

# Network Programming

David Hackbarth



What is Multiplayer?

# Multiplayer

- more than one player
- two versions
  - co-op
  - competitive
- two options
  - local
  - remote

# Computer Network

- ✦ Electronic
- ✦ Connection between two active devices over passive components
- ✦ Transport of packages (bits)
- ✦ Communication, exchange of information, supply of resources

Please,

Do

Not

Throw

Sausage

Pizza

Away!

# OSI Model

**P**lease,

**D**o

**N**ot

**T**hrow

**S**ausage

**P**izza

**A**way!

Physical Layer

Data Link Layer

Network Layer

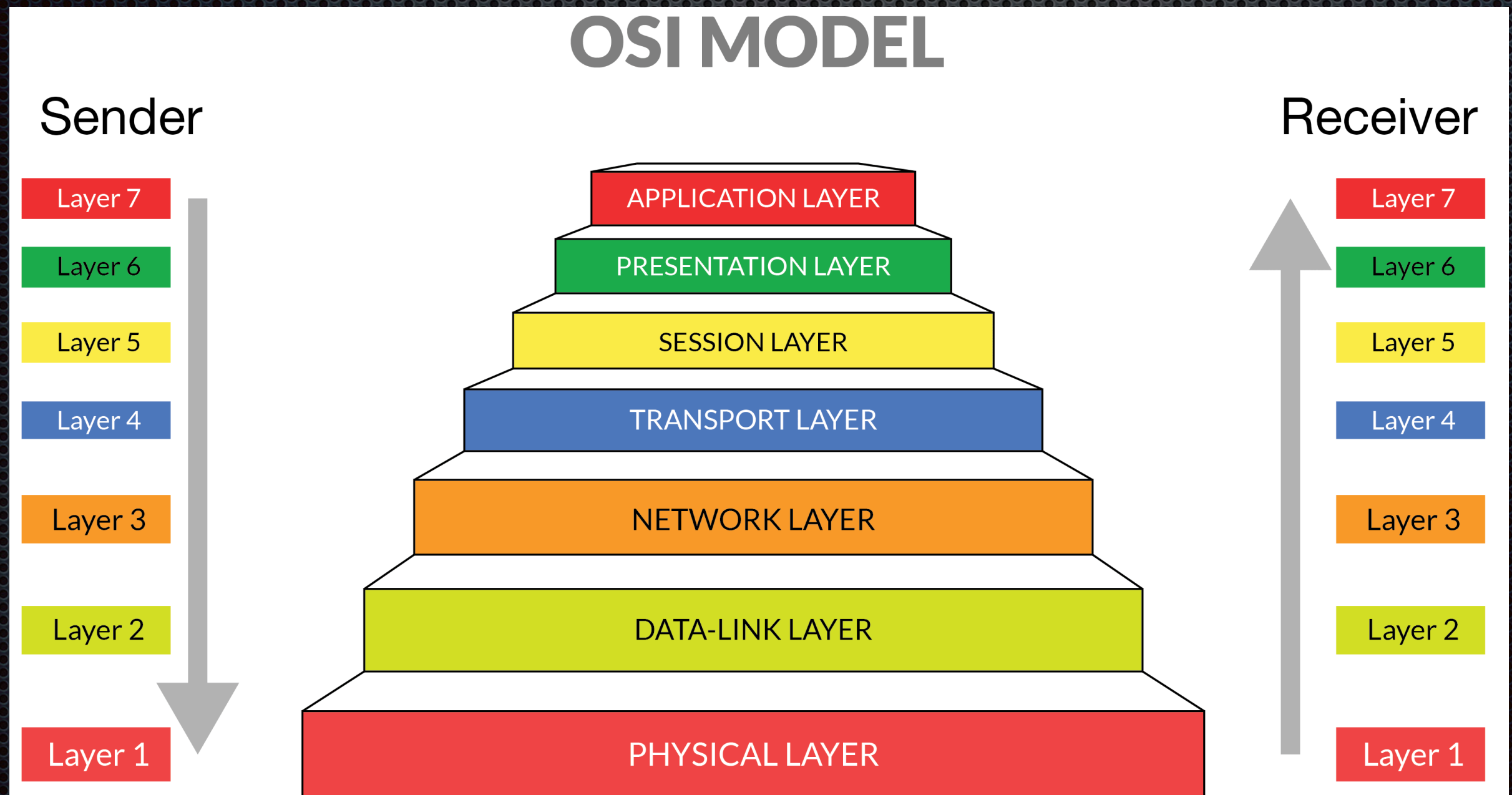
Transport Layer

Session Layer

Presentation Layer

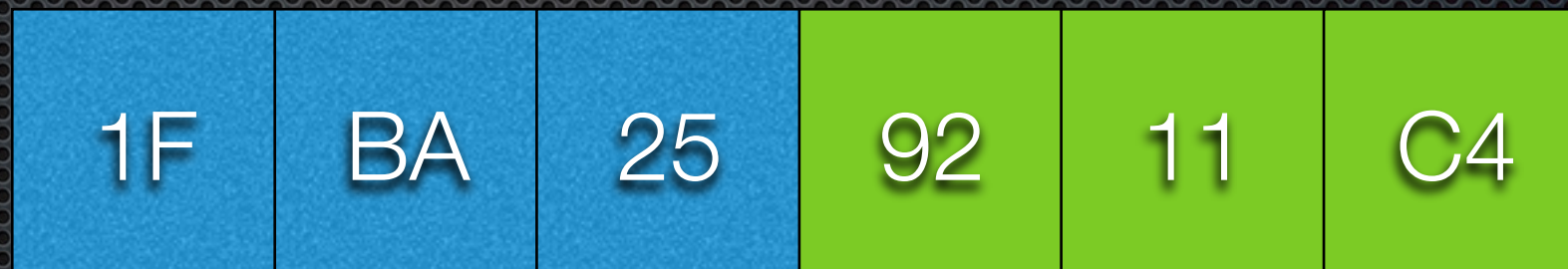
Application Layer

# OSI Model - Open System Interconnection



# MAC Address

- ✦ Media Access Control Address
- ✦ unique identifier for hardware
- ✦ 48 bit



Vendor ID

Device ID

# IP Address

- ✦ Internet Protocol
- ✦ Version 4 & 6 (IPv4 / IPv6)
- ✦ unique within a network

## IPv4

- 32 bits
- over 4.29 billion addresses
- 192.168.0.1

## IPv6

- 128 bits
- $3.403 * 10^{38}$  addresses
- 2020:fff4:0010:abcd:  
ef10:2345:0000:0001

# Subnetting

- ✦ Subnetmask
- ✦ 32 bits
- ✦ CIDR: 192.168.0.23/24

|            | decimal      |           | binary                      |           |
|------------|--------------|-----------|-----------------------------|-----------|
| IP Address | 192.168.0.   | 23        | 11000000.10101000.00000000. | 00010111  |
| Subnetmask | 255.255.255. | 0         | 11111111.11111111.11111111. | 00000000  |
|            | network part | host part | network part                | host part |

# Subnetting

- ✦ 192.168.0.23/24
- ✦ 192.168.0.0 - Network Address
- ✦ 192.168.0.255 - Broadcast Address

# Reserved Networks - Private

| Block          | Range                         | No of Addresses | Class Networks |
|----------------|-------------------------------|-----------------|----------------|
| 10.0.0.0/8     | 10.0.0.0 - 10.255.255.255     | 16.777.216      | 1 x A          |
| 172.16.0.0/12  | 172.16.0.0 - 172.31.255.255   | 1.048.576       | 16 x B         |
| 192.168.0.0/16 | 192.168.0.0 - 192.168.255.255 | 65536           | 256 x C        |
| 169.254.0.0/16 | 169.254.0.0 - 169.254.255.255 | 65536           | -              |

