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Theory Assignment 4

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1.

TCP’s Slow Start can be a bottleneck in high-bandwidth, high-latency networks because it starts off cautiously, sending only a small amount of data and slowly increasing the rate over time. This means it takes a while before the connection can fully take advantage of the available bandwidth, which leads to inefficient data transfer in networks that could handle much more from the start. QUIC, a newer transport protocol developed by Google and later standardized, addresses this issue with faster connection setup (thanks to 0-RTT handshakes), smarter and more precise loss detection, and support for modern congestion control methods like BBR. These improvements help QUIC avoid the slow ramp-up problem, allowing data to flow more efficiently right from the beginning, especially in networks where speed and responsiveness really matter.

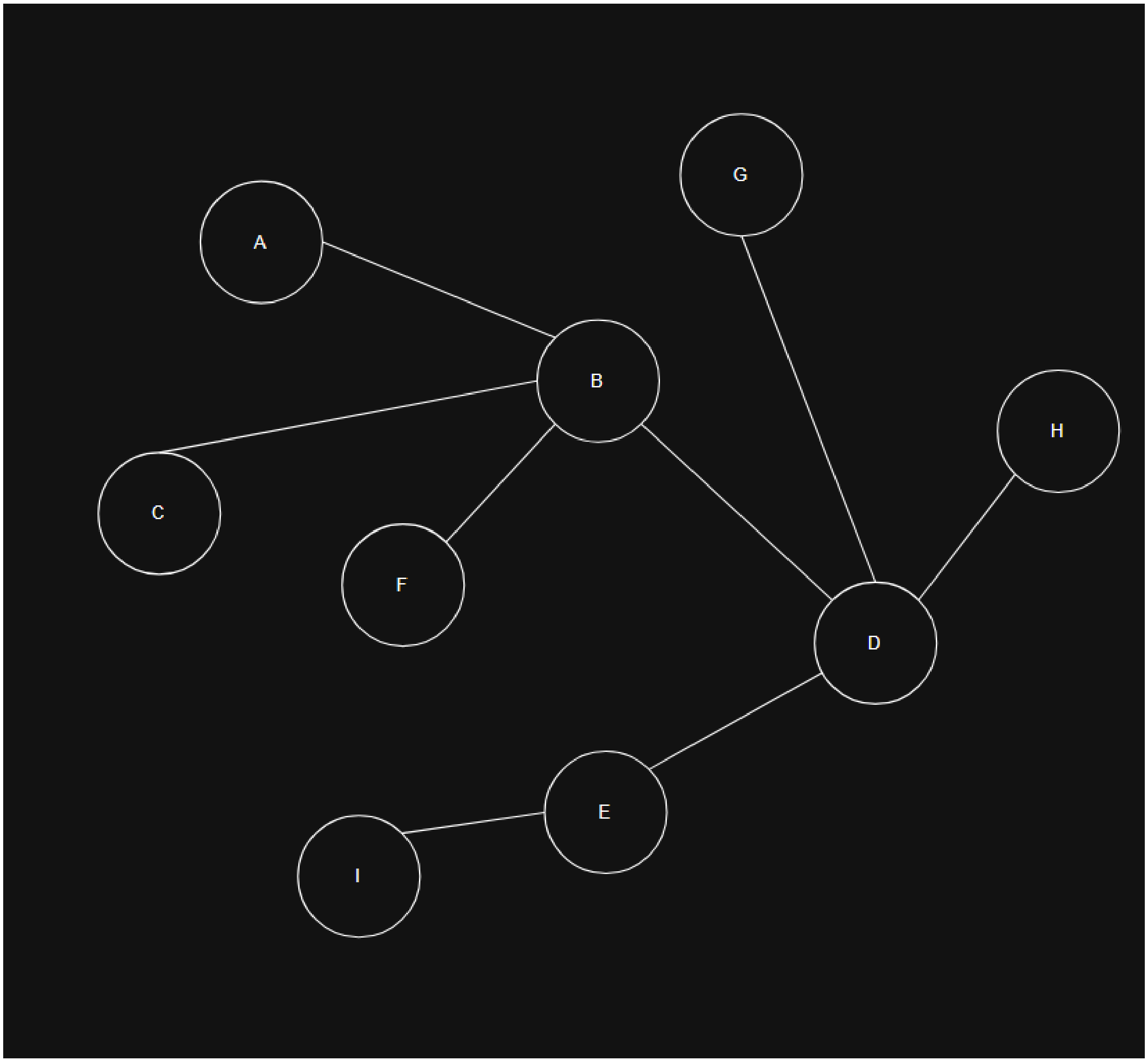
2.

NAT routers help save IPv4 addresses by letting multiple devices on a local network share one public IP address. But while that's great for efficiency, it can cause problems for things like peer-to-peer apps and VoIP calls. The biggest issue is that NAT blocks incoming connections unless they’re part of a request that started from inside the network. That makes it hard for other devices on the internet to reach you directly, which is kind of the whole idea behind peer-to-peer communication. NAT also messes with IP addresses and ports in the data, which can break certain protocols like the ones used in VoIP that rely on that information staying the same. Things get even trickier with symmetric NATs, which assign different mappings for each connection, making it hard to use common workarounds like hole punching. To deal with all this, apps have to use extra tools like STUN or TURN servers, which can slow things down and hurt call quality. All in all, NAT is helpful in many ways, but it does get in the way of smooth, direct communication between devices.

