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

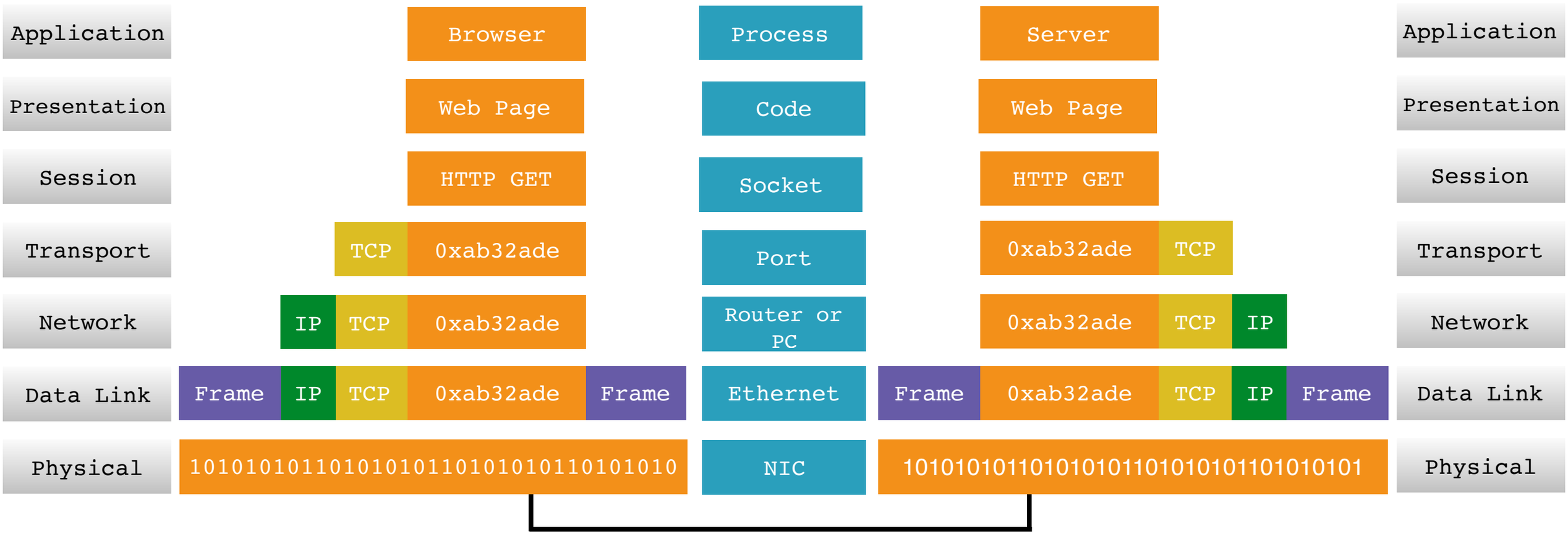
Key Concepts

- Throughput
- Latency
- Reliability

OSI Model

Layer	Description	Transfer Unit	Example
Application	Actual application	Application Data	Browser
Presentation	Translation of data for the application layer	Application Data	HTML, CSS
Session	Application level socket	Application Data	TDS, HTTP, SSH
Transport	Data segmentation and delivery	Segment	TCP, UDP
Network	Addressing and routing	Packet	IP, routers, computers
Data link	Encoding between end stations, and access control	Frame	Ethernet encoding, switches
Physical	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
- MTU - Total length of frame payload. Not fragment-able

- Very high bandwidth, very low latency
- Devices at this layer - switches, network interfaces

Ethernet Frame

6 bytes	6 bytes	2 bytes	46-1500 bytes	4 bytes
Destination MAC	Source MAC	Type	Payload	CRC

