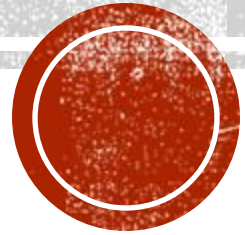
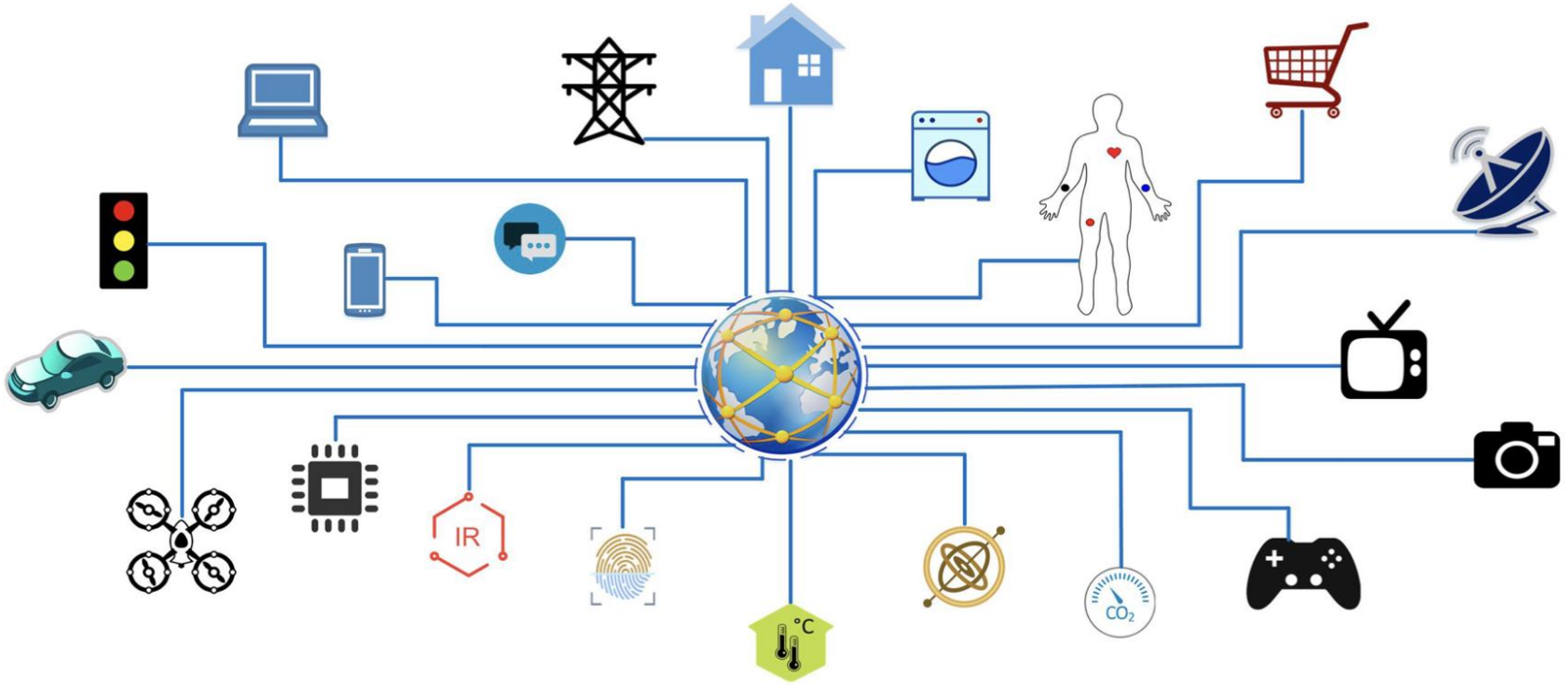
CHAPTER 9: MULTIMEDIA COMMUNICATION SYSTEM



Multimedia Systems

Robinhood Khadka

- Multimedia Communication



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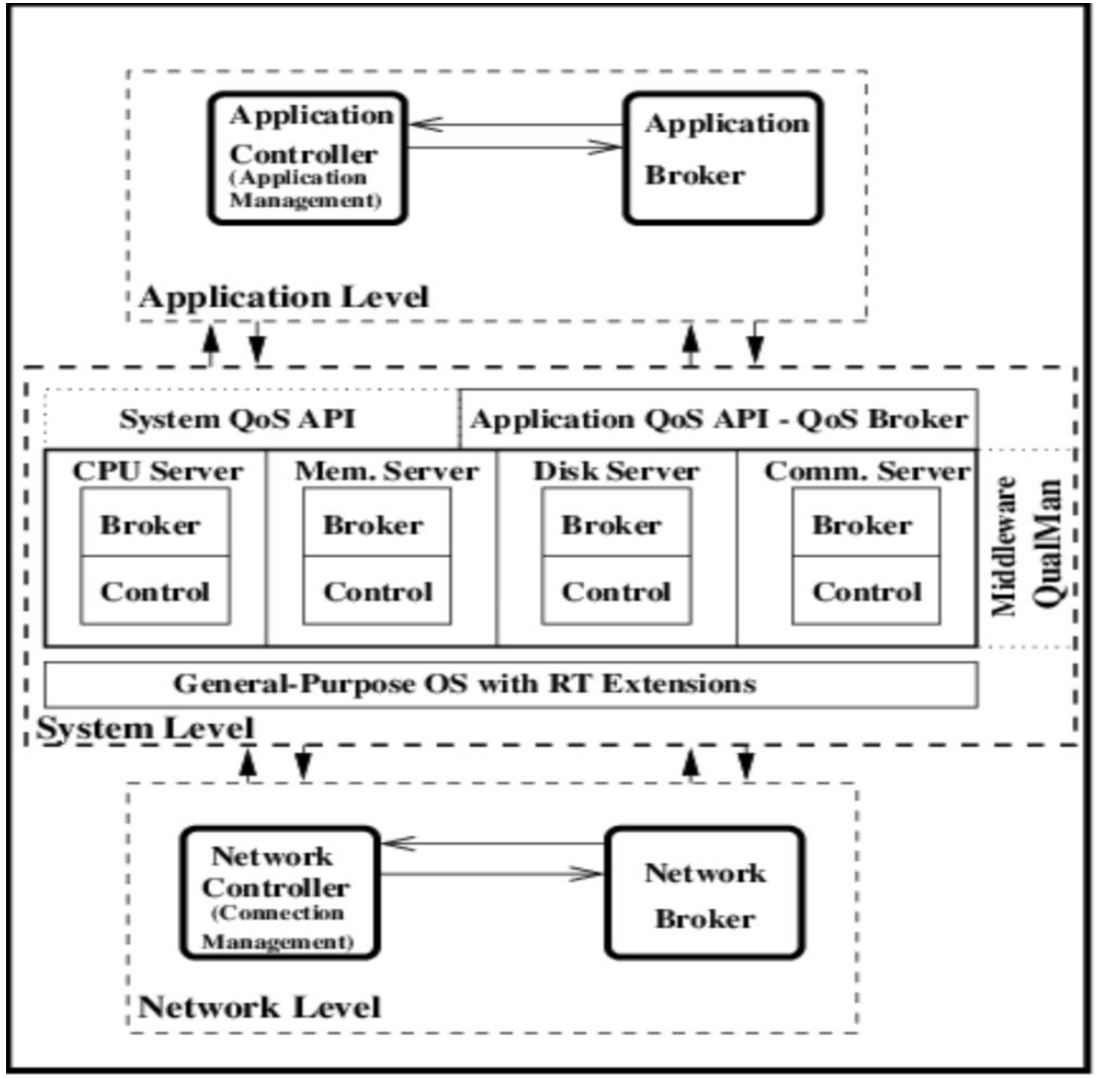
MULTIMEDIA COMMUNICATION SYSTEM



