

How the Internet Works



- A global network of interconnected computer networks using common protocols



- The Internet: physical and protocol infrastructure



- The World Wide Web: an application-layer service running on it



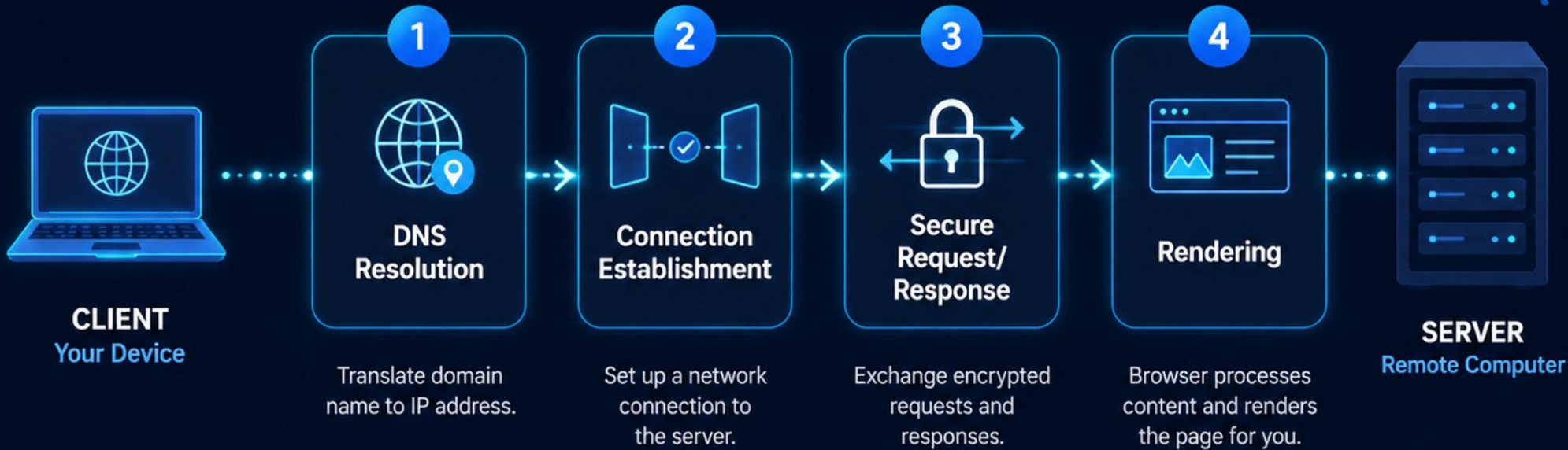
- Training layers: physical, logical addressing, transport, and application



- Framed around one question: "What happens when you type a URL and press Enter?"



The Big Picture: A 30-Second Tour



- Walk through the four high-level stages: DNS resolution, connection establishment, secure request/response, and rendering.



- Introduce the client-server model: your device (client) requests resources from a remote computer (server).



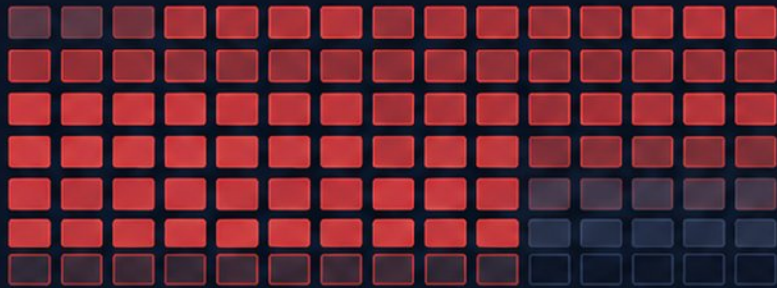
- Emphasize that every step involves multiple layers working together, from physical cables to application logic.

