

# Networking Internals for the SQL Server Professional

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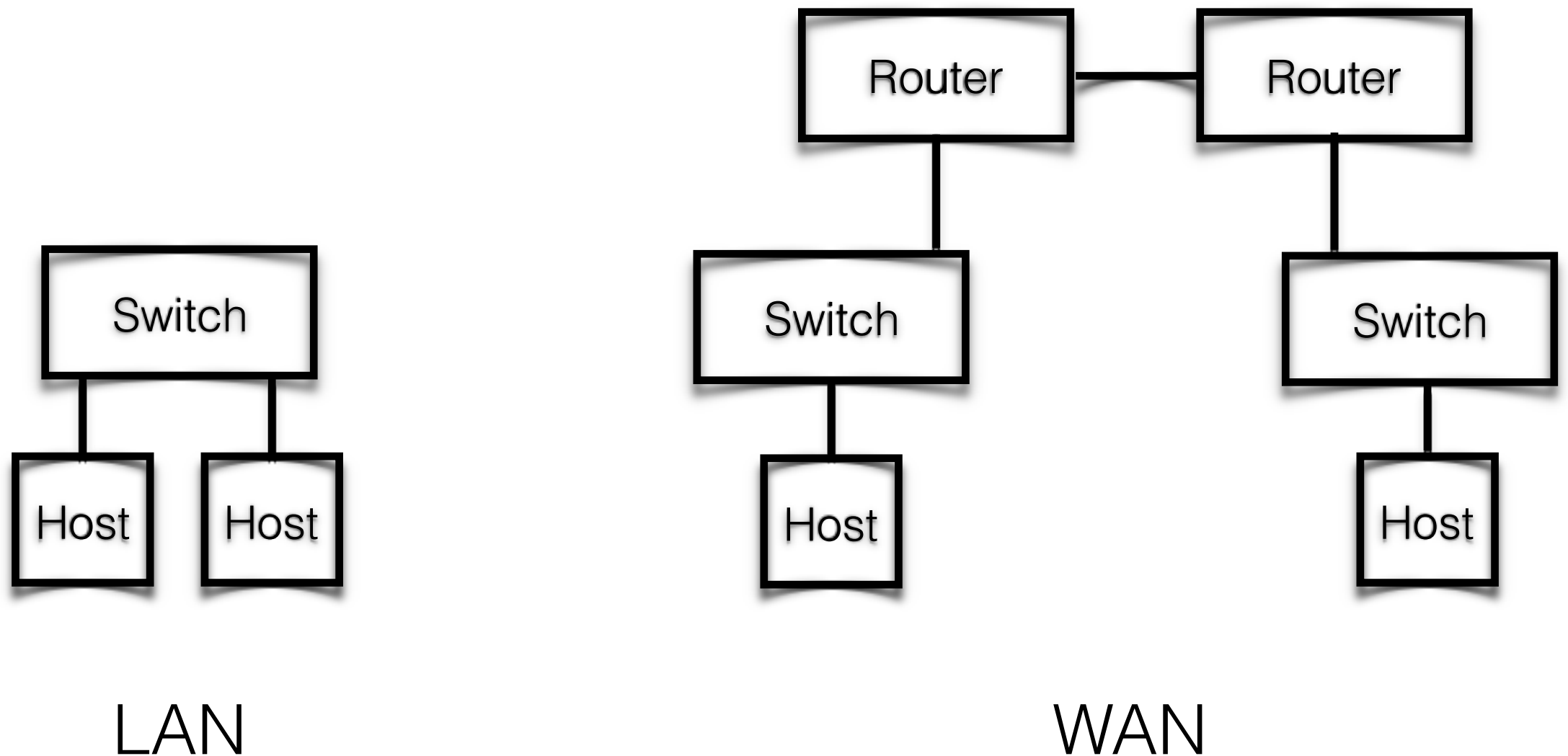
# Overview

- Network Topologies and the OSI model
- Ethernet
- Internet Protocol
- Transmission Control Protocol
- DEMOS!
- SQL Server performance problems
- SQL Server availability problems

