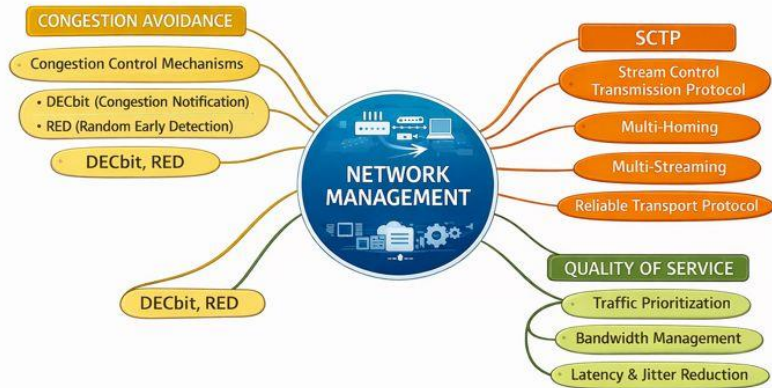


23ITT204 - COMPUTER NETWORK

UNIT 2 - TRANSPORT LAYER

CONGESTION AVOIDANCE



Congestion Avoidance in the Transport Layer

How TCP prevents network overload and maintains efficient dataflow through intelligent congestion control mechanisms. This fundamental protocol is key to stable, fair, and high-performance Internet communication across the globe.

TCP Congestion Control: The Big Picture

TCP employs a sophisticated congestion window (CWND) mechanism to regulate the amount to prevent congestion, collapse and ensuring optimal network performance.

- 1 **SlowStart Phase**
Exponential growth of the congestion window to quickly discover available network capacity. CWND doubles each round-trip time until reaching the threshold.
- 2 **Congestion Avoidance Phase**
Linear, cautious growth after threshold is reached. The window increases conservatively to probe for additional capacity without overwhelming the network.
- 3 **Congestion Detection**
Packet loss or duplicate ACKs signal network congestion, triggering immediate window reduction to alleviate pressure and restore equilibrium.

Additive Increase / Multiplicative Decrease

How AIMD Works

Additive Increase: After reaching the slow start threshold, the congestion window grows linearly by 1 segment per round-trip time (RTT), allowing gradual capacity exploration.

Multiplicative Decrease: When congestion is detected, CWND is aggressively cut in half or reset to 1 segment, depending on the severity of the signal received.

This carefully tuned balance prevents catastrophic congestion collapse while ensuring fair bandwidth distribution among competing flows across the network.

Example Scenario

CWND grows steadily: 20^3 21^3 22 segments per RTT. Upon detecting packet loss, it immediately drops to 11 segments, then resumes linear growth.

Why Congestion Avoidance Matters

Without TCP's congestion avoidance mechanisms, modern Internet infrastructure would face severe degradation and potential collapse under load.

Prevents Packet Loss

Eliminates buffer overflow situations that lead to dropped packets and degraded service quality for all users.

Reduces Delays

Minimizes unnecessary retransmissions and queuing delays, ensuring predictable latency for time-sensitive applications.

Avoids Throughput Collapse

Prevents the catastrophic scenario where excessive congestion causes network throughput to plummet dramatically.

TCP's congestion avoidance enforces a **packet conservation principle**: new packets are sent into the network only when old packets are acknowledged and have left the system.

The result is stable, efficient, and fair utilization of network resources across millions of simultaneous Internet connections worldwide, enabling the seamless digital experiences we rely on daily.