- **Applications**

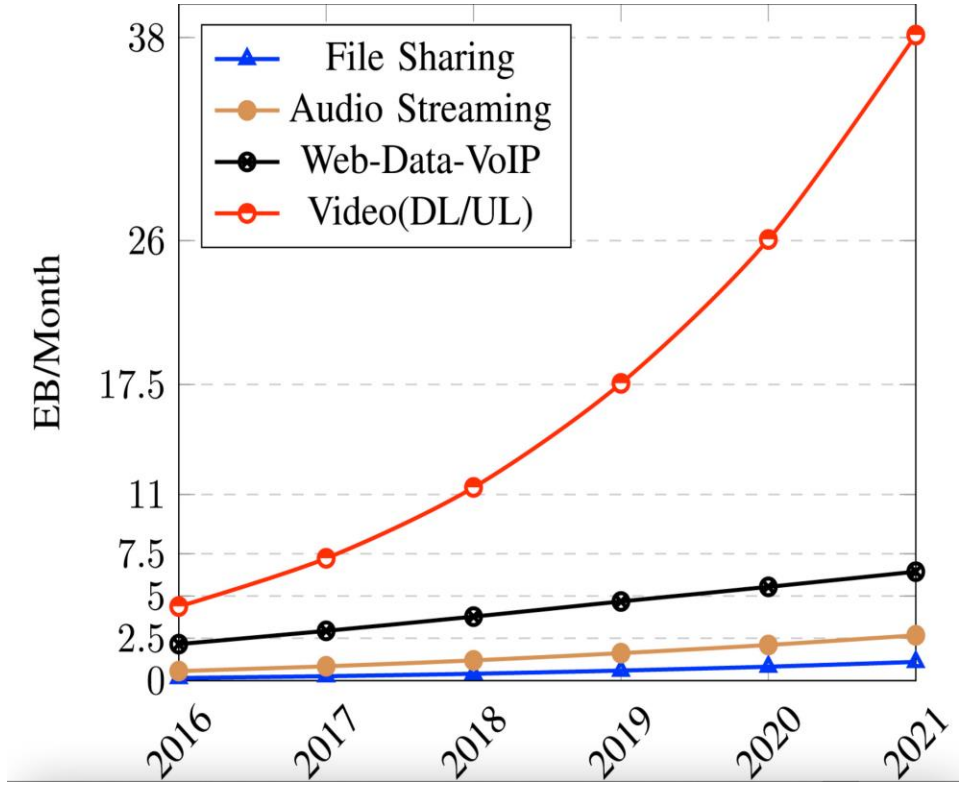
  - ✓ Video Conferencing (Zoom, Microsoft Teams)
  - ✓ Streaming Services (YouTube, Netflix)
  - ✓ Online Education (Webinars, interactive classes)
  - ✓ Telemedicine (Remote medical consultations)
  - ✓ Social Media (Sharing multimedia content)

INTRODUCTION

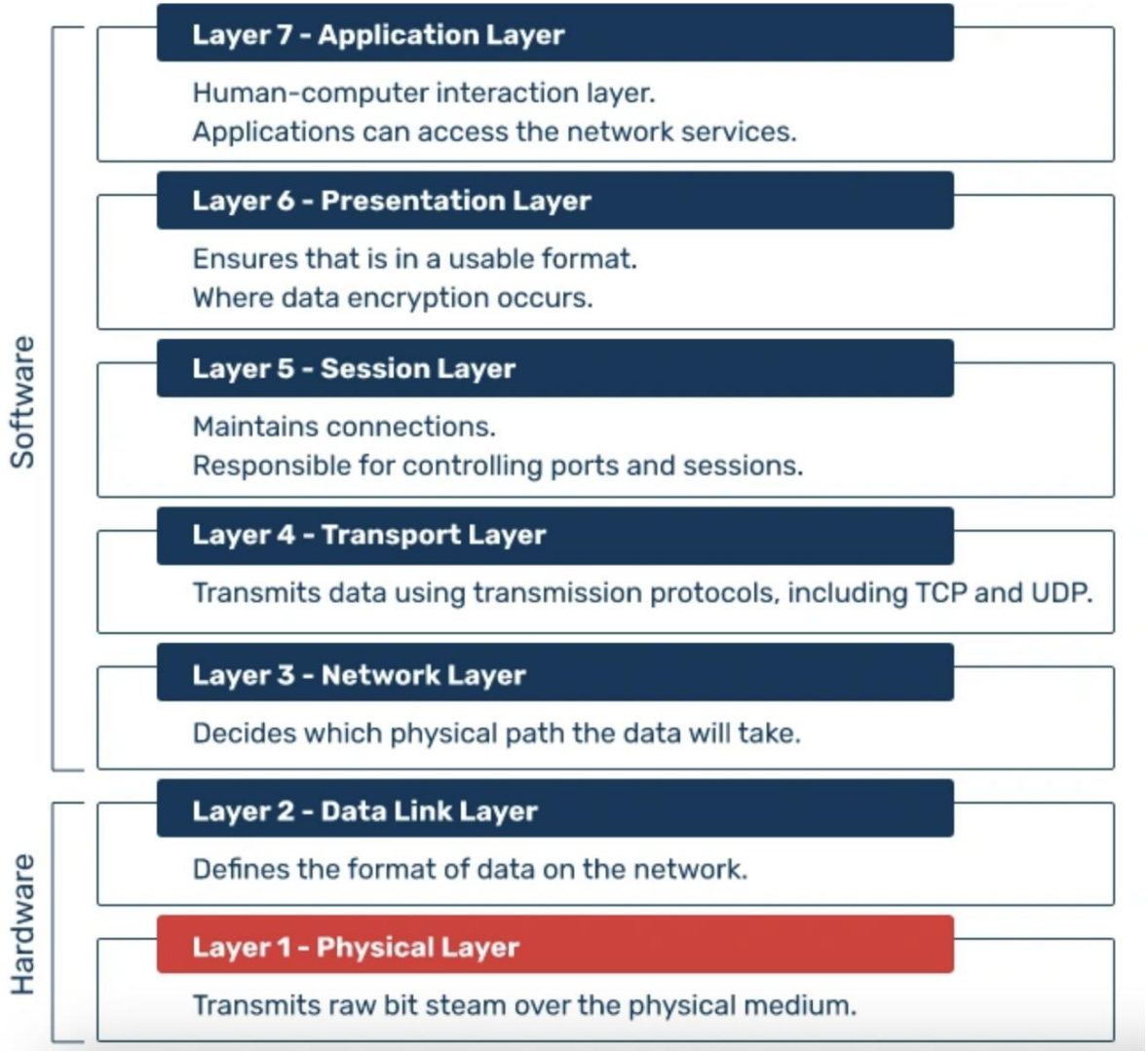
- An MMCS(Multimedia Communication System) or media space is "formed by the combination of audio, video and computer networking technologies to provide a flexible, dynamic interconnection environment for collaborative work groups"
- When a computer requires information from remote computers or servers, multimedia information must travel through computer networks.
- Because the amount of information involved in the transmission of video and audio can be substantial, the multimedia information must be compressed before it can be sent through the network in order to reduce the communication delay.
- Constraints, such as limited delay and jitter, are used to ensure a reasonable video and audio effect at the receiving end.
- Therefore, communication networks are undergoing constant improvements in order to provide for multimedia communication capabilities.
- Obviously, compared to the traditional services, these multimedia applications require a higher level of Quality of Service (QoS) and Quality of Experience (QoE).