# Key Concepts

- Throughput
- Latency
- Reliability

# Network Topologies

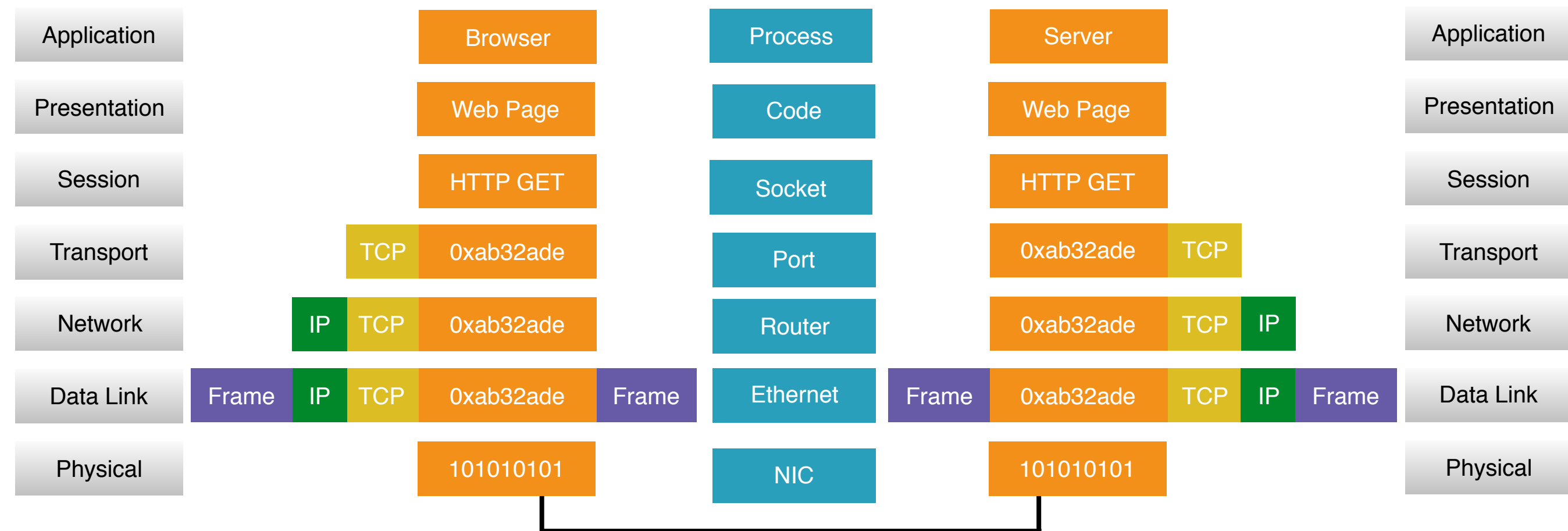


# OSI Model

| Layer               | Description                                       | Transfer Unit    | Example                     |
|---------------------|---|------------------|-----------------------------|
| <b>Application</b>  | Actual application                                | Application Data | Browser                     |
| <b>Presentation</b> | Translation of data for the application layer     | Application Data | HTML, CSS                   |
| <b>Session</b>      | Application level socket                          | Application Data | HTTP, SSH                   |
| <b>Transport</b>    | Data segmentation and delivery                    | Segment          | TCP, UDP                    |
| <b>Network</b>      | Addressing and routing                            | Packet           | IP, routers                 |
| <b>Data link</b>    | Encoding between end stations, and access control | Frame            | Ethernet encoding, switches |
| <b>Physical</b>     | The actual wire                                   | bits (0101010)   | Ethernet NICs, hubs, modems |

# How Data Moves Through a Network...

## Encapsulation



**Encapsulation!**

# Layer 2 - Data Link

- Ethernet
- Responsible for encoding and transmitting frames on the LAN
- MAC Address - uniquely identifies an end station
- arp - binds layer 2 MAC to layer 3 IP
- Very high bandwidth, very low latency
- Devices at this layer - switches, network interfaces



# Ethernet Frame



# Layer 2 - Data Link

- Things to look out for
  - No link
  - Speed or duplex mismatch
  - CPU Saturation on switches

