

# Networking

## 1. Networking

### 1.1 CSCI 330

# CSCI 330 UNIX and Network Programming

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Networking



## 1.2 Unit Overview

### Unit Overview

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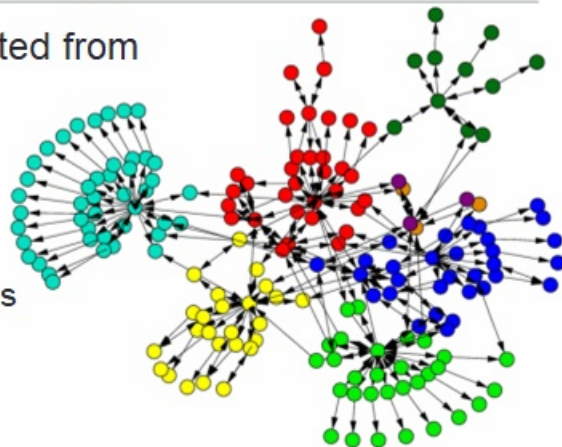
- Network concepts & terminology
- OSI reference model for protocols
  - Physical layer
  - Data Link layer
  - Network layer
  - Transport layer

## 1.3 Network Terminology

### Network Terminology

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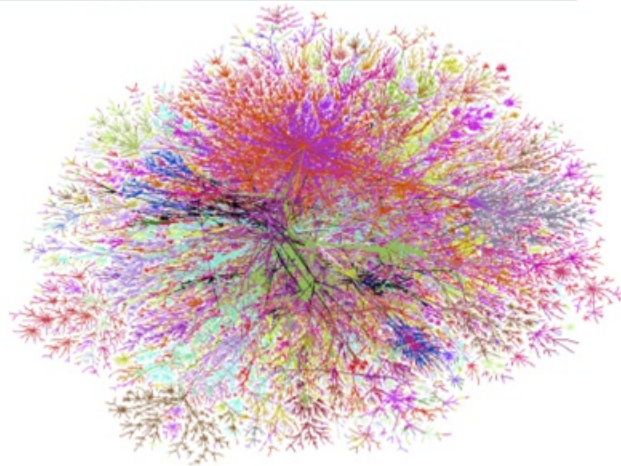
- connected graph constructed from
  - node
  - link
- nodes can reach others via path
  - sequence of nodes and links



## 1.4 Internet Terminology

### Internet Terminology

- node
  - host or intermediary
- link
  - point-to-point or broadcast
- link medium
  - wired or wireless
- path
  - routed or switched



## 1.5 Networking Protocol

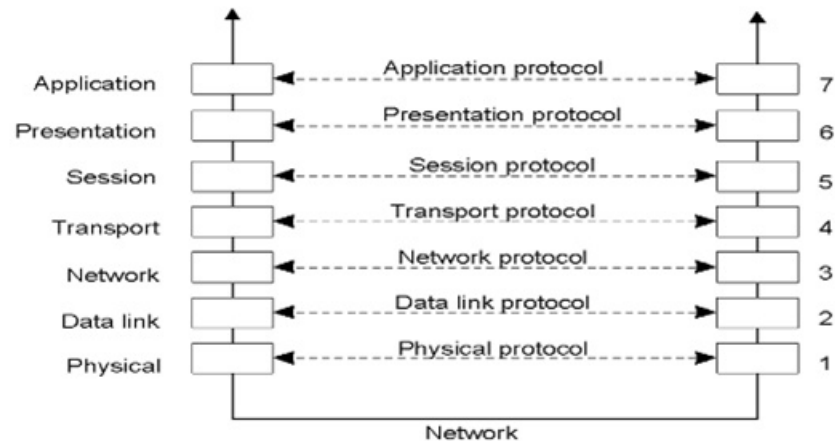
### Networking Protocol

- communication in a network is governed by rules and conventions
- information is exchanged between nodes via messages
- messages use well-defined format
- each message has an exact meaning intended to provoke a defined response of the receiver

**a protocol describes the syntax, semantics, and synchronization of communication**

## 1.6 OSI reference model

### OSI reference model



## 1.7 Layered protocols

### Layered protocols

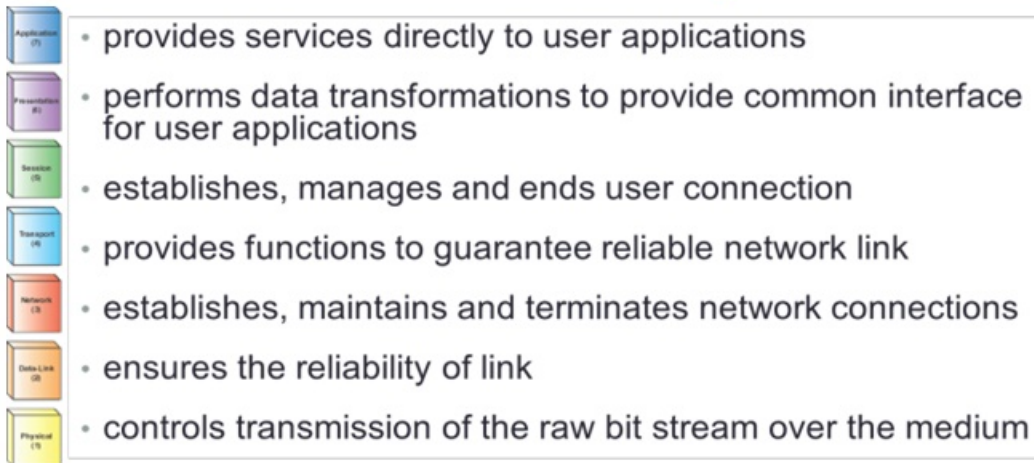
- complexities of communication organized into successive layers of protocols
  - lower-level layers: specific to medium
  - higher-level layers: specific to application
- standards achieve inter-operability