# Reserved Networks

- ✦ 127.0.0.0/8 (Loopback)
  - ✦ 127.0.0.1 - Localhost
- ✦ 224.0.0.0/4 (Multicast)

# Ports

- ✦ more than one service
- ✦ ports as address
- ✦ 16 bit
- ✦ 0 - 1023 reserved
- ✦ 1024 - 49151 registered
- ✦ 49152 - 65535 open

# Port examples

- ✦ HTTP (Hypertext Transfer Protocol) - 80
- ✦ HTTPS (Hypertext Transfer Protocol Secure) - 443
- ✦ FTP (File Transfer Protocol) - 20/21
- ✦ POP3 (Post Office Protocol Version 3) - 110
- ✦ IMAP (Internet Mail Access Protocol) - 143
- ✦ SMTP (Simple Mail Transfer Protocol) - 25

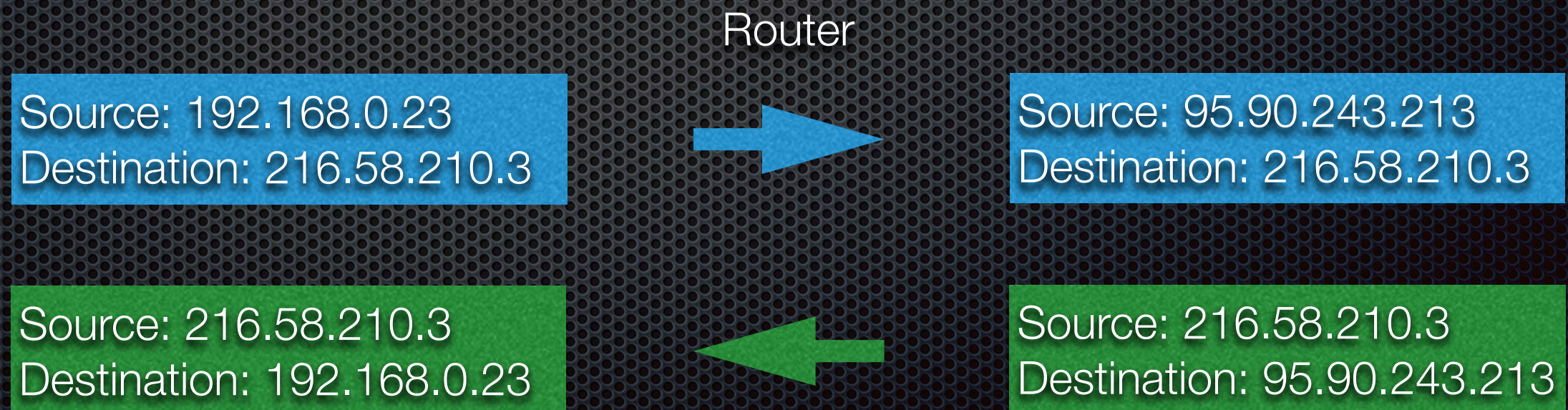
# Port examples



- ✦ PlayStation Network - 3479/3480
- ✦ battle.Net - 3723/6112
- ✦ Teamspeak (Voice) - 9987
- ✦ League of Legends - 5000-5500
- ✦ Steam - 27000 - 27015

# Network Address Translation

- ✦ NAT
- ✦ device exchange private IP address with public IP address for routing
- ✦ private network will be hidden (IP Masquerading)



# TCP

- ✦ Transmission Control Protocol
- ✦ Connection based
- ✦ Reliable
- ✦ Sequenced
- ✦ High overhead
- ✦ Slowly
- ✦ Unit: Segments