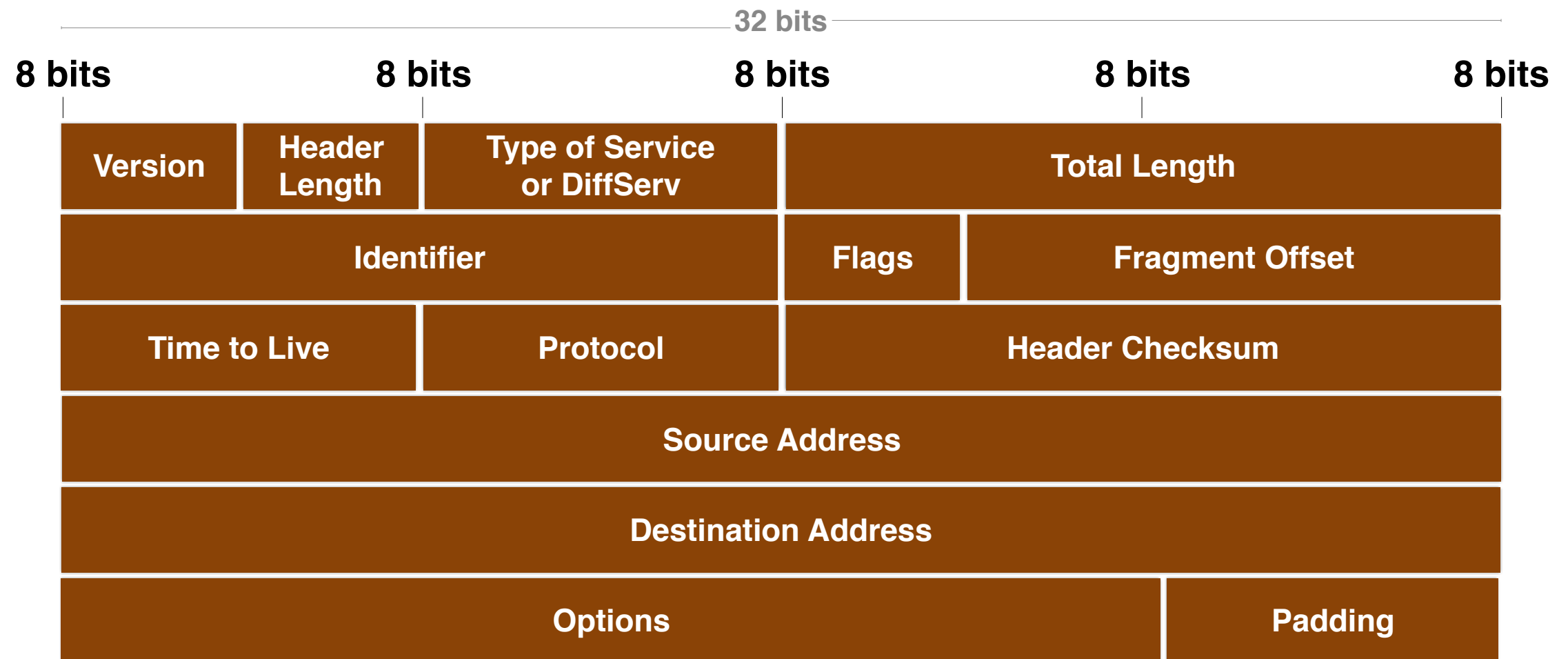
# Layer 3 - Network

- Internet Protocol (IP)
- Responsible for addressing and routing between networks
- Packet - Addressing information and layer 4 data
- Devices at this layer - routers, firewalls...and your machines

# Internet Protocol

- Connects networks
- Connectionless
- Source, destination are defined but the network determines the path
- Routers and hosts define routing tables that define what to do with the packet
- Routers forward packets
- Routers connect networks, generally with higher latency, lower bandwidth connections

# IP Packet Header



# Internet Protocol

- Things to look out for
  - Routing issues
  - Time to live - TTL
  - Bad network masks
  - Dropped packets
  - Misplaced resources
  - Routers as choke points
    - Bandwidth or CPU constrained
  - Name Resolution Latency