Endpoints and Identity: IP Addresses

IPV4: 32-BIT ADDRESS SPACE

~4.3 BILLION ADDRESSES

EFFECTIVELY EXHAUSTED



IPV6: 128-BIT ADDRESS SPACE

VIRTUALLY UNLIMITED ADDRESSES



- IP addresses uniquely identify devices on a network



- IPv4: 32-bit, ~4.3 billion addresses – now effectively exhausted



- IPv6: 128-bit, virtually unlimited address space



- IPv4 address costs rose from ~\$7 (2015) to ~\$55–60 (2026)

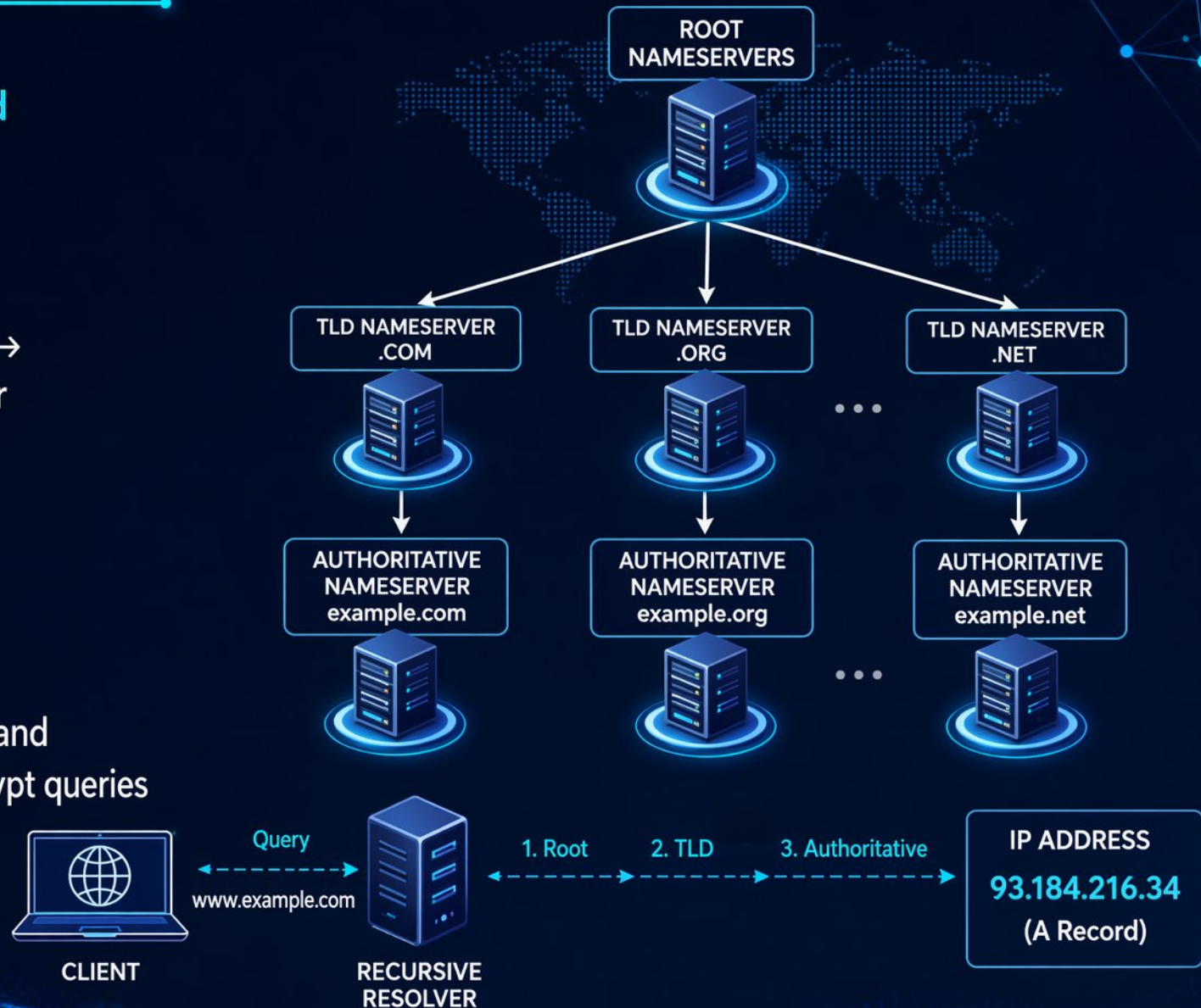


- Google: ~50% of users access via IPv6; France (86%), India (72%) lead



The Internet's Phonebook: DNS

- **Hierarchical, distributed** database translating names to IP addresses
- **Lookup chain:** resolver → root → TLD → authoritative nameserver
- **Record types:** A (IPv4), AAAA (IPv6), CNAME (alias)
- **Privacy:** DNS over HTTPS (DoH) and DNS over TLS (DoT) encrypt queries