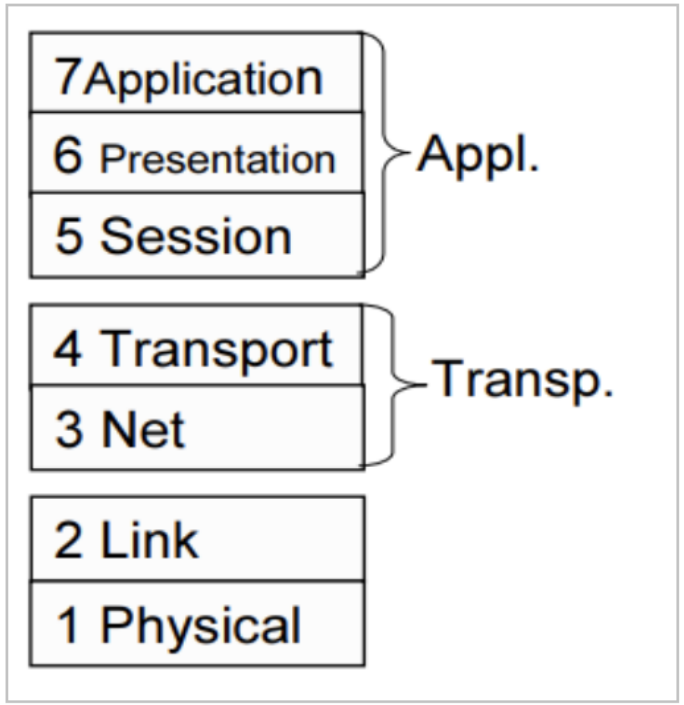
INTRODUCTION

- *Graph shows that exponential growth of video downlink and uplink more than any other multimedia application.*
- In multimedia communication, the efficient use of spectrum and its pricing (measured in MHz-pop) directly impacts the delivery of various types of media content, including video, audio, images, and interactive applications.
- Video streaming (like Netflix, YouTube) is downlink-heavy since users primarily receive content.
- Video conferencing (like Zoom, Google Meet) generates significant uplink traffic since both participants send and receive video.
- "Multimedia communication system deals with the transfer, protocols, services, and mechanisms of discrete media data (such as text and graphics) and continuous media data (like audio and video) in/over digital networks."



OSI LAYER: APPLICATION/TRANSPORT SUBSYSTEM





APPLICATION-SUBSYSTEM

- The application subsystem handles the generation, processing, and presentation of multimedia data. It manages user-level applications, interface requirements, and multimedia formats for large groups.

1. Multimedia Application Layer:

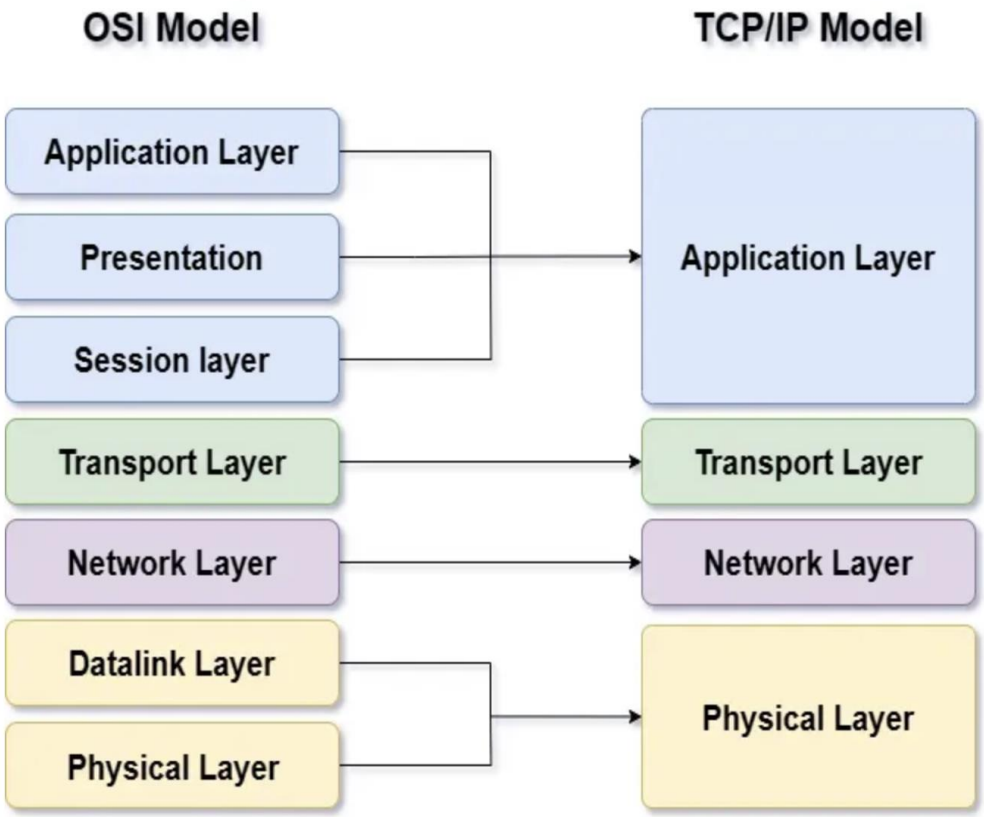
- Examples: Video conferencing tools, streaming services, gaming platforms. Functions: Provides user interaction, content creation, editing, playback, and controls.