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

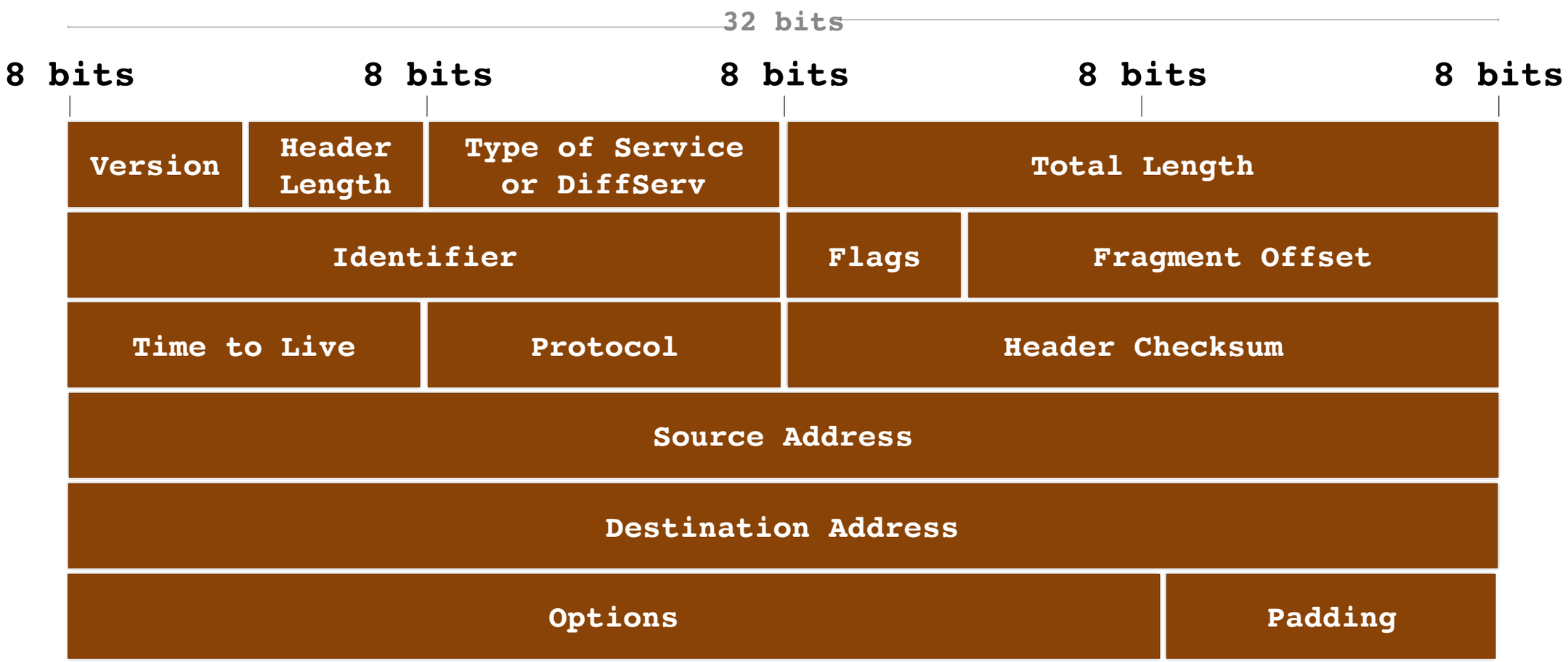
Internet Protocol

- Connects networks
- Connectionless
- Source, destination are defined but the network determines the path
- Routers forward packets
- Routers and hosts define routing tables that define what to do with the packet
- Routers connect networks, generally with higher latency, lower bandwidth connections
- arp - binds layer 2 MAC to layer 3 IP

IP Routing Decision Process

- Check the destination address in the IP header
- Compare that with the network mask to determine if the destination is on a remote network
- If it's local deliver it on the directly connected interface
- If it's not local, look up a specific route in the local routing table
- If it's not local and not in the routing tables, send it to the default route