# UDP

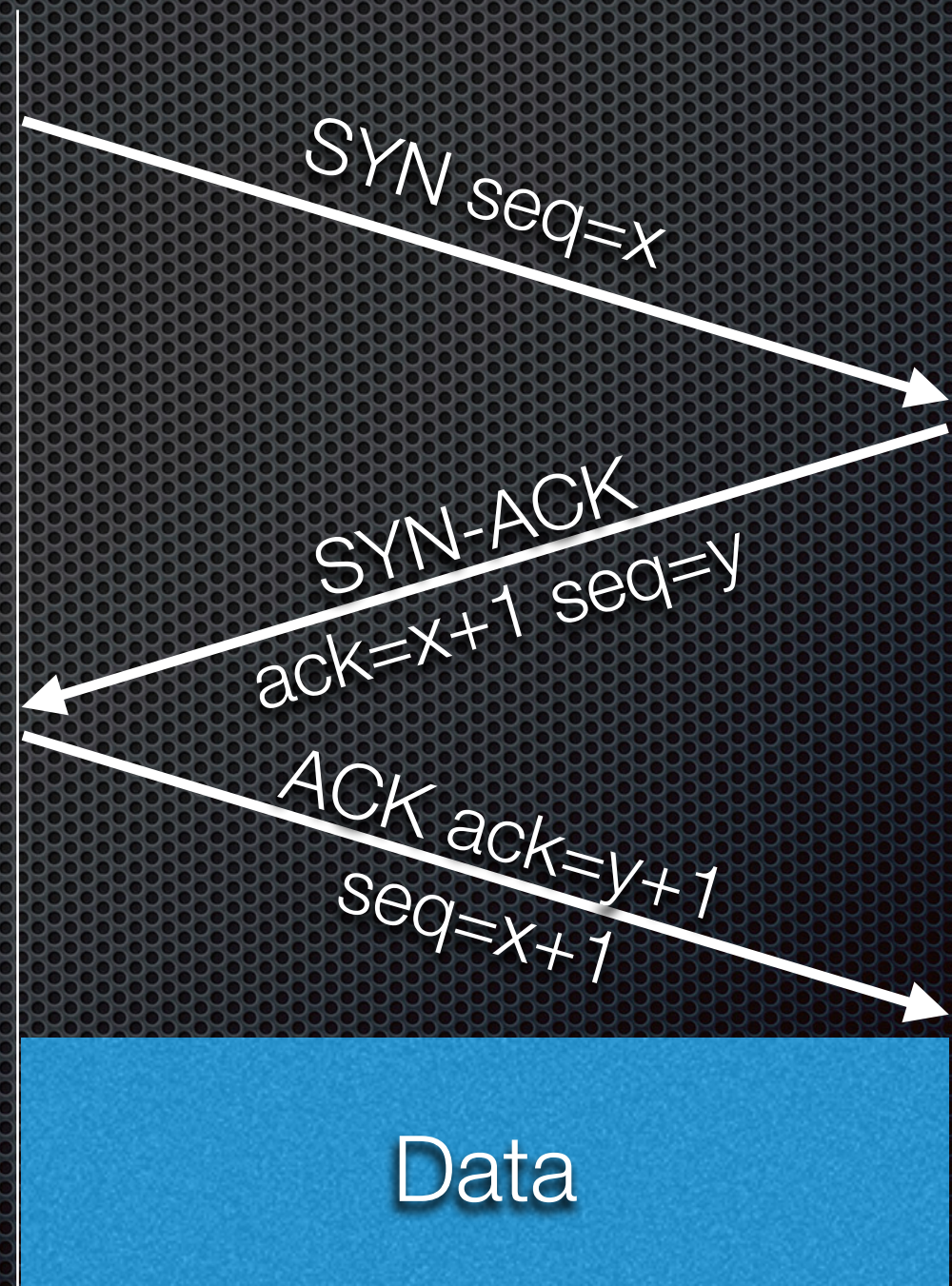
- ✦ User Datagram Protocol
- ✦ Connectionless
- ✦ Unreliable
- ✦ Unsequenced
- ✦ Small overhead
- ✦ Faster
- ✦ Unit: Datagrams