2. Encoding and Compression:

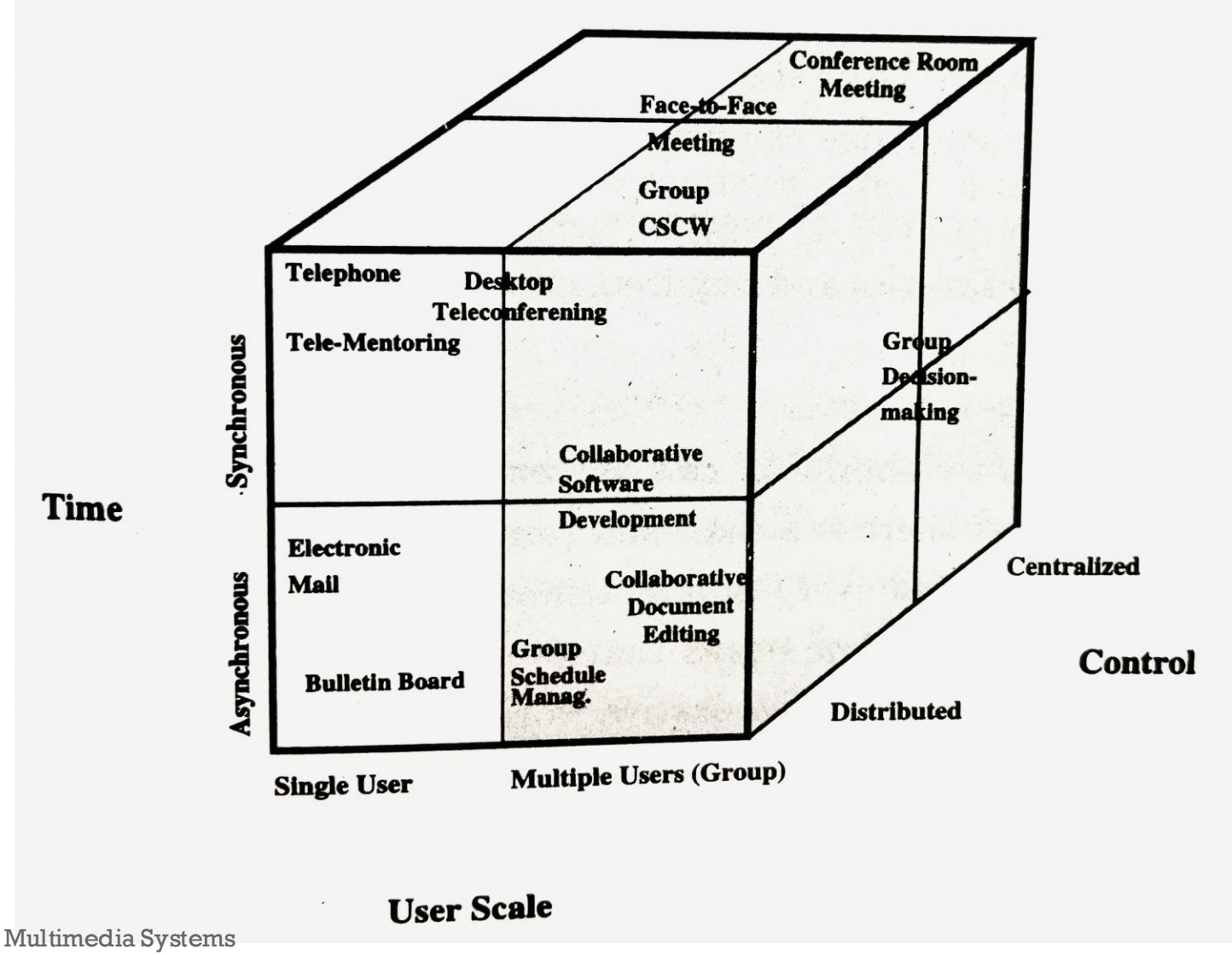
- Multimedia data like video, audio, and images are large and need compression to be transmitted efficiently. H.264, H.265 (for video), MP3 (for audio).

3. Synchronization and Multimedia Control:

- Ensures lip synchronization between audio and video. Coordinates the timing between multiple media streams.



COLLABORATIVE DIMENSION



COLLABORATIVE COMPUTING DIMENSIONS

- Collaborative computing is the computer supported cooperative work connected by the networks, PCs and the software that facilitates the cooperation.

  - The collaborative dimensions are
    1. Time ,
    2. User Scale,
    3. Control

  1. Time:

  - With respect to time, there are two modes of cooperative work: *Asynchronous and Synchronous*
  - Asynchronous cooperative work specifies processing activities that do not happen at the same time.
  - Synchronous cooperative work happens at the same time.

2. User Scale:

- Specifies whether a single user collaborates with another user or a group of more than two users collaborate together.
- A group may be static or dynamic during its lifetime.
- Static: If its participating members are pre-determined.
- Dynamic: If the number of group members varies during the collaborative activity

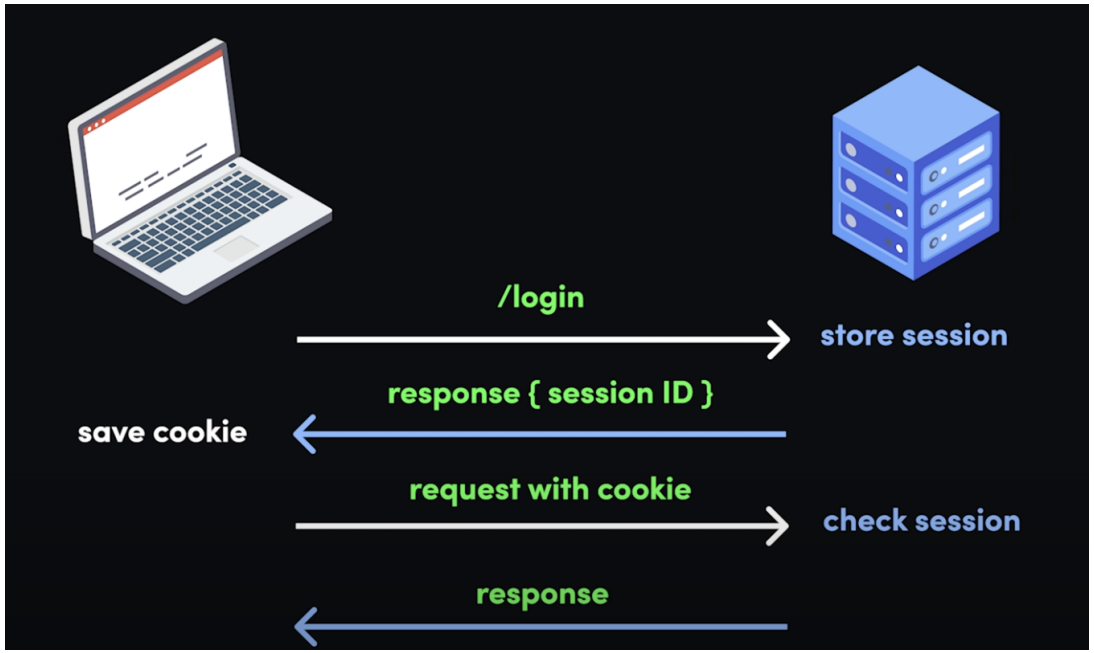
  e.g. Video conferencing is also a user to group interaction application.