Physical Infrastructure: The Global Backbone



- 99% of intercontinental traffic runs through submarine fiber-optic cables



- 694 cable systems and 1,893 landing stations active or under construction



- Longest cable: 2Africa spans 45,000 km, connecting 33 countries



- Last-mile: FTTH, DOCSIS cable, 5G cellular, and satellite (Starlink)



- Internet Exchange Points (IXPs) enable direct network peering and efficient traffic exchange



694

CABLE SYSTEMS



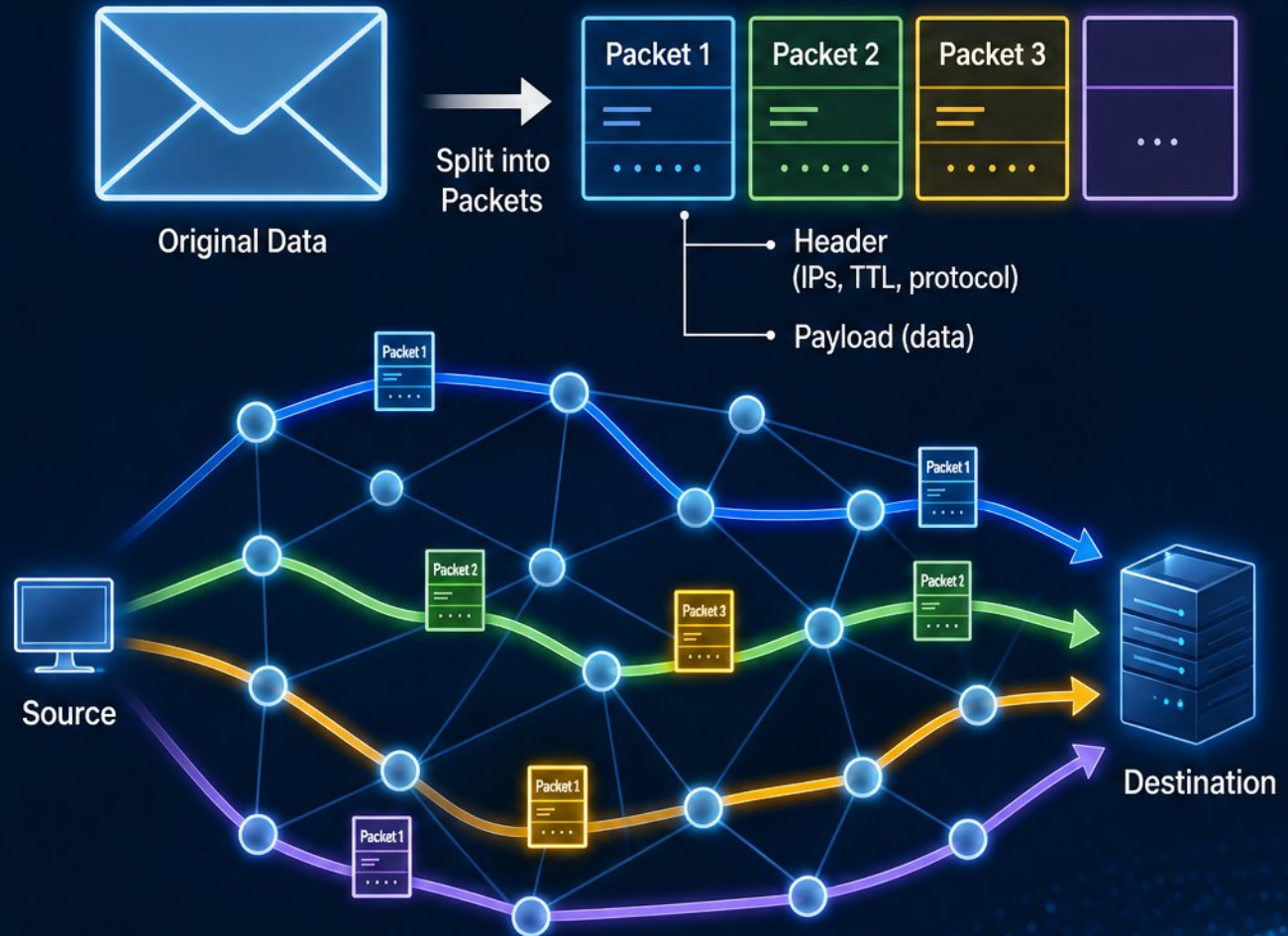
1,893

LANDING STATIONS

ACTIVE OR UNDER CONSTRUCTION

Packets and Packet Switching

- Data broken into discrete **packets**, each independently routed to destination
- **Contrast:** circuit switching reserves a dedicated path for the entire session
- **IP packet anatomy:** header (IPs, TTL, protocol) and payload (data)
- **Efficiency:** multiple communications dynamically share the same physical links



Packets may take different paths and arrive out of order.
The network reassembles them at the destination.