IP Packet Header



Internet Protocol

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

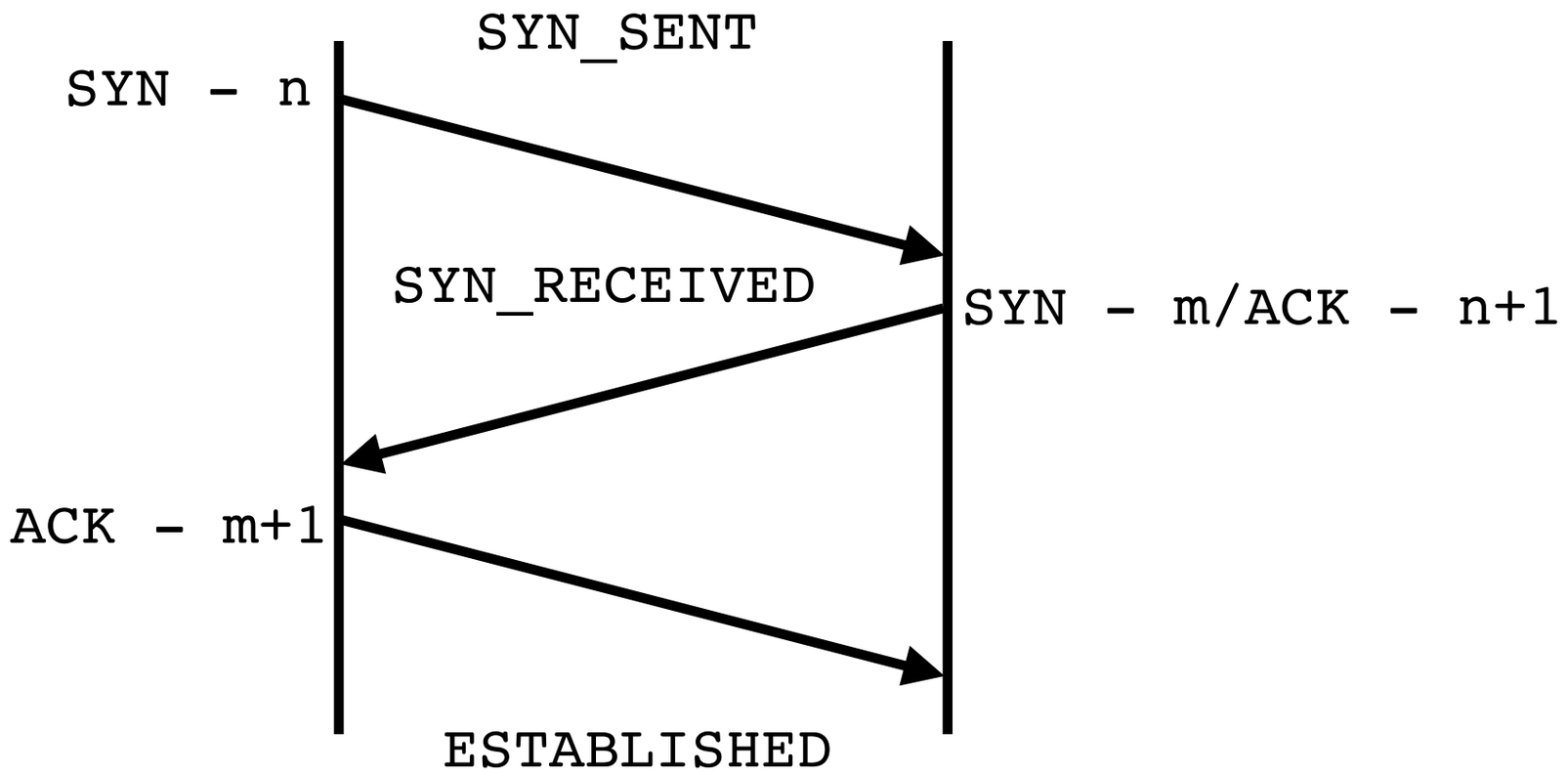
Layer 4 - Transmission Control Protocol

- 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 and WAN optimizers

TCP's Killer Performance Optimization

- Positive acknowledgement of each segment
- ACK'ing every segment is slow, because latency!
- Bandwidth and latency are tightly correlated
- 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