# TCP

- bi-directional
- very popular for important data
- 3-Way-Handshake

Client

Server

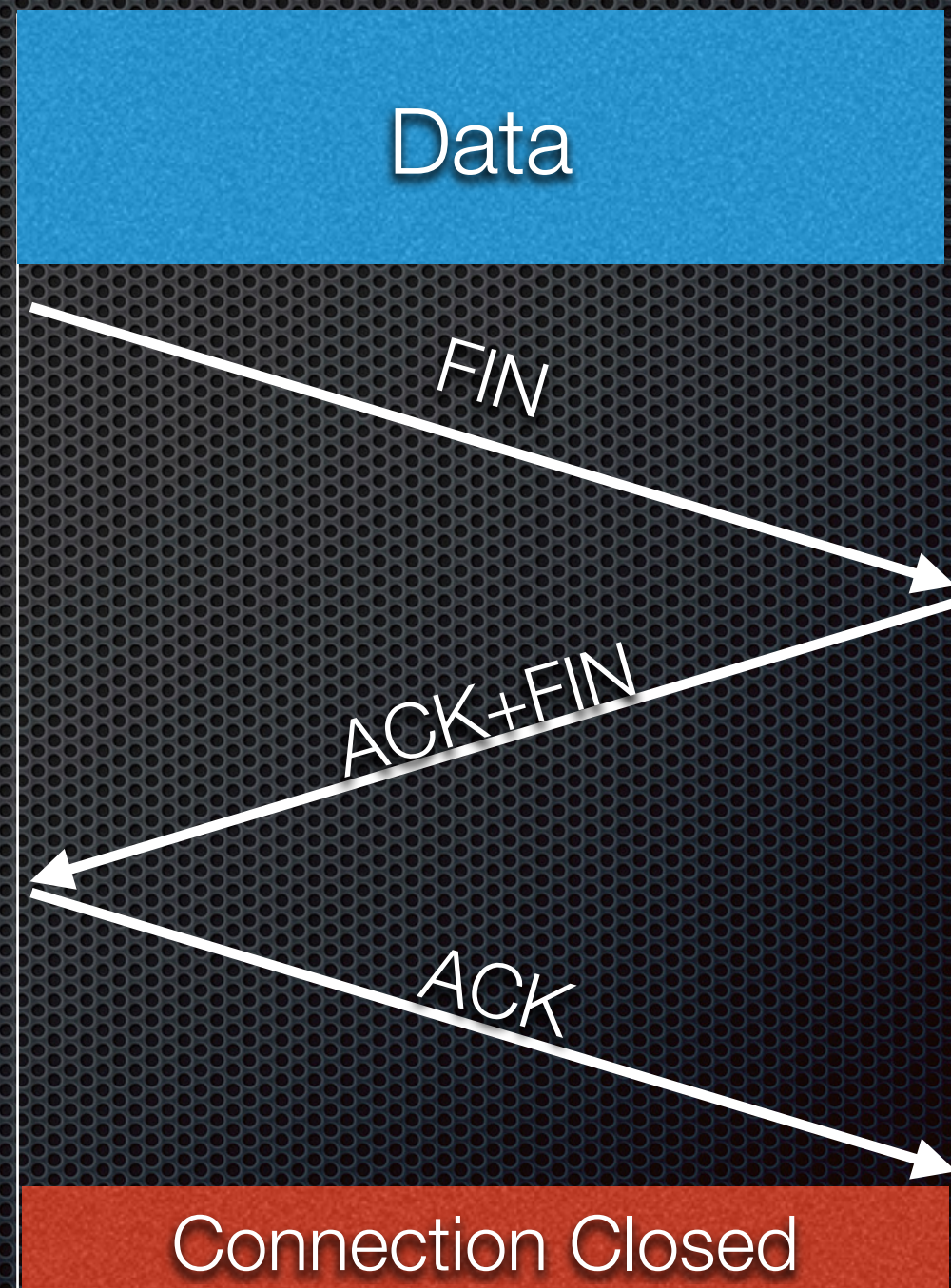


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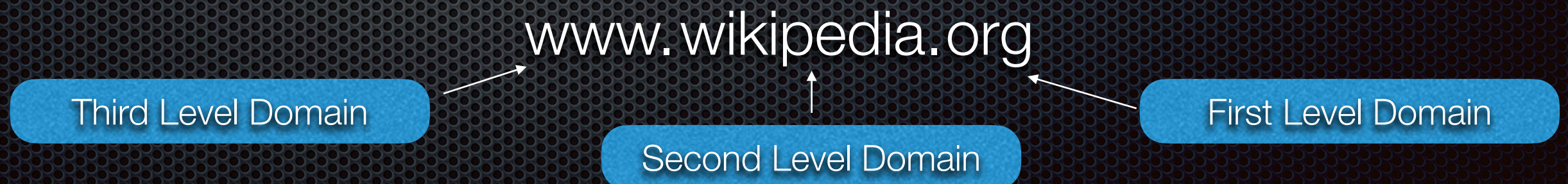
Client

Server



# Domain Name System

- ✦ DNS
- ✦ Port: 53
- ✦ translate names into IP and vice versa
- ✦ nameserver
- ✦ Fully Qualified Domain Name (FQDN)



# Dynamic Host Configuration Protocol

- ✦ DHCP
- ✦ Port: 67/68
- ✦ get network information automatically
  - ✦ IP, DNS-Server, Routing

## P2P

- ✦ connection between two end points
- ✦ often used in 1vs1 or file sharing

## Client-Server

- ✦ one server and infinite amount of clients
- ✦ one central communication point
- ✦ e.g. MMO, FPS, ...
- ✦ Dedicated vs. Hosted Server

# Matchmaking

- ✦ in the beginning based on ip addresses
- ✦ Halo 2 (2004) introduced self-hosting with playlists and parties
- ✦ StarCraft 2 (2010) introduced ranking system with promotion and relegation
- ✦ in general based on rules

# Non-Authoritative Server

- ✦ actual position sync is non-authoritative
- ✦ complete client-side implementation
- ✦ direct input
- ✦ no control / no verification => cheating
- ✦ solution: authoritative server

# Authoritative Server

- ✦ dumb clients
- ✦ clients sends only commands/events
- ✦ server verifies and send back results
- ✦ authoritative server != dedicated server
- ✦ other problems

# Problems

- ✦ waiting for results (ping)
- ✦ latency (lag)
- ✦ missing packets

**Player 1 view** - move with LEFT and RIGHT arrow keys

Lag =  ms · ☐ Prediction · ☐ Reconciliation · ☐ Interpolation



Non-acknowledged inputs: 0

**Server view** · Update  times per second



Last acknowledged input: Player 0: #0 Player 1: #0

**Player 2 view** - move with A and D keys

Lag =  ms · ☐ Prediction · ☐ Reconciliation · ☐ Interpolation



Non-acknowledged inputs: 0

# Solutions & other Problems

- ✱ client-side prediction

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# Solutions & other Problems

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- ✦ server reconciliation

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# Solutions & other Problems

- ✦ client-side prediction
- ✦ server reconciliation
- ✦ dead reckoning
- ✦ entity interpolation