# Layer 4 - Transmission Control Protocol

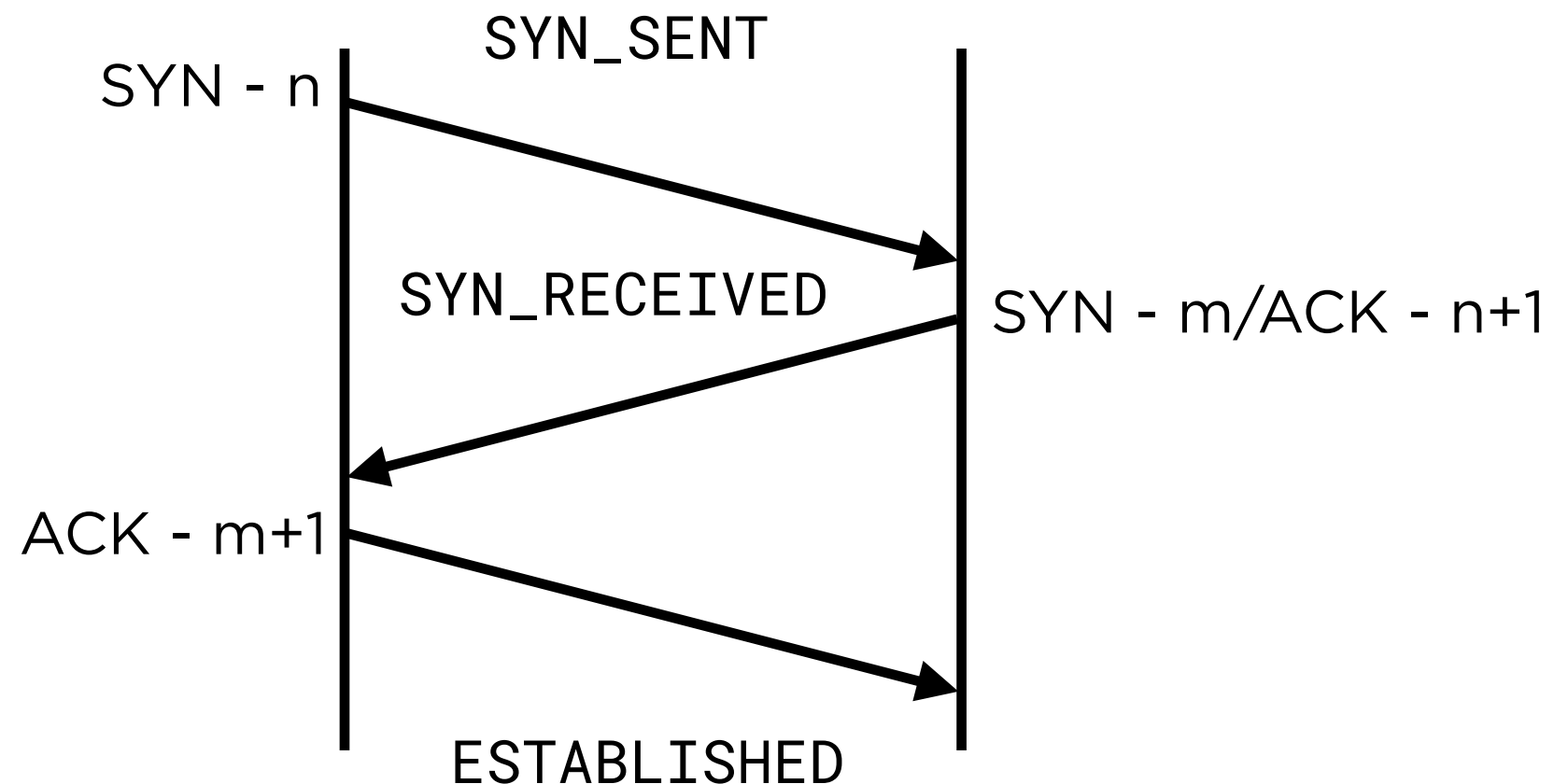
- Responsible for segmentation, ordering of data and reliable delivery
- Segment
  - Application data is broken into segments, IP use used to transport the segment to the destination host
- Sockets and Ports
  - Uniquely defines a connection
  - source IP + source port + destination IP + destination port
- Devices at this layer
  - Operating systems, application aware firewalls, load balancers

