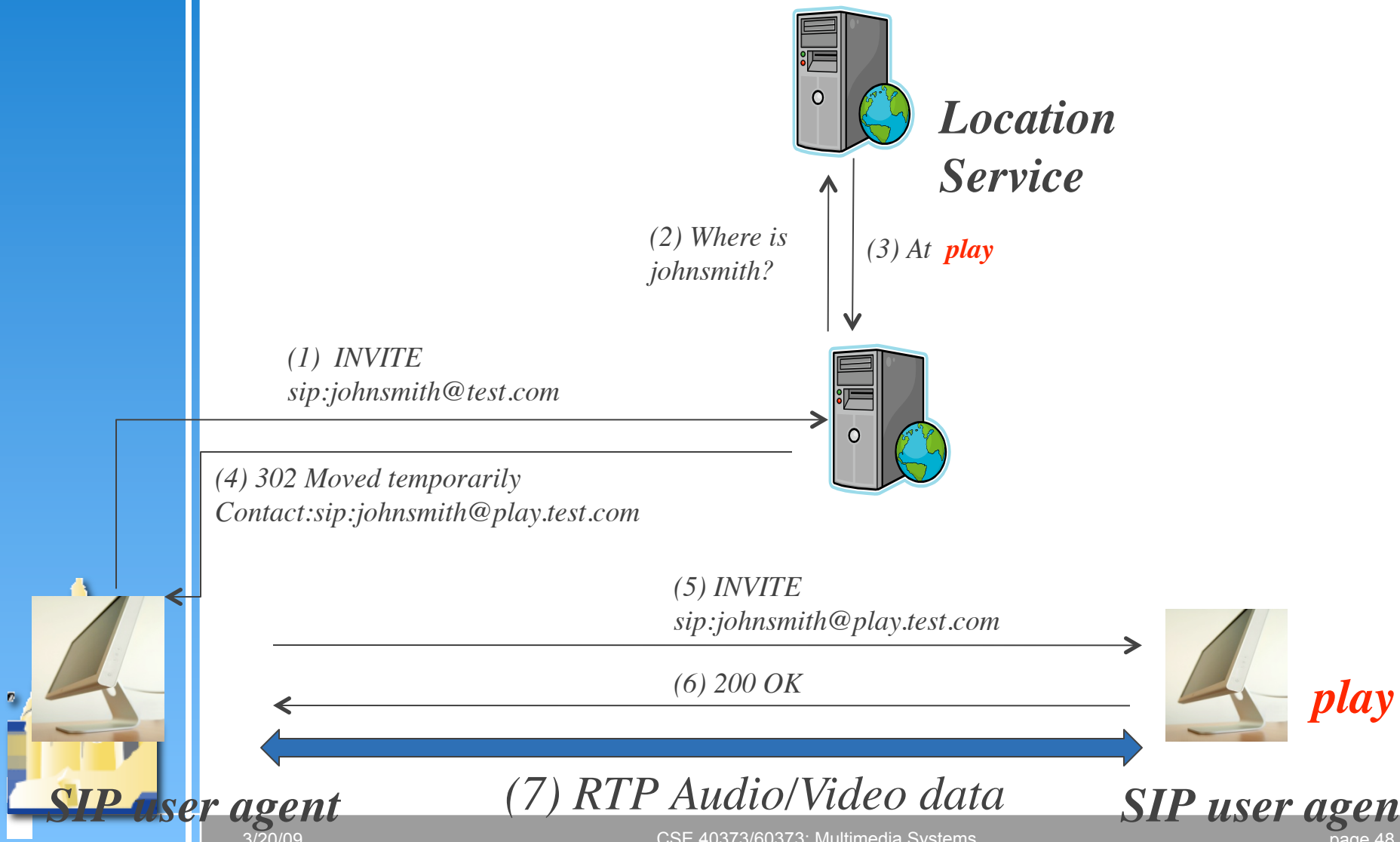
- To be invited and identified, called party must be named
- SIP chooses email-like identifier
  - user@domain
  - user@host
  - user@IPaddress
  - phone-number@gateway
- SIP's address: part of SIP URL
  - sip:j.doe@example.com
  - URL can be placed on web page
- Interactive audio/video requests translation
  - name@domain to host@host



Call Setup Process using SIP

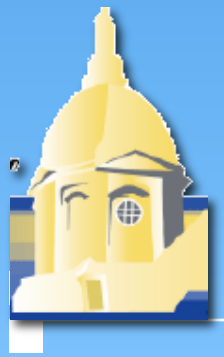


SIP Redirect Server Operation



SIP Requests/Methods

- INVITE—Indicates a client is being invited to participate in a call session.
- ACK—Confirms that the client has received a final response to an INVITE request.
- BYE—Terminates a call and can be sent by either the caller or the callee.
- CANCEL—Cancels any pending searches but does not terminate a call that has already been accepted.
- OPTIONS—Queries the capabilities of servers.
- REGISTER—Registers the address listed in the To header field with a SIP server.



SAP – Session Announcement Protocol

- RTSP and SIP are designed for one-on-one session
- SAP is multicast announcement protocol
- Protocol
  - Distributed servers periodically send multicast packets (advertisements) containing descriptions of sessions generated by local sources
  - Advertisements are received by multicast receivers on well-known , static multicast address/port
- Advertisement contains SDP information to start media tools needed in the session