3. Control:

Control during collaboration can be centralized or distributed.

- Centralized control means that there is a chairman (e.g., main manger).
- Distributed control means that every group member has control over his/her own tasks.

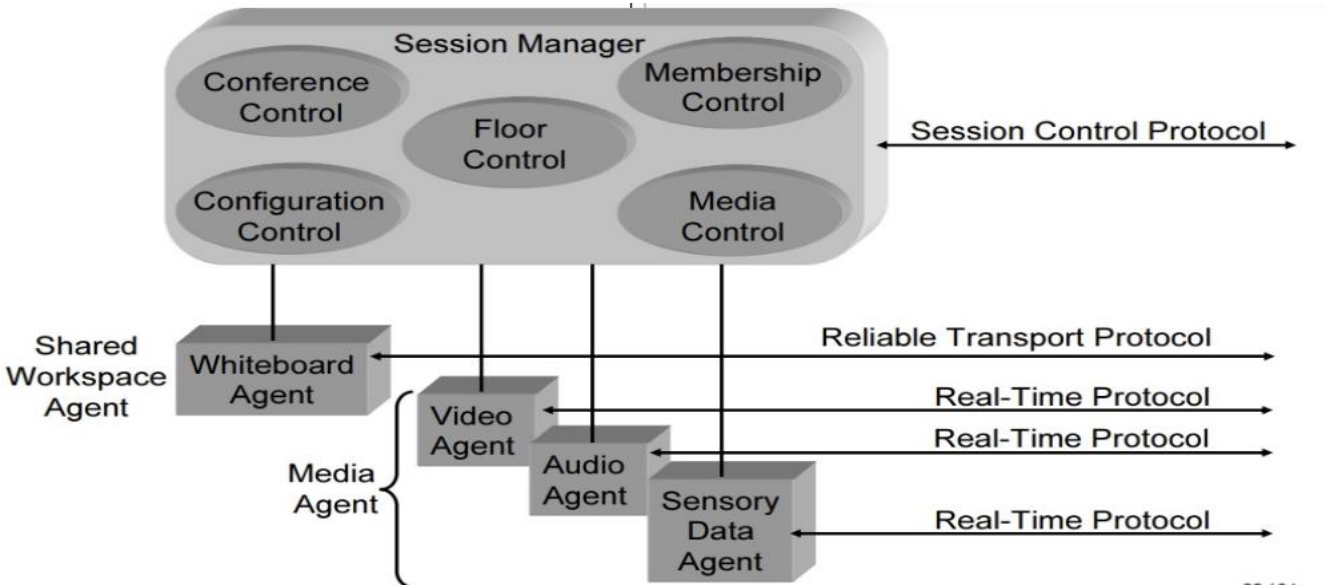
SESSION MANAGEMNT



- Session management is the process of handling interactions between a user and a web application.
- Session management addresses this by creating a session—a series of related user interactions within a specific timeframe.
- By managing sessions effectively, web applications can maintain user state, personalize experiences, and enhance security.

SESSION MANAGEMENT

- Session management is an important part of the multimedia communication architecture.
- It is the core part which separates the control, needed during the transport, from the actual transport.



- A session is the total logged in time of a user or it can be the entire conference from its commencement to its termination. It includes:

- (1) Membership control management: such as participant authentication or presentation of coordinated user interfaces.
- (2) Floor Control management :control and manage the access to the shared workspace, the resources etc. It is also required for maintaining the data consistency.
- (3) Media control management, such as intercommunication among media agents or synchronization.
- (4) Configuration management, such as an exchange of interrelated QoS parameters of selection of appropriate services according to QoS.
- (5) Conference control management, such as an establishment, modification and a closing of a conference.

TRANSPORT-SUBSYSTEM

- The transport subsystem provides the underlying infrastructure for transmitting multimedia data across networks. It deals with data transport, ensuring quality of service (QoS), and managing network congestion.

1. Transport Protocols:
   - User Datagram Protocol (UDP): Commonly used for real-time multimedia applications due to its low latency and simplicity.
   - Transmission Control Protocol (TCP): Used for reliable but non-real-time data (e.g., file transfers, HTTP streaming).

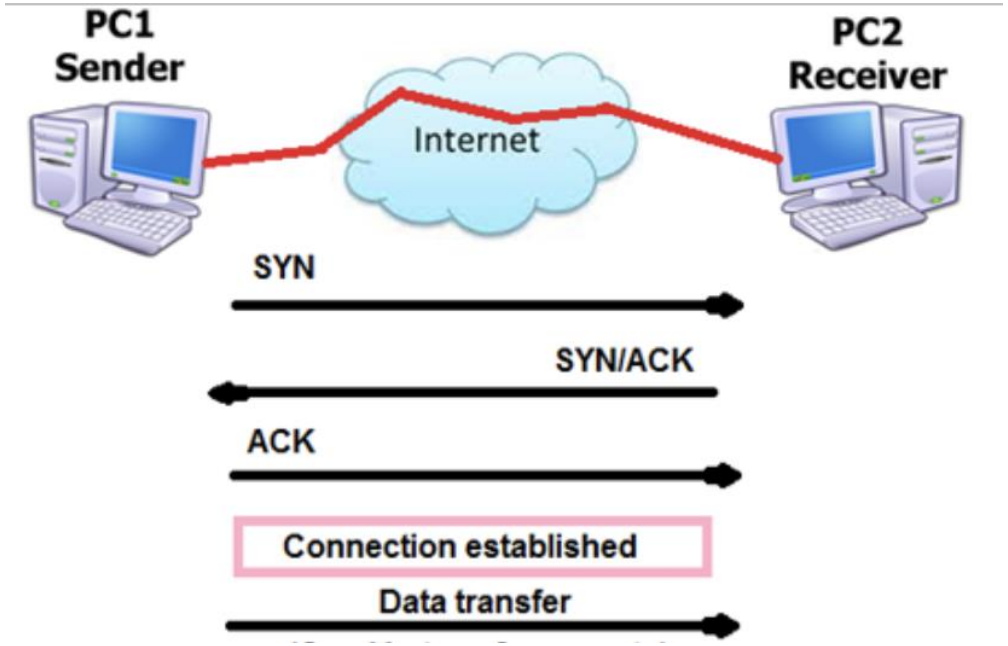
2. Quality of Service (QoS):
   - Bandwidth Management: Allocating sufficient bandwidth for smooth playback of multimedia.
   - Latency and Jitter Control: Ensuring minimal delay and fluctuation for real-time communication.