Open Systems Interconnection model:

OSI reference model

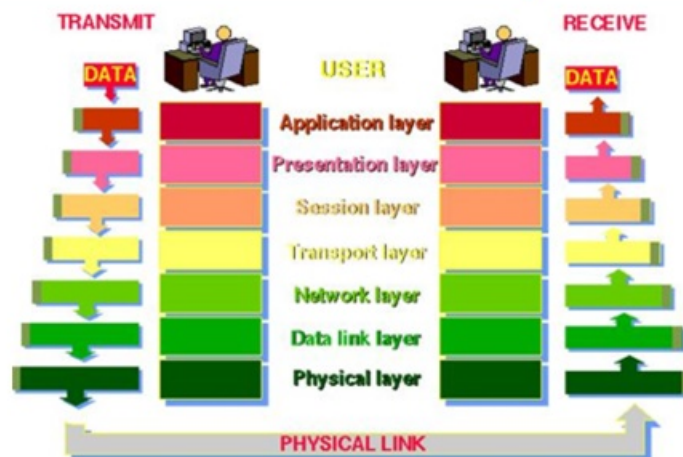
## 1.8 OSI reference model layers

### OSI reference model layers



## 1.9 OSI reference model layers

### OSI reference model layers





### 1.10 Physical Layer: Wired Media

## Physical Layer: Wired Media

- **Ethernet**
  - 10BASE-T, 100BASE-TX, 1000BASE-T
  - 10GbE, 40GbE, 100GbE
- **Business/backbone:**
  - DS1(T1): 1.54Mbps to DS5: 400Mbps
  - OC-1: 50Mbps to OC-768: 40Gbs
- **Last mile:**
  - Modem
  - DSL
  - cable: DOCSIS
  - FiOS
  - up to GigaBits/s ?

### 1.11 Physical Layer: Wireless Media

## Physical Layer: Wireless Media

- **Cellphone Data**
  - EDGE, GPRS, HSPA+
  - 4G LTE up to 100Mbps
  - 5G over 100Mbps
- **Satellite**
  - Wildblue: 12Mbps
  - HughesNet: 15Mbps
  - Starlink: ?
- **WiFi: 802.11**
  - up to 150Mbps & MIMO
  - new: "ac" up to 1Gbs
- **WiMax: 802.16**
  - up to 40Mbps
- **WPAN**
  - BlueTooth up to 2Mbps
  - NFC up to 423Kbs
  - ZigBee up to 256Kbs

### 1.12 Data Link Layer: functionalities

## Data Link Layer: functionalities

- Medium access control
  - arbitrate who transmits
- Addressing
  - address of receiver, address of sender
- Framing
  - delimited unit of transmission for data & control
- Error control and reliability
- Flow control

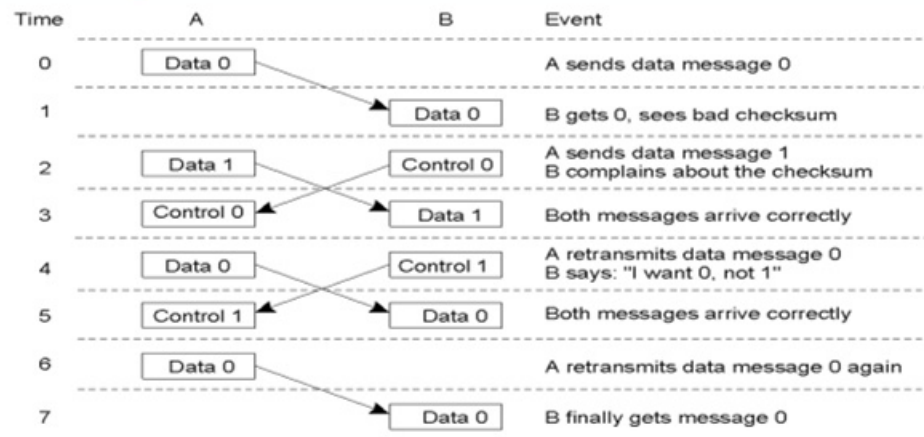
### 1.13 Example: Ethernet frame

## Example: Ethernet frame

Preamble	Destination MAC address	Source MAC address	Type/ Length	User Data	Frame Check Sequence (FCS)
8	6	6	2	46 - 1500	4

