

Application Layer – Overview

Kameswari Chebrolu

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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
 - (97) – 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

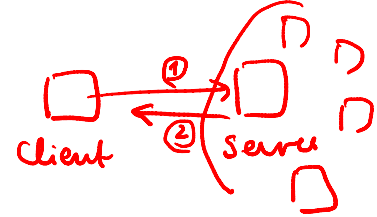
Client-Server Architecture

- 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

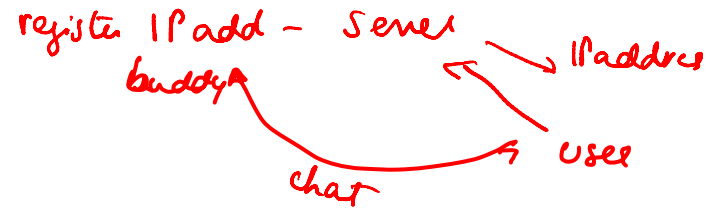
↳ music file, video games etc

- 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	<u>SMTP</u> (RFC 2821)	TCP ✓
Remote terminal access	Telnet (RFC 854)	TCP
Web	<u>HTTP</u> (RFC 2616)	TCP ✓
File Transfer	FTP (RFC 959)	TCP
Streaming Multimedia	<u>Proprietary</u>	TCP or UDP ✓
Internet Telephony	<u>Proprietary</u>	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 sen

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

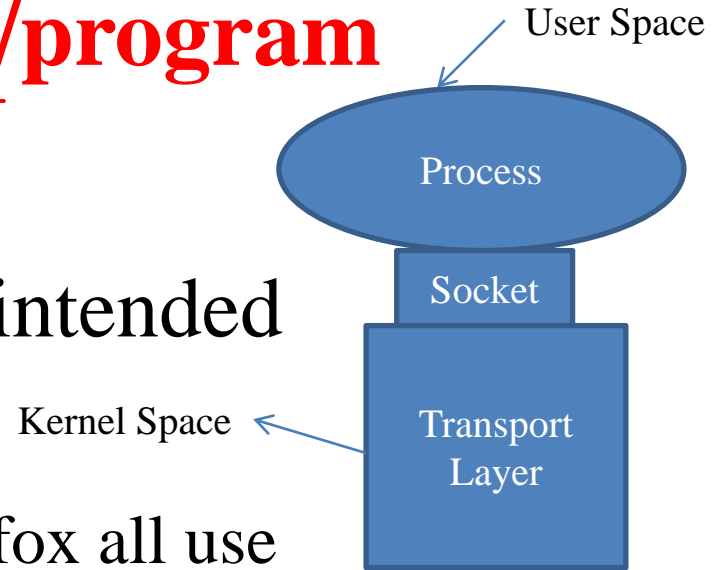
Application Process/program

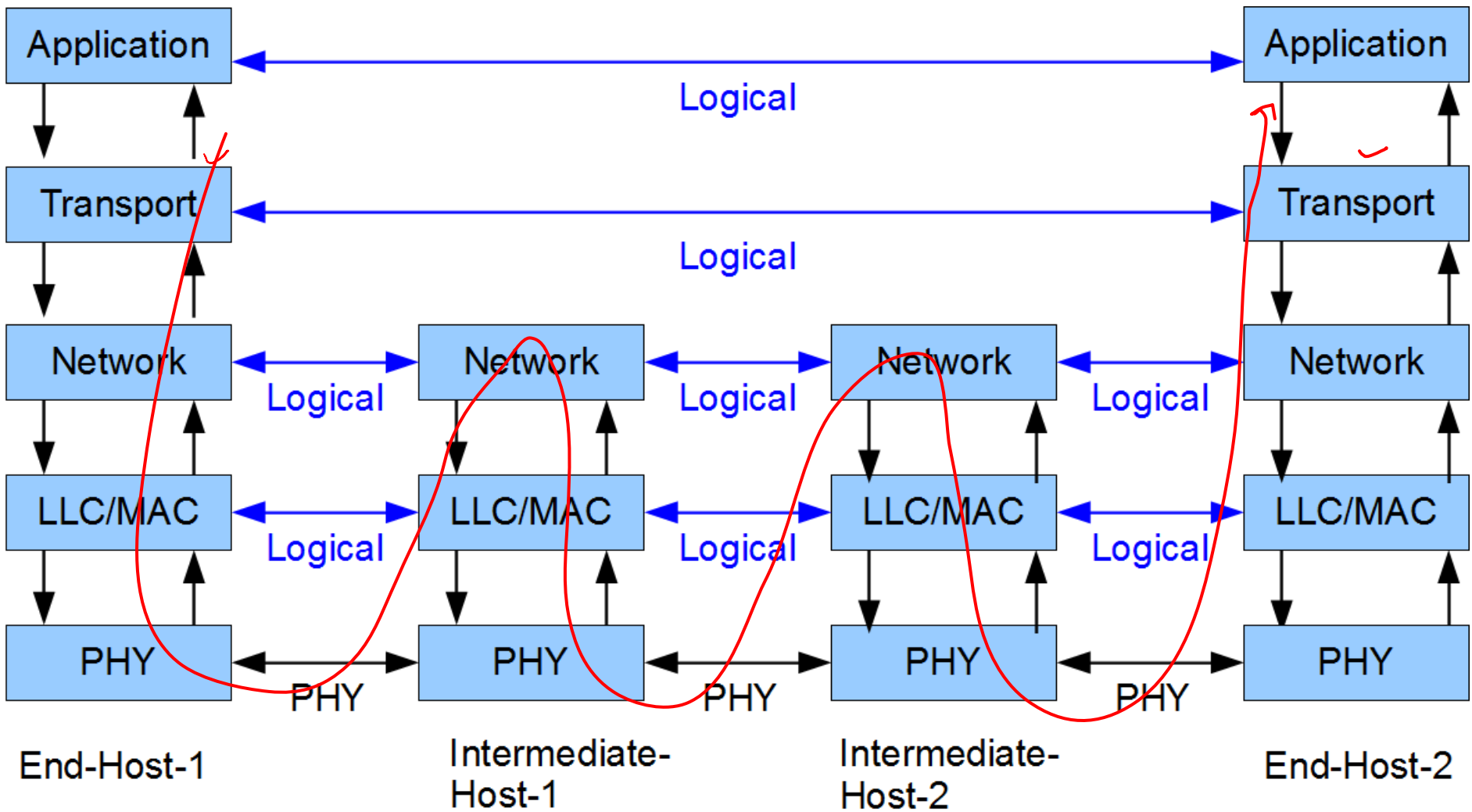
- Application programs use the application protocol to achieve intended task

- E.g. Internet Explore, Chrome, Firefox all use HTTP to enable web access

- Processes identified by IP address:Port

- Popular services have well know port numbers (e.g. 80 for web; 25 for email server)





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