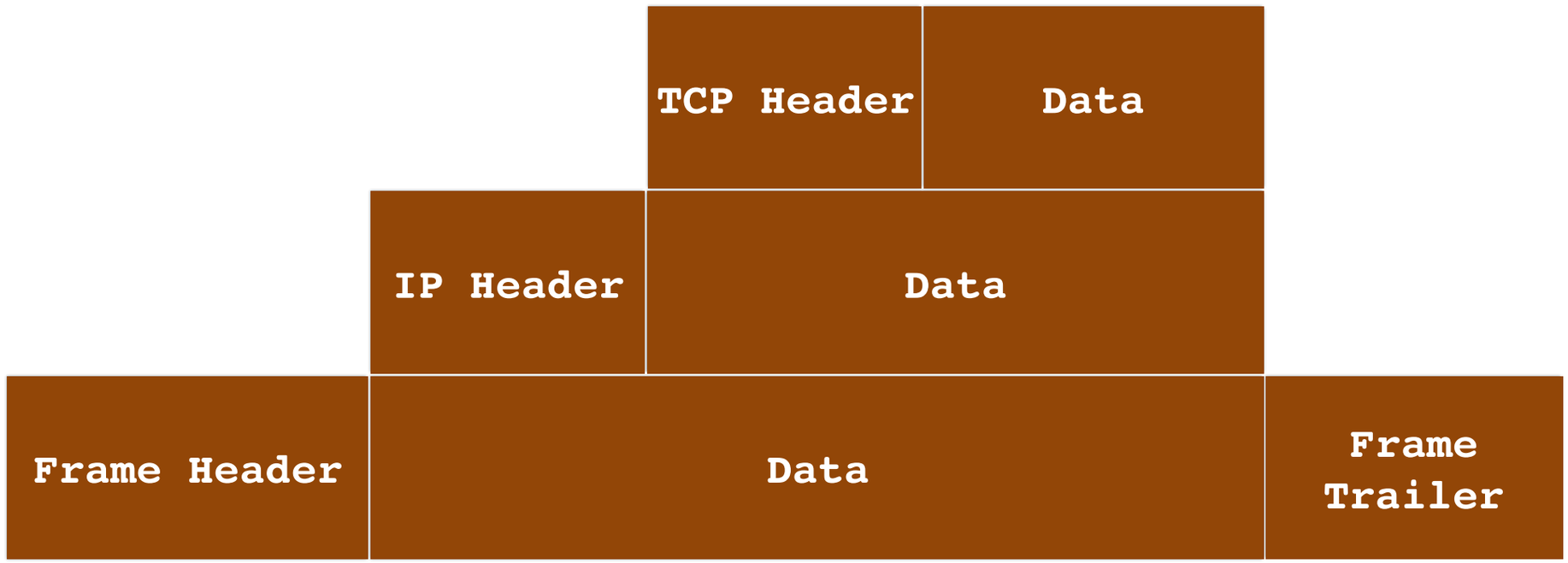


Establishes Initial Sequence Numbers
Critical to ordered, reliable delivery in both directions

TCP

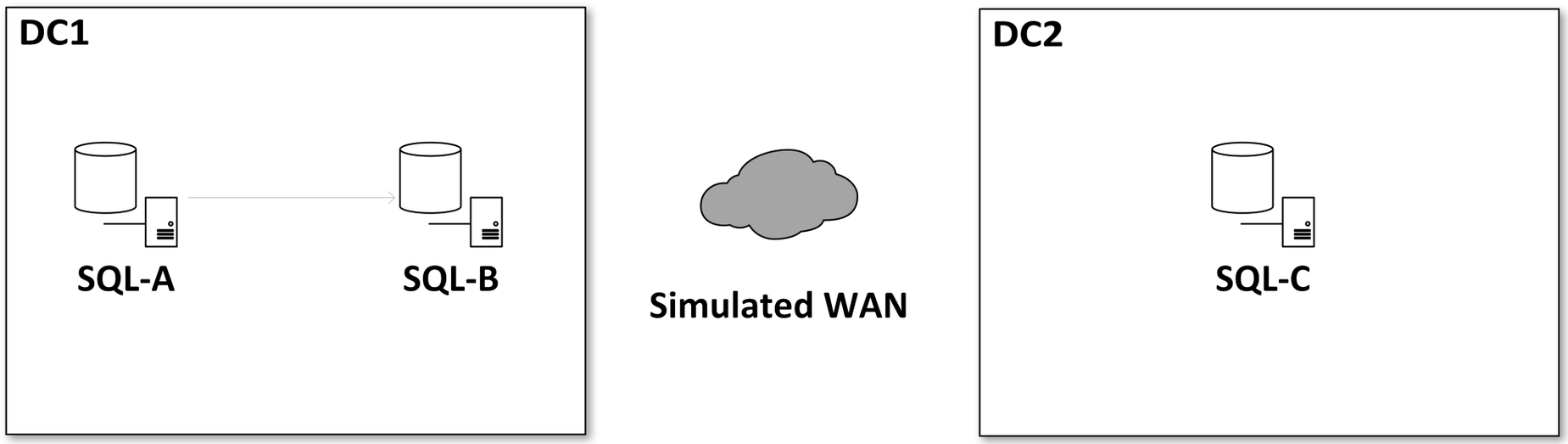
- Things to look out for
  - Latency - at any layer
  - Dropped Packets
  - OS Queuing
  - Firewalls
  - Row by agonizing row (RBAR)

Data Encapsulation Refresher



Demos

- **Wireshark**
- **Layer 2**
  - `arp`
- **Layer 3**
  - `tracert`
    - Time to live (TTL)
- **Layer 4**
- `netstat`
  - Established connections
  - Connections blocked by firewalls
- **Measuring bandwidth**
  - `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 (pretty much anything that accesses your SQL Server over the network)
  - `ASYNC_NETWORK_IO`
- Network based disk IO
  - iSCSI/NFS
    - Disk Latency Issues or even IO errors
      - Slow Systems
      - Locking/Blocking
      - Intermittent database errors
- Cloud Scenarios

Availability Problems

- Availability Group Latency
  - `HADR_SYNC_COMMIT`
  - `HADR_SYNCHRONIZING_THROTTLE`
  - `HADR_TRANSPORT_FLOW_CONTROL`
- Mirroring, Log Shipping
- Backups
  - `BACKUPIO`
- Restores!

What do you need to do?

- Capacity planning - have you planned for the throughput and latency requirements of your application.
  - Baselining and Benchmarking
    - Ensure IO intense or latency sensitive resources are close to each other on properly sized interconnects
- Test!

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 is 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!

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