Application Layer – Overview

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Milestone

- Network infrastructure in place to enable variety of applications
  - Can transfer packets from a app process on a given host to another process on another host
- Role of application developers:
  - understand the building blocks and their interaction
  - Make the right choices and implement required functionality

History of Internet Services

- 1970’s and 1980’s: Text based applications

1971

  - Email, Telnet, File-transfer, Newsgroups, Chat

- 1990’s: World-wide-web, Search, E-commerce (Amazon, Ebay, Paypal, Craigslist)

- 2000’s: P2P file transfer (Napster, Bit-torrent), Social-Networking (Facebook,Twitter), Real-time applications (Skype, Youtube)

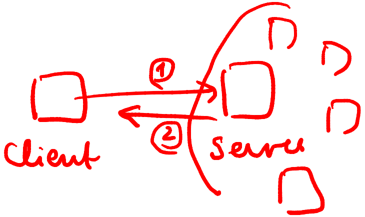
History of Internet Services

- Past few years: Cloud based services
  - Storage services: Dropbox, Apple's iCloud, Amazon's S3 (simple storage service)
  - Virtual Servers: Amazon's EC2 (elastic compute cloud)
  - Data processing: Amazon's Elastic Map-reduce
  - Database services: Amazon's RDS (relational database service)

Application Architecture

- Three types
- Client-Server
  - E.g. Web, Email, FTP
- Peer-to-Peer
  - Bit-torrent, Gnutella
- Hybrid of client-server and peer-to-peer
  - Skype, Instant messenger

Client-Server Architecture



- Client:
  - Initiates connection to server;
  - Intermittently connected; dynamic IP address
- Server:
  - Provides specific services (e.g. google server provides search functionality); may employ server farm
  - Always on; fixed IP address

Pure Peer-to-Peer Architecture

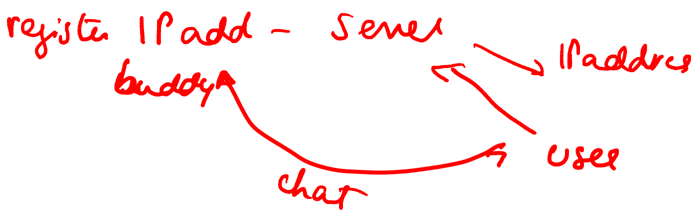
↳ music file, video games etc

- No server; end-systems coordinate to provide required service
- End-systems maybe intermittently connected; can have dynamic IP addresses
- Scalable system, but tends to be complex

Hybrid Architecture

- Initial contact is to a central server
  - Used to determine info about other end-systems
- After this, end-systems talk directly

IM → Instant Messaging



Application Protocols

Application	Protocol	Transport
E-mail	SMTP (RFC 2821)	TCP ✓
Remote terminal access	Telnet (RFC 854)	TCP
Web	HTTP (RFC 2616)	TCP ✓
File Transfer	FTP (RFC 959)	TCP
Streaming Multimedia	Proprietary	TCP or UDP
Internet Telephony	Proprietary	Often UDP

Application Protocols

- Define types of messages exchanged,
  - e.g., request, response
- Message syntax:
  - Fields in messages
- Message semantics
  - meaning of information in fields
- Rules for when to send and how to act on messages

Application Protocols

- Many protocols also have a companion protocol that specifies format of the data exchanged

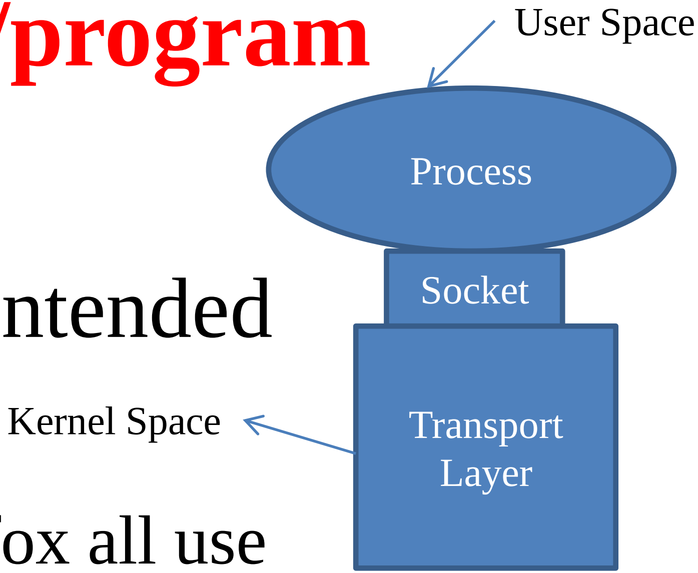
web ser

  - HTML is companion protocol of HTTP
  - RFC 822 and MIME define format of email messages; companion of SMTP → Email