3.

CSMA and Slotted ALOHA are both MAC (Medium Access Control) protocols designed to manage how devices share a communication channel, but they differ significantly in performance. Slotted ALOHA improves upon pure ALOHA by dividing time into slots, allowing devices to transmit only at the beginning of a slot, which reduces but doesn't eliminate collisions. Its maximum throughput is around 36.8%, and it tends to suffer from high collision probability and delay, especially under heavy traffic. On the other hand, CSMA (Carrier Sense Multiple Access) allows a device to listen to the channel before transmitting. This carrier sensing greatly reduces the chances of collision and improves efficiency, with some versions of CSMA achieving much higher throughput up to 85% and generally lower delay. However, CSMA can become less effective in environments with high propagation delay or where channel sensing isn't feasible. In such cases, like in satellite communications or very simple wireless systems, Slotted ALOHA may actually be preferred due to its simplicity and lack of dependence on sensing the channel. Overall, CSMA is usually more efficient, but Slotted ALOHA still has its niche in specific network scenarios.

4.



5.

A)

A fully-connected network topology brings several notable advantages. First, it offers high redundancy and reliability. Since each device in the network is directly linked to every other device, there are multiple potential paths for data to travel. This means that if one connection fails, the data can easily be rerouted through another path, maintaining the network's functionality without downtime. Another advantage is the boost in performance and speed. With direct communication between devices, there is minimal delay, as data doesn't need to traverse through intermediary nodes, making it an excellent choice for applications requiring fast data transmission. Moreover, troubleshooting becomes more manageable in a fully-connected setup. With every device having a direct connection to all others, pinpointing and isolating the source of any issues is relatively straightforward. Lastly, for smaller networks, a fully-connected topology can be simpler to design and manage, with fewer complications in ensuring efficient communication.

B)

Despite its benefits, a fully-connected topology presents significant drawbacks, particularly for large-scale networks. One of the most pressing challenges is the exponential increase in cable requirements. As the number of devices grows, the number of necessary connections increases dramatically. For instance, a network of just 100 devices would require 4,950 connections, making it not only impractical but also extremely costly to implement. This leads to the second major issue: the high cost and complexity of maintaining such a network. The infrastructure to support a fully-connected setup, including cables, switches, and network management systems, becomes increasingly expensive as the network size expands. Moreover, this topology has limited scalability. When new devices are added, they must be connected to every other existing device, which makes the process of expanding the network slow and cumbersome. Lastly, network congestion is a real concern. With so many devices and connections, there is a higher risk of bottlenecks, which can lead to slower data transfer speeds and decreased overall network performance.

C)

It was very hard to sustain it and also to put it all together.

6.

A)

There is a total data of 15 bits, 11 are data and 4 are parity.

P1: 1,3,5,7,9,11,13,15

P2: 2,3,6,7,10,11,14,15

P3: 4-7,12-15

P8: 8-15

B)

The total data is 24 bits 19 are data and 5 are parity bits.

P1: 1,3,5,7,9,11,13,15,17,19,21,23

P2: 2,3,6,7,10,11,14,15,18,19,22,23

P3: 4-7,12-15,20-23

P8: 8-15, 24

P16: 16-24

7.

Ethernet LANs have achieved superior performance compared to Token Ring LANs, despite Token Ring’s advantage of avoiding collisions, due to several factors. Token Ring, while collision-free, suffers from slower speeds due to the token-passing mechanism, which introduces latency and reduces efficiency, especially under heavy traffic. Additionally, Token Ring networks are more complex to manage, as a failure in the centralized token-passing system can disrupt the entire network. Moreover, scalability becomes an issue as adding devices increases the time for the token to complete its loop, resulting in greater delays. In contrast, Ethernet's success came with the introduction of Switched Ethernet, which eliminated collisions by providing point-to-point communication through switches, allowing devices to communicate simultaneously without interference. This full-duplex communication system increased bandwidth utilization and drastically improved network throughput. Ethernet also benefited from advancements in technology, such as Gigabit and 10 Gigabit Ethernet, which further boosted performance. The simplicity of Ethernet combined with the scalability and cost-effectiveness of switched architectures allowed Ethernet to outpace Token Ring networks in both speed and reliability, making it the dominant choice for modern LANs.

8. CRC (Cyclic Redundancy Check) is preferred over other error-detection methods like checksums or parity bits in high-reliability systems because it offers a higher level of error detection accuracy and is computationally efficient. Unlike parity bits or checksums, which can only detect basic errors, CRC can catch more complex errors, such as burst errors where multiple bits are altered, making it ideal for environments where data integrity is

critical. It’s also quick and easy to implement, even for large datasets, making it a practical choice for systems with high data throughput. However, while CRC is excellent for detecting errors, it doesn't correct them. To enable error correction, one could combine CRC with error-correcting codes (ECC), such as Reed-Solomon or Hamming codes. These codes not only detect but also correct errors by adding redundancy, allowing systems to both detect and fix errors in transmitted data. By using CRC for fast detection and ECC for correction, high-reliability systems can ensure both robust error detection and the ability to recover from mistakes.