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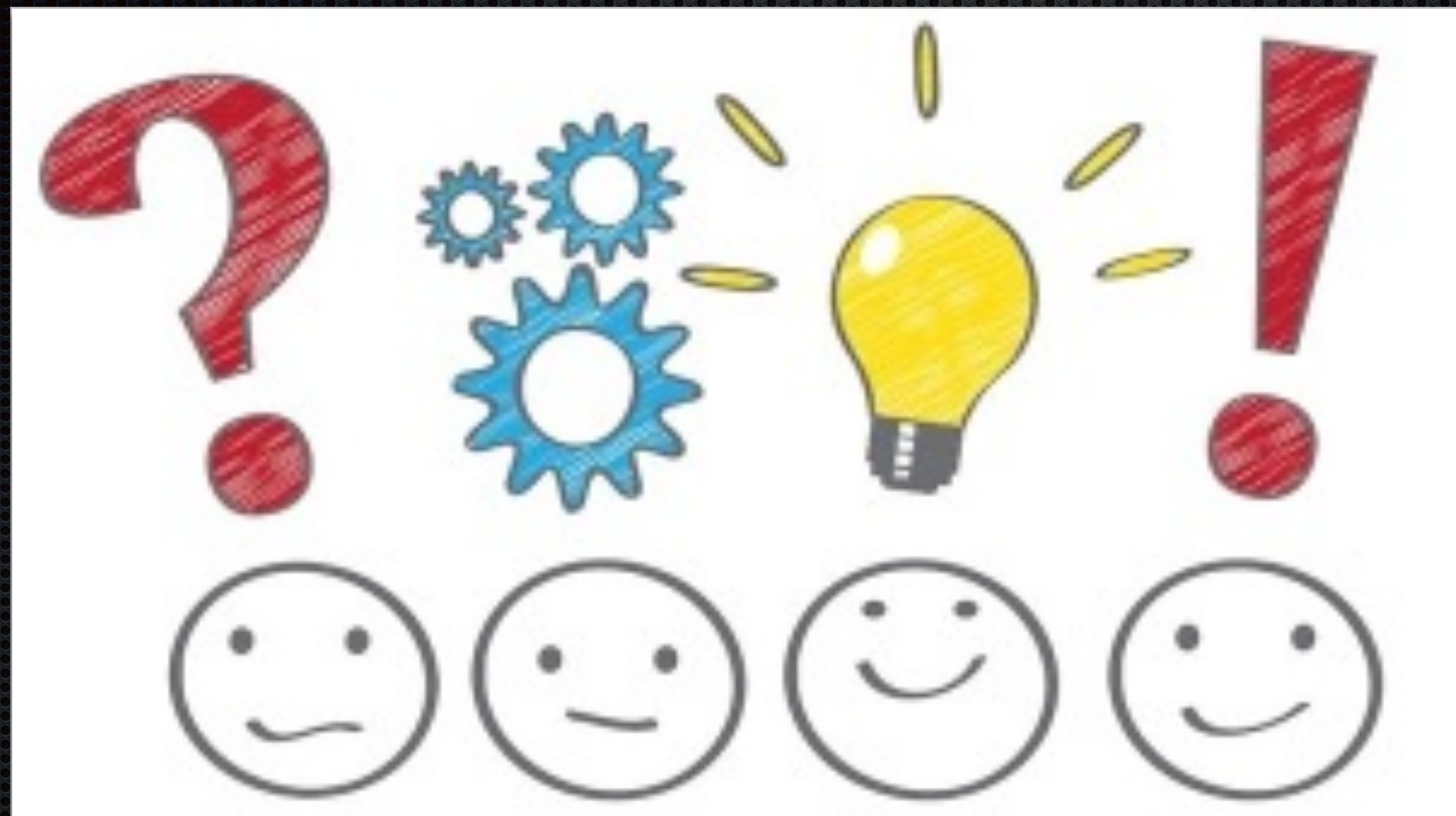
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# Solutions & other Problems

- ✦ client-side prediction
- ✦ server reconciliation
- ✦ dead reckoning
- ✦ entity interpolation
- ✦ lag compensation

# Links

- <https://gafferongames.com/>
- <https://developer.valvesoftware.com/wiki/Category:Networking>
- <https://dev.epicgames.com/documentation/en-us/unreal-engine/networking-and-multiplayer-in-unreal-engine>
- <https://www.gamedeveloper.com/programming/1500-archers-on-a-28-8-network-programming-in-age-of-empires-and-beyond>
- <https://doc.photonengine.com/fusion/current/getting-started/fusion-intro>
- <https://docs-multiplayer.unity3d.com/netcode/current/about/>
- <https://www.gabrielgambetta.com/client-side-prediction-live-demo.html>



# Coding Time

There are two types of people.

```
if (Condition)
{
    Statements
    /*
     *
     */
}
```

```
if (Condition) {
    Statements
    /*
     *
     */
}
```

Programmers will know.