3. Error Control and Retransmission:
   - Handles packet loss, especially important for video conferencing or VoIP.

4. Flow Control:
   - Prevents overwhelming the network or receiver with too much data at once.

TRANSPORT LAYER

- The transport layer ensures the reliable arrival of messages across a network and provides error-checking mechanisms and data flow controls.
- In order to distribute a multimedia product, it is necessary to have a set of protocols which enable smooth transmission of data between two hosts.
- Protocols are the rules and conventions useful for network communication between two computers.
- E.g.: TCP(Transmission Control Protocol), UDP(User Data Protocol)



TRANSPORT LAYER PROTOCOLS

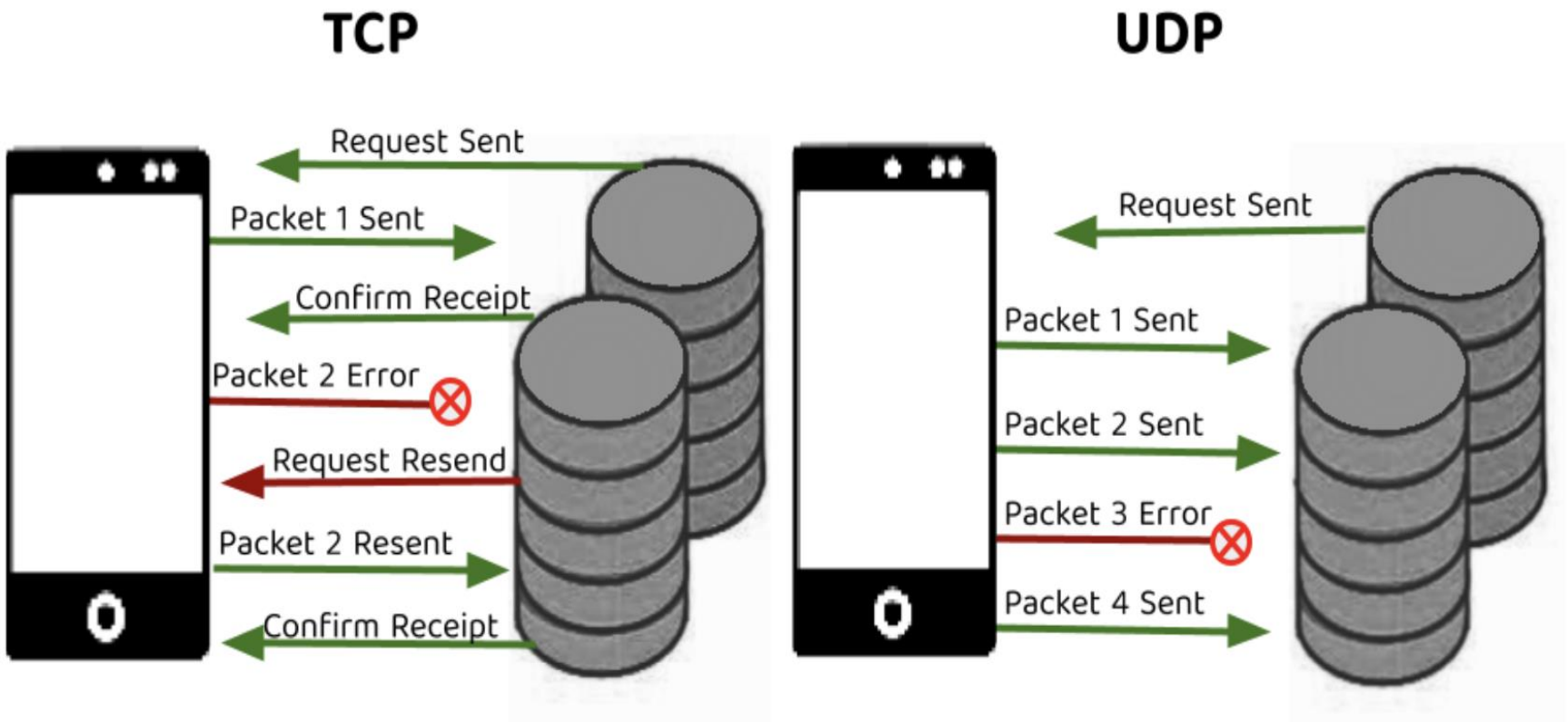
TCP/IP

- Connection Oriented Protocol
- Transports the segments
- ACK signal is received after successful communication
- During a failure the segments are re-transmitted.
- A 3-way Handshake signal is used
- Guarantees the data packet.
- E.g. HTTP,FTP
- For the protocol to work, it must create, maintain, and close a connection. the destination device must confirm receipt before any additional packets are sent.

UDP

- Connection less Protocol
- Doesn't establish any session between sender and receiver.
- Also known and Fire and Forget Protocol.
- Faster then TCP since there is no overhead
- Query Response Protocol (One request one reply) e.g. google.com
- Speed (VOIP ,Online games)
- Continuous Streaming(Skype, YouTube)
- UDP has a significantly lower overhead and a fixed header length, making it faster and more efficient than TCP.

TCP VS UDP


TCP
Request Sent
Packet 1 Sent
Confirm Receipt
Packet 2 Error
Request Resend
Packet 2 Resent
Confirm Receipt
UDP
Request Sent
Packet 1 Sent
Packet 2 Sent
Packet 3 Error
Packet 4 Sent

CONTD..

REAL-TIME TRANSPORT PROTOCOL(RTP)

- It is a network protocol used to deliver streaming audio and video media over the internet.
- RTP applications can use the Transmission Control Protocol (TCP), but most use the User Datagram protocol (UDP) instead because it allows for faster delivery of data.
- RTCP doesn't actually transport any media data, but rather helps with quality control.
- RTP is an application service built on user datagram protocol (UDP), so it is connectionless, with best-effort delivery
- Although RTP is connectionless, it does have a sequencing system that allows for the detection of missing packets

EXPRESS TRANSPORT PROTOCOL(XTP)