# TCP's Killer Performance Optimization

- Positive acknowledgement of each segment
- ACK'ing every segment is slow, because latency!
- Congestion control
  - Congestion Window - if the number of unacknowledged segments is too high, the sender will reduce the window
- Flow control
  - Sliding Window - more than one segment in transport at a point in time. Managed by the receiver



# TCP Connection Establishment -Three Way Handshake

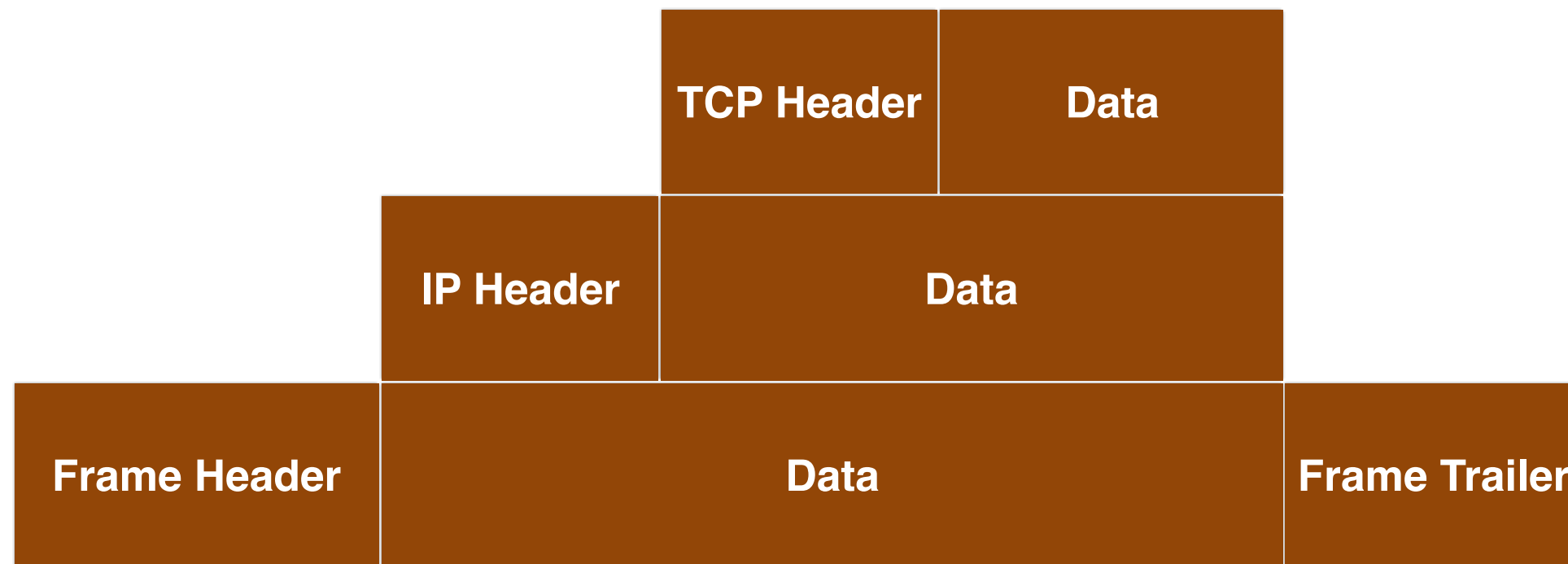


Establishes Initial Sequence Numbers  
Critical to ordered delivery in both directions