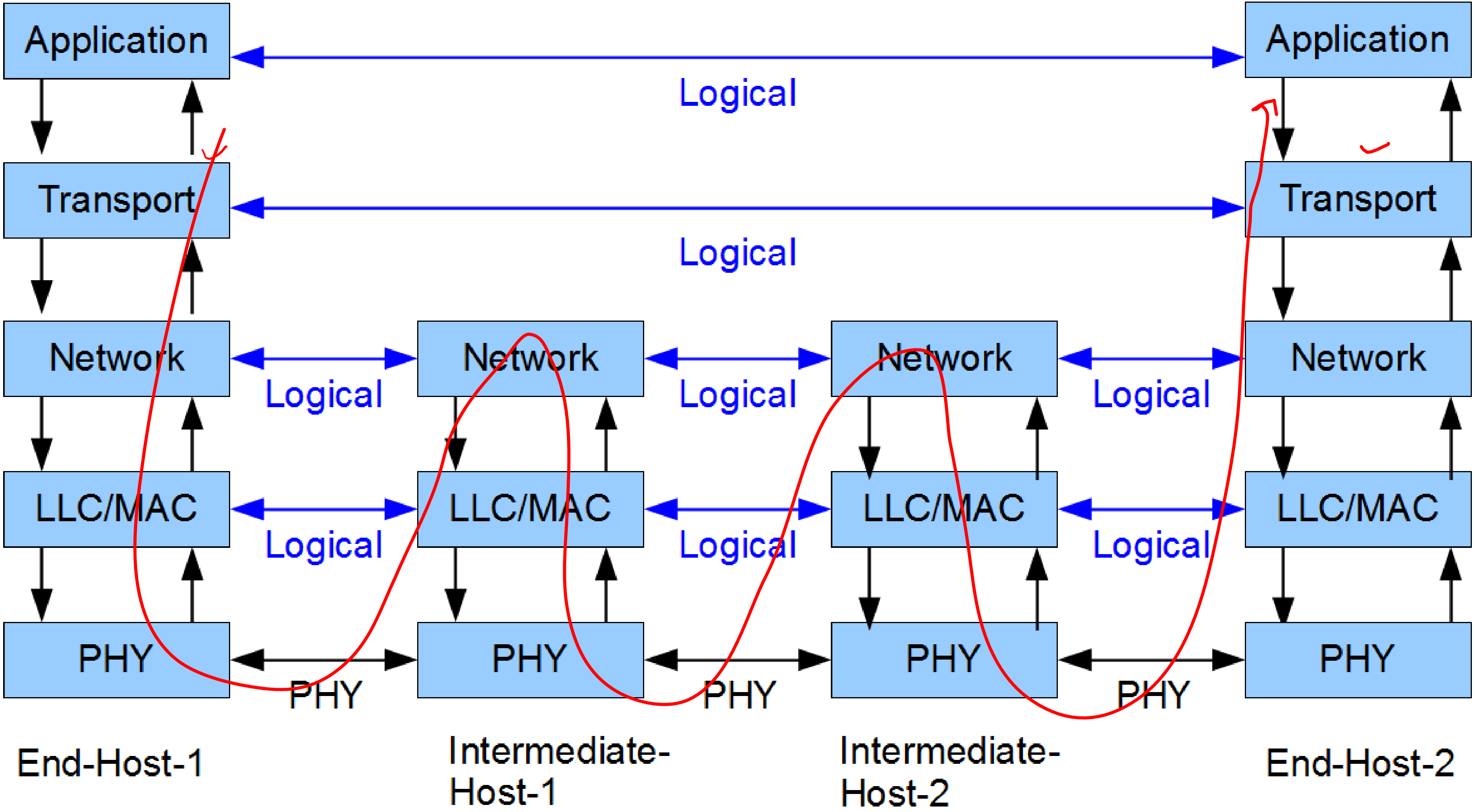
Application Process/program

- Application programs use the application protocol to achieve intended task
  - E.g. Internet Explore, Chrome, Firefox all use HTTP to enable web access

GUI is difference



- Processes identified by IP address:Port
  - Popular services have well know port numbers (e.g. 80 for web; 25 for email server)


Application
Application
Logical
Transport
Transport
Logical
Network
Network
Network
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Logical
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LLC/MAC
LLC/MAC
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LLC/MAC
Logical
Logical
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PHY
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PHY
PHY
PHY
PHY
PHY
End-Host-1
Intermediate-Host-1
Intermediate-Host-2
End-Host-2

Summary

- Over the past 4 decades, many new and interesting networking applications have emerged

- Three predominant architecture types are used
  - Client-server, peer-to-peer, hybrid

- There are many application protocols; supporting protocols and implementations

- Ahead: Look at some popular applications