Routing: Finding the Path

- Routers consult forwarding tables to determine the next hop for each packet.
- BGP connects autonomous systems, serving as the glue of global routing.
- Path selection uses metrics: hop count, latency, bandwidth, and policy.
- Example: A packet from Tokyo to London hops through multiple ASes.



The Transport Layer: TCP and Reliability



- Connection-oriented protocol ensuring reliable, ordered data delivery



- Three-way handshake: SYN, SYN-ACK, ACK establishes bidirectional channel



- Sequence numbers and acknowledgments (ACKs) detect lost packets



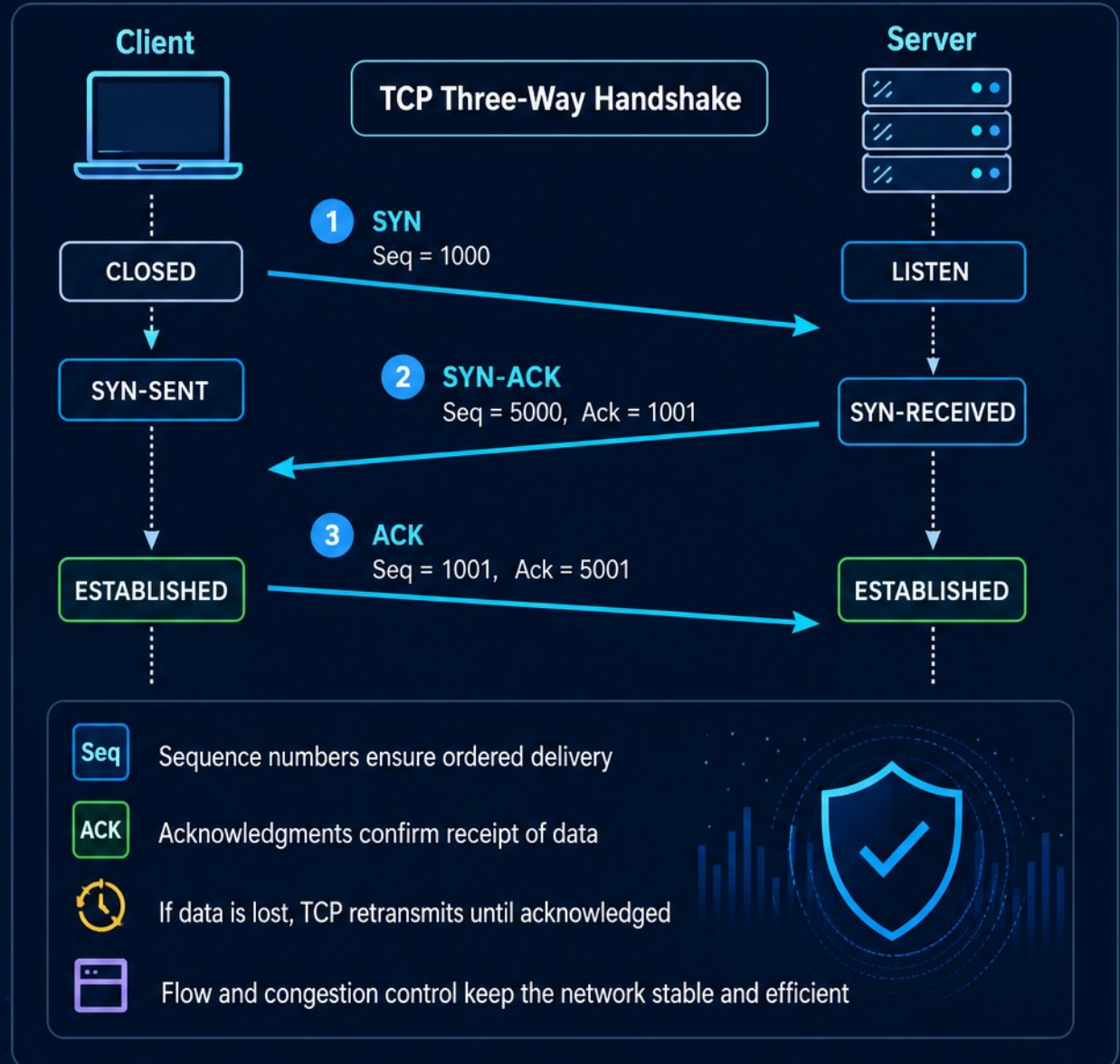
- Automatic retransmission of unacknowledged data