### 1.14 Example: Data Link flow

## Example: Data Link flow



### 1.15 Network Layer

## Network Layer

- also called: Internet Protocol Layer
  - provides host to host transmission service, where hosts are not necessarily adjacent
- layer provides services:
  - addressing
    - hosts have global addresses: IPv4, IPv6
    - uses data link layer protocol to translate address: ARP
  - routing and forwarding
    - find path from host to host



## 1.16 IPv4 Address

### IPv4 Address

- IP address
    - 32bit unique identifier, written as quad
  - network
    - first n bits of IP number, written as "/n"
    - 8 - class A, 16 - class B, 24 - class C
    - more than 24 - class D
  - netmask
    - 32 bit number with first n bits all 1, rest 0
  - broadcast
    - network number (first n bits), rest all 1
  - gateway IP
  - name server IP
- 127.0.0.1
  - 131.156.145.90
  - 131.156.0.0/16
  - 131.156.145.0/24
  - 255.255.255.0
  - 131.156.145.255
  - 131.156.145.1
  - 131.156.145.2

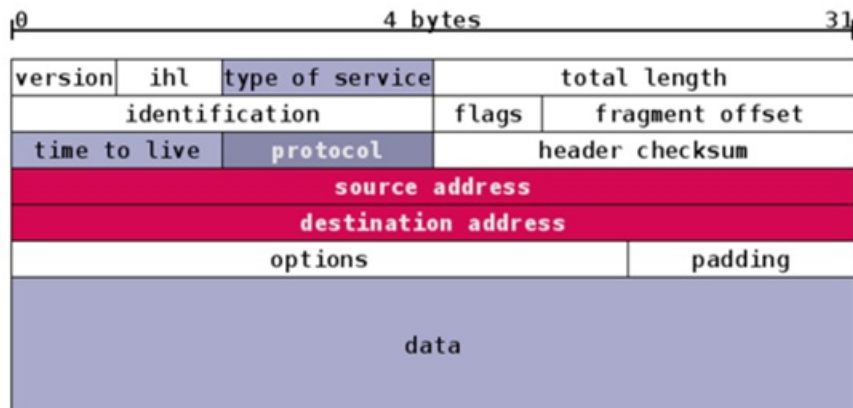
## 1.17 IPv6 Address

### IPv6 Address

- IP address: 128-bit unique identifier
- 8 groups of 16-bit values,  
each group in 4 hex digits, separated by ":"
  - ex.: 2001:0db8:0000:0000:0000:ff00:0042:8329
- can be abbreviated:
  - remove leading zeroes: 42 instead of 0042
  - omit consecutive sections of zeroes:  
2001:db8::ff00:42:8329

## 1.18 Internet Protocol Packet

### Internet Protocol Packet



## 1.19 IP Layer: routing and forwarding

### IP Layer: routing and forwarding

- done by hosts on path from sender to receiver
- forwarding:
  - host has 2 network interfaces
  - transfers packet from incoming to outgoing interface
- routing:
  - finds path from sender to receiver
  - simple routing: know receiver or send to gateway
  - advanced routing: determine which gateway to send to (typically with multiple outgoing network interfaces)

## 1.20 Transport Layer

### Transport Layer

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- provides end-to-end communication services for applications
- byte format as abstraction on underlying system format
- raises reliability
- enables multiplexing:
  - provides multiple endpoints on a single node: port
  - refines connection address via port number

## 1.21 Transport layer ports

### Transport layer ports

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- 0 to 1023: well-known ports
  - 20 & 21: File Transfer Protocol (FTP)
  - 22: Secure Shell (SSH)
  - 23: Telnet remote login service
  - 25: Simple Mail Transfer Protocol (SMTP)
  - 53: Domain Name System (DNS) service
  - 80: Hypertext Transfer Protocol (HTTP) used in the World Wide Web
  - 110: Post Office Protocol (POP3)
  - 119: Network News Transfer Protocol (NNTP)
  - 143: Internet Message Access Protocol (IMAP)
  - 161: Simple Network Management Protocol (SNMP)
  - 443: HTTP Secure (HTTPS)
- 1024 to 49151: IANA registered ports
- 49152 to 65535: dynamic or private port

## **1.22 Transport layer programming**

### **Transport layer programming**

- common abstraction: socket
- first introduced in BSD Unix in 1981
- socket is end-point of communication link
  - identified as IP address + port number
- operates as client and server

## **1.23 Transport layer protocols**

### **Transport layer protocols**

- TCP: transmission control protocol
  - connection oriented, guaranteed delivery
  - stream oriented: basis for: http, ftp, smtp, ssh
- UDP: user datagram protocol
  - best effort
  - datagram oriented: basis for: dns, rtp
- DCCP: datagram congestion control protocol
- SCTP: stream control transmission protocol

## 1.24 Summary

### Summary

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- Network concepts & terminology
- OSI reference model for protocols
  - Physical layer
  - Data Link layer
  - Network layer
  - Transport layer