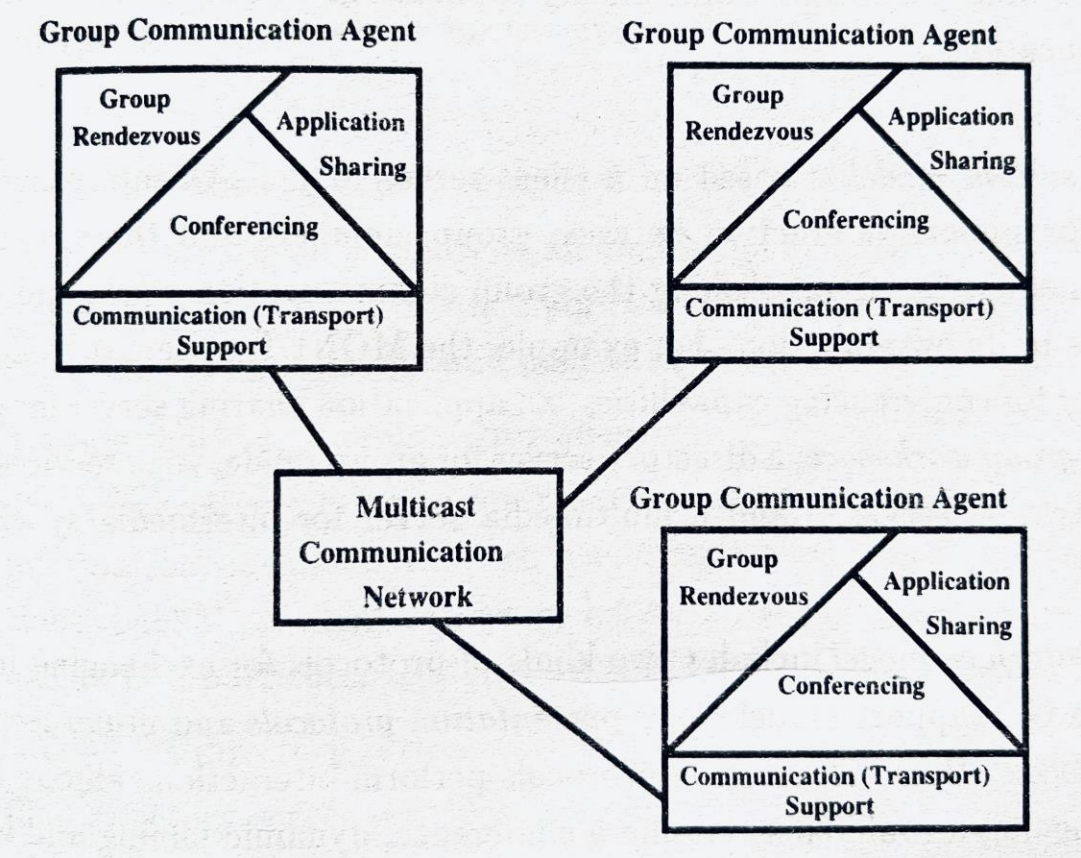
- In search of a better approach, an international group of protocol designers formed the XTP Forum.
- A new protocol which addresses the issues of previous protocols.
- Xpress Transport Protocol which provides, all in one transport protocol, all of the functionality found in TCP and UDP
- XTP can run simultaneously with any or all of these protocols and can be used in those situations where its functionality is needed.

NETWORK LAYER

- Transport layer is a End to End Layer whereas the network layer is a point to point layer.
- Routers and gateways operate in the network layer
- The routers read the header(IP address , size) and sends the packets into its destination (Routing and Forwarding)
- It translates logical network address into physical address
- The Internet Protocol (IP) is one of the main protocols used at this layer, along with several other protocols for routing, testing, and encryption.

- The primary jobs of network layer includes:
  - ✓ Logical addressing
  - ✓ Routing
  - ✓ Encapsulation
  - ✓ Fragmentation and re-assembly
  - ✓ Error Handling(ICMP-Internet Control Message protocol)

GROUP COMMUNICATION ARCHITECTURE



- Group communication involves the communication of multiple users in a synchronous and asynchronous mode with centralized or distrubuted control as shown in the figure of collaborative dimension.
- A multicast communication network is a type of network designed to deliver data to a group of recipients simultaneously rather than to just one destination (unicast).
- It allows for efficient one-to-many or many-to-many communication by sending a single data stream that is shared among multiple recipients who are interested in the same content.
- It consists of support model, system model and interface model.
- The support model includes the communication agents that communicate via multicast communication network as shown in figure.

COMMUNICATION AGENTS(SUPPORT MODEL)

- Group communication agents uses the following for their communication.
- 1. Group Rendezvous:
  - It denotes a method which allows one to organize meetings, and get all the information about the group, ongoing meetings and other information. It is the process used to bring together participants (or nodes) in a group communication session.
  - This concept is critical in group-based applications like video conferencing, online gaming, or collaborative work environments.
- 2. Applicaton sharing :
  - It denotes a technique which allow one to replicate information to multiple users simultaneously. With this, all users can immediately see the updated information.e.g. editor in shared documents.
- 3. Confrencing:
  - It facilitates real-time collaboration or discussion among geographically distributed users through a shared network infrastructure.

GROUP COMMUNICATION ARCHITECTURE

- 1. **Support Model**: The support model refers to the mechanisms and protocols that enable and manage group communication in a multimedia environment. It focuses on how data is transmitted and synchronized across multiple participants.
  - Communication Mechanisms: Defines whether communication is unicast, multicast, or broadcast.
  - Group Management: Protocols for joining, leaving, and managing group memberships.
  - Quality of Service (QoS): Mechanisms to ensure timely delivery, low latency, and appropriate bandwidth allocation for multimedia data.
  - Reliability and Synchronization: Methods to handle packet loss, retransmissions, and maintaining synchronization across streams (e.g., for audio and video).

- **2. System Model:** The system model describes the overall architecture of the multimedia communication system, including its components, their roles, and interactions.
  - Participants (Nodes): Users or devices that send or receive multimedia data.
  - Communication Channels: Paths over which data is transmitted.
  - Control Entities: Servers or controllers that manage the session, handle media streams, and enforce policies.

CONTD..

- **3. Interface Model**

The interface model defines how users or applications interact with the multimedia group communication system. It focuses on the user experience, control mechanisms, and application-level access to multimedia services.

- User Interfaces (UI): Interfaces for users to join or leave sessions, control playback, and configure communication settings.
- APIs (Application Programming Interfaces): Access for developers to use multimedia services.
- Control Functions: Interfaces for managing volume, muting, screen sharing, or video camera control in a video call.

QUALITY OF SERVICE

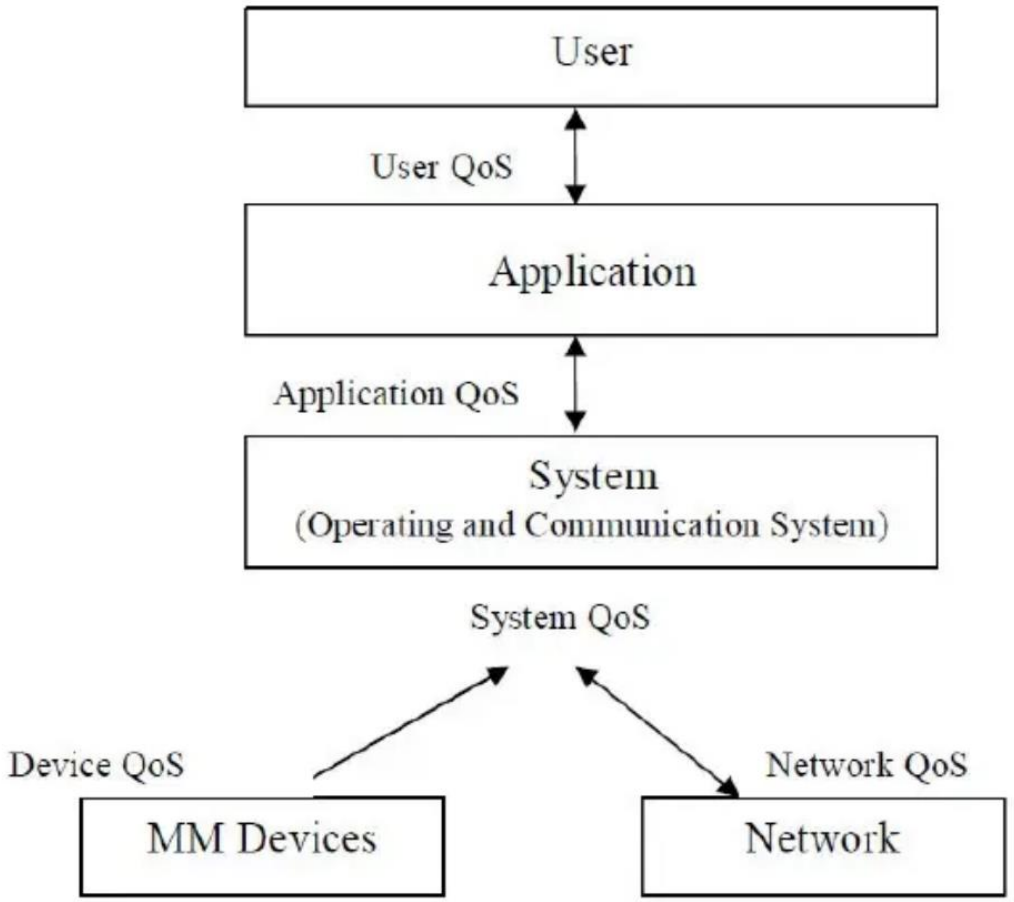
- Every product is expected to have a quality apart from satisfying the requirements.
- The quality is measured in various parameters like delay, lag, jitter, latency.
- Parameterization of the servies is defined in ISO(International Standard Organization)
- The ISO standard defines the QoS as a concept for specifying how good the offered networking services are.