- Flow control prevents sender from overwhelming the receiver



- Congestion control prevents network overload



The Transport Layer: UDP and Real-Time Applications

TCP: Connection-Oriented (Reliable)

Ordered, reliable delivery with flow control



UDP: Connectionless (Best-Effort)

Fire-and-forget delivery with minimal overhead



- **Connectionless:** No handshake, no delivery guarantees
- **Best-effort:** Packets may be lost, duplicated, or reordered
- **Low latency:** Ideal for real-time, delay-sensitive applications
- **No head-of-line blocking:** One lost packet doesn't stall others
- **Powers** live streaming, gaming, VoIP, and DNS queries



LIVE
STREAMING



GAMING



VOIP



DNS
QUERIES

The Application Layer: HTTP and the Web



- Application layer is the topmost layer where user-facing protocols like HTTP operate



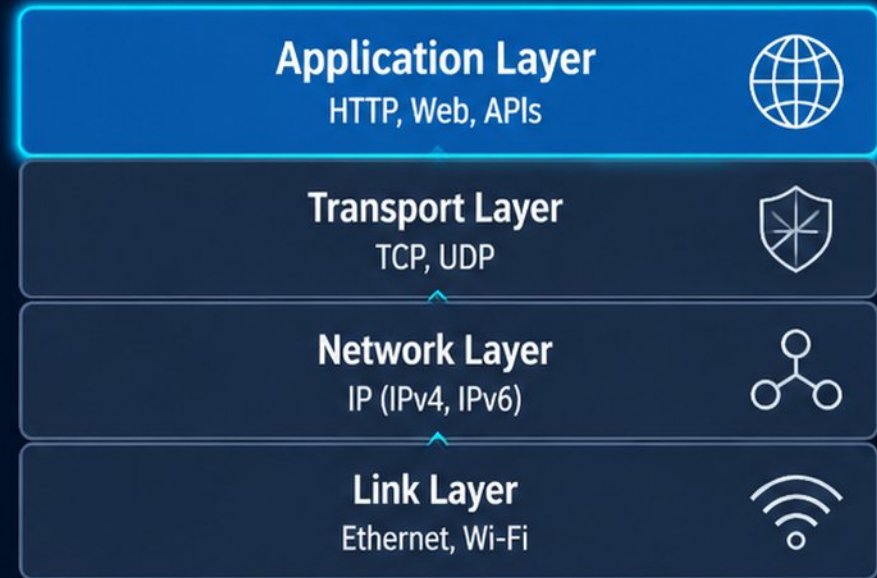
- Request-response cycle: client sends GET/POST, server returns status (200, 404)



- Modern pages assemble from dozens of requests: HTML, CSS, JS, images



- HTTP evolution: HTTP/1.1 → HTTP/2 (multiplexing) → HTTP/3 (built on QUIC/UDP)