# TCP

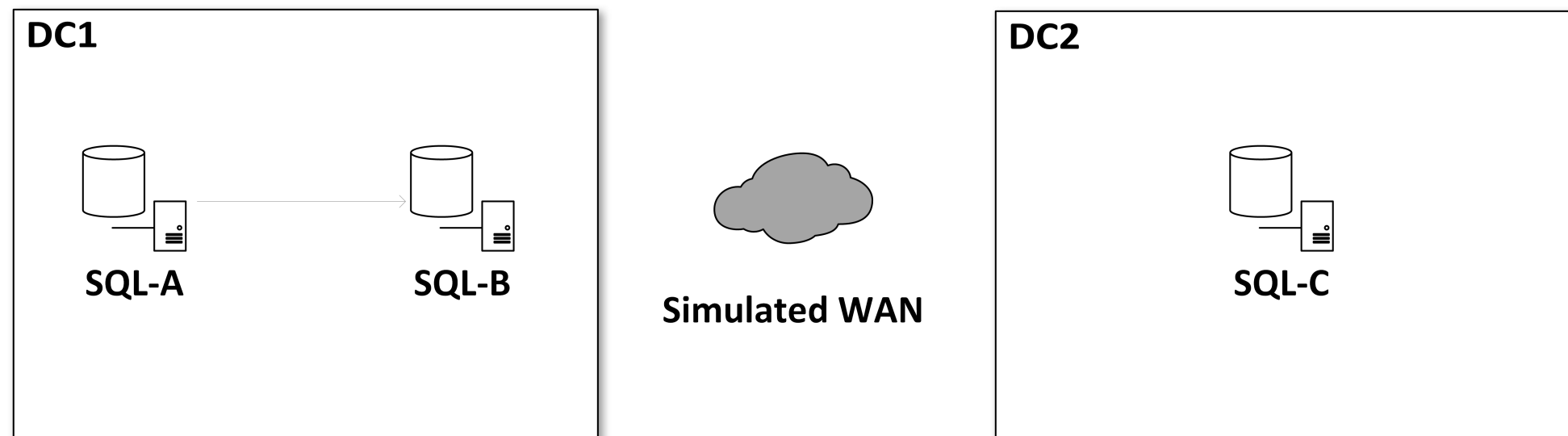
- Things to look out for
  - Latency - at any layer
  - Dropped Packets
  - OS Queuing
  - Firewalls
  - Application errors
  - Row by agonizing row (RBAR)

# Data Encapsulation



# Demos

- **Wireshark**
- **Layer 2**
  - arp
- **Layer 3**
  - `tracert`
    - Time to live (TTL)
- **Layer 4**
  - `netstat`
    - Established connections
    - Connections blocked by firewalls
- **Measuring latency**
  - `iperf`
    - Impact of network latency
    - Impact of reliability issues



# The Big Reveal!

- Why did I tell you about all these fundamental concepts?
  - Throughput, latency and reliability are everything
    - They determine how much data you move and how fast
  - With the demos, you should be able to isolate a network bottleneck or anomaly
- If you're suffering from a network performance or reliability issue...
  - It WILL impact your SQL Server's performance
  - It WILL impact your SQL Server's availability

# Performance Problems

- Application Performance
  - `ASYNC_NETWORK_IO`
- Network based disk IO
  - iSCSI/NFS
    - Disk Latency Issues or even IO errors
      - Slow Systems
      - Locking/Blocking
      - Intermittent database errors

# Availability Problems

- Availability Group Latency
  - HADR\_SYNC\_COMMIT
  - HADR\_SYNCHRONIZING\_THROTTLE
  - HADR\_TRANSPORT\_FLOW\_CONTROL
- Mirroring, Log Shipping
- Backups
  - BACKUP\_IO
- Restores!

# Key Takeaways

- Knowing networking fundamentals are key to isolating performance or reliability issues
- Use the OSI layers as your troubleshooting methodology
- With the demos, you should be able to isolate a network bottleneck or anomaly
- SQL Server will suffer if network performance and reliability are questionable
- Benchmark and baseline your systems, so you know what's normal and what's not normal



# Additional Resources

- **Pluralsight**
  - **LFCE - Advanced Linux Networking**
    - Internet Protocol, Routing, TCP Internals and Troubleshooting!
- **Blog**
  - **Understanding Network Latency and Impact on Availability Group Replication**
    - <http://bit.ly/2l83AKu>

# Need more data or help?

**<http://www.centinosystems.com/blog/talks/>**

Links to resources

Demos

Presentation

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# Questions?

Thank You!