QOS PARAMETERS

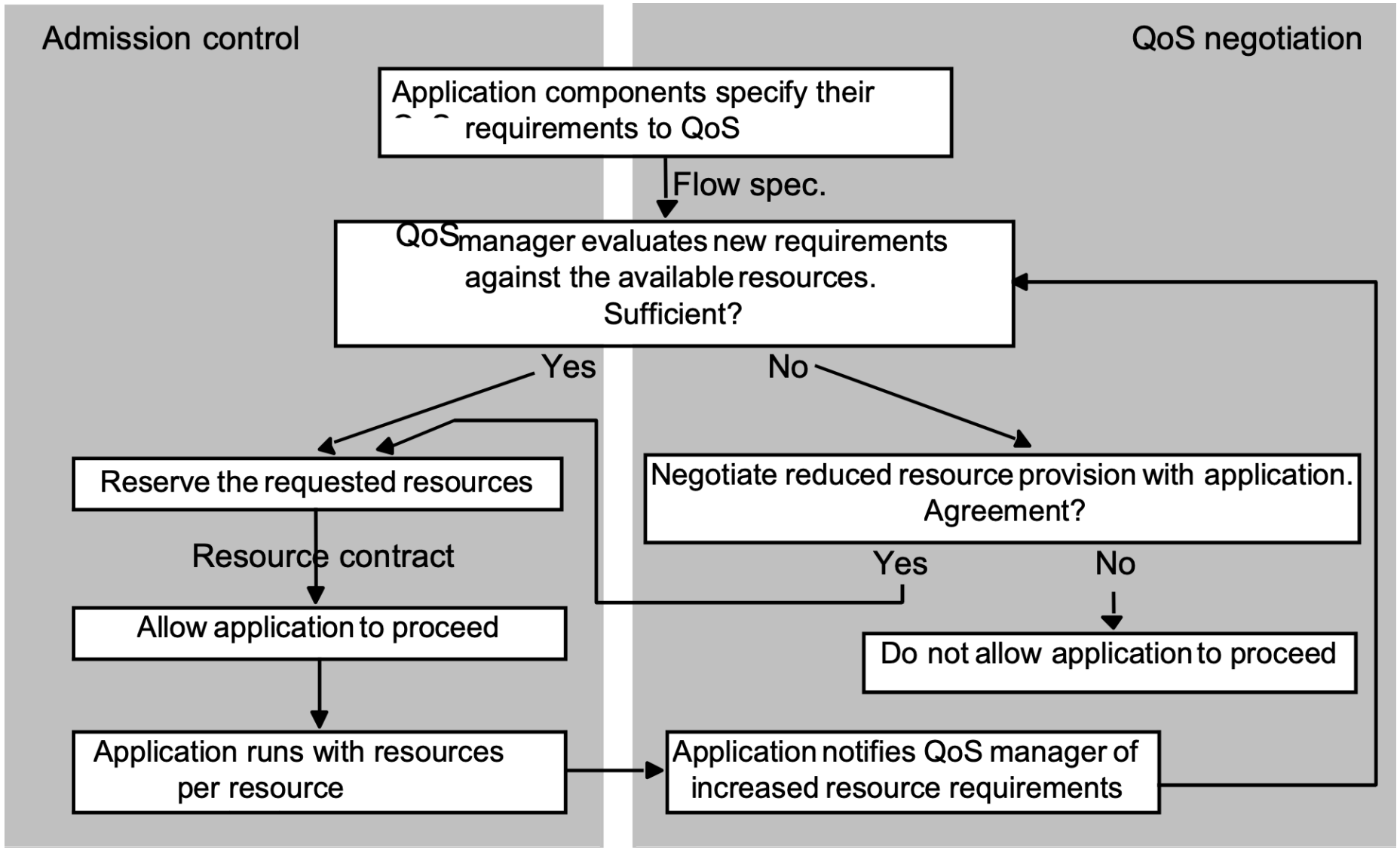
Category	Example Parameters
Performance Oriented	Delay Bit rate
Format Oriented	Video Resolution Frame Rate Storage Format Compression Scheme
Synchronization Oriented	Skew between the beginning of Audio and Video sequences
Cost Oriented	Connection and data transmission charges Copyright fees
User Oriented	Subjective image Sound Quality

QOS LAYERING

- An enhancement of QoS was achieved by introducing QoS into transport layer.
- A layered model of the Multimedia communication system with respect to QoS was implemented as shown in the figure.
- It consists of three layers:
  - Application
  - System (OS and Comm. Systems)
  - Device(MM Device & Network Device)
- User Layer: At this level, QoS is specified qualitatively.
- Applications specify QoS requirements and the Systems provide a QoS guarantee.



QOS NEGOTIATION FOR RESOURCE



QOS NEGOTIATION FOR RESOURCE

- QoS notion, mechanisms to specify QoS requirements, QoS negotiation and renegotiation, admission control and resource management is important in multimedia system.
- To negotiate QoS between an application and its underlying system, an application must specify its QoS requirements to the QoS Manager.
- This is done by the transmission of a set of parameters. Three parameters are of primary interest when it comes to processing and transporting multimedia streams: bandwidth, latency, and loss rate.
- If the QoS extended is not acceptable, the application can degrade to a lower QoS to run on.
- If this too is not acceptable the application has to wait for the resources to be freed by other application.

END OF CHAPTER 9