Client

HTTP Request

GET /index.html HTTP/1.1
Host: example.com

HTTP Response

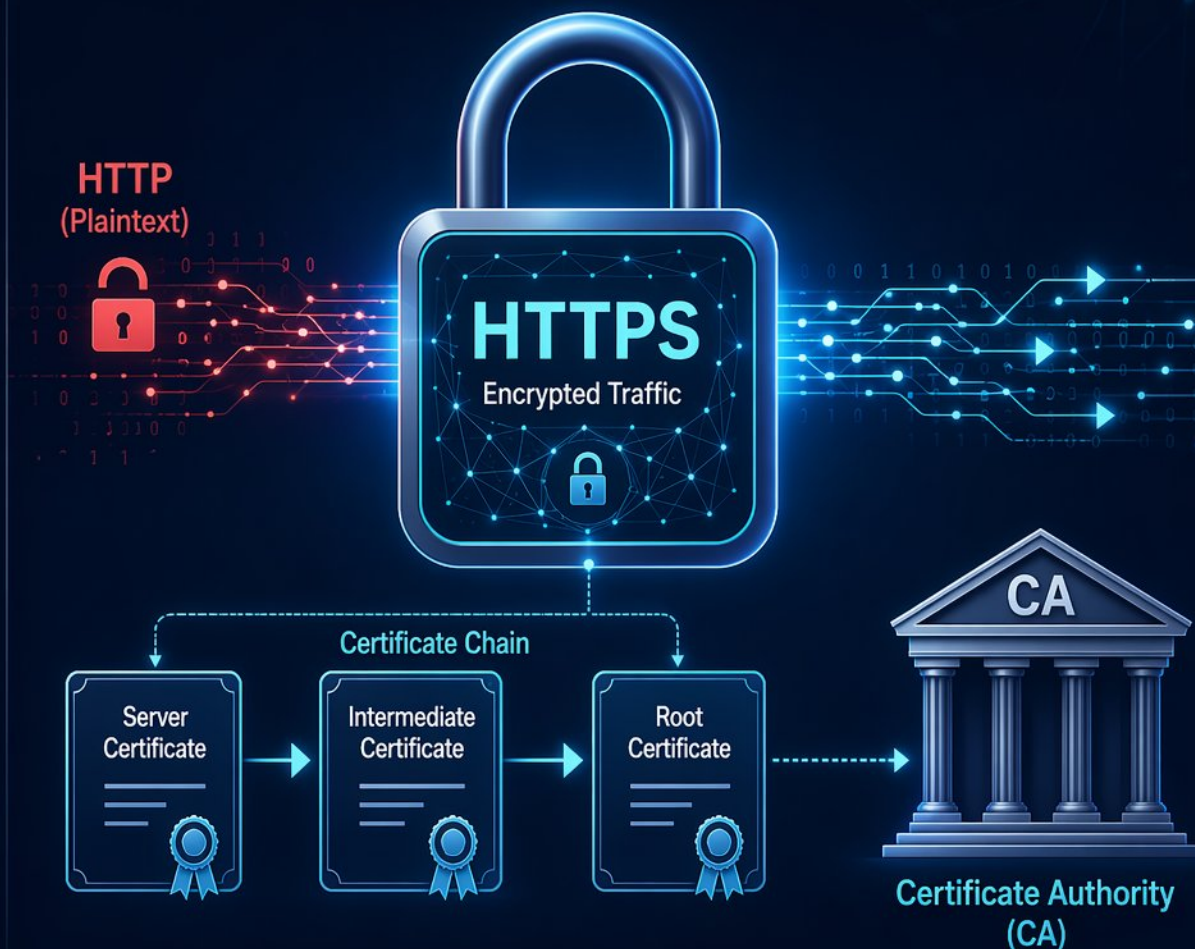
HTTP/1.1 200 OK
Content-Type: text/html



Server

Securing the Web: HTTPS and TLS

- HTTP (plaintext) vs. HTTPS (HTTP over TLS encryption)
- TLS handshake: cert validation, key exchange, encrypted session
- Certificate Authorities (CAs) & Let's Encrypt: 56.7% of certs in 2026
- 93.9% of web traffic uses modern TLS (1.3 + QUIC); TLS 1.2 legacy at 6.1%



Confidentiality
Data is encrypted
in transit



Integrity
Data cannot be
tampered with



Authentication
Server identity
is verified



Modern Protocols
TLS 1.3 + QUIC
for performance

The Evolution of Transport: QUIC and HTTP/3



- **QUIC:** transport on UDP with TLS 1.3 encryption built in by default



- Key wins: 0-RTT resumption, no head-of-line blocking, connection migration



- HTTP/3 at ~21% of requests, 39% of websites; enabled by default on major CDNs



- Start at the CDN edge, keep HTTP/2 fallback, monitor LCP and TTFB by protocol

PROTOCOL STACK EVOLUTION

THE PAST: TCP + TLS + HTTP/2



HTTP/2



TLS 1.2+



TCP



IP

THE FUTURE: QUIC + HTTP/3



HTTP/3



QUIC
(TLS 1.3 Built-in)



UDP



IP



0-RTT
Resumption



1990s
TCP

Reliable transport



2000s
TLS

Secure the connection



2015+
HTTP/2

Faster over TCP



Now
QUIC + HTTP/3

Faster, more resilient,
built for the modern web

End-to-End Journey: A Practical Trace



Full site load: DNS cache → recursive query → TCP handshake → TLS negotiation → HTTP/2 or HTTP/3 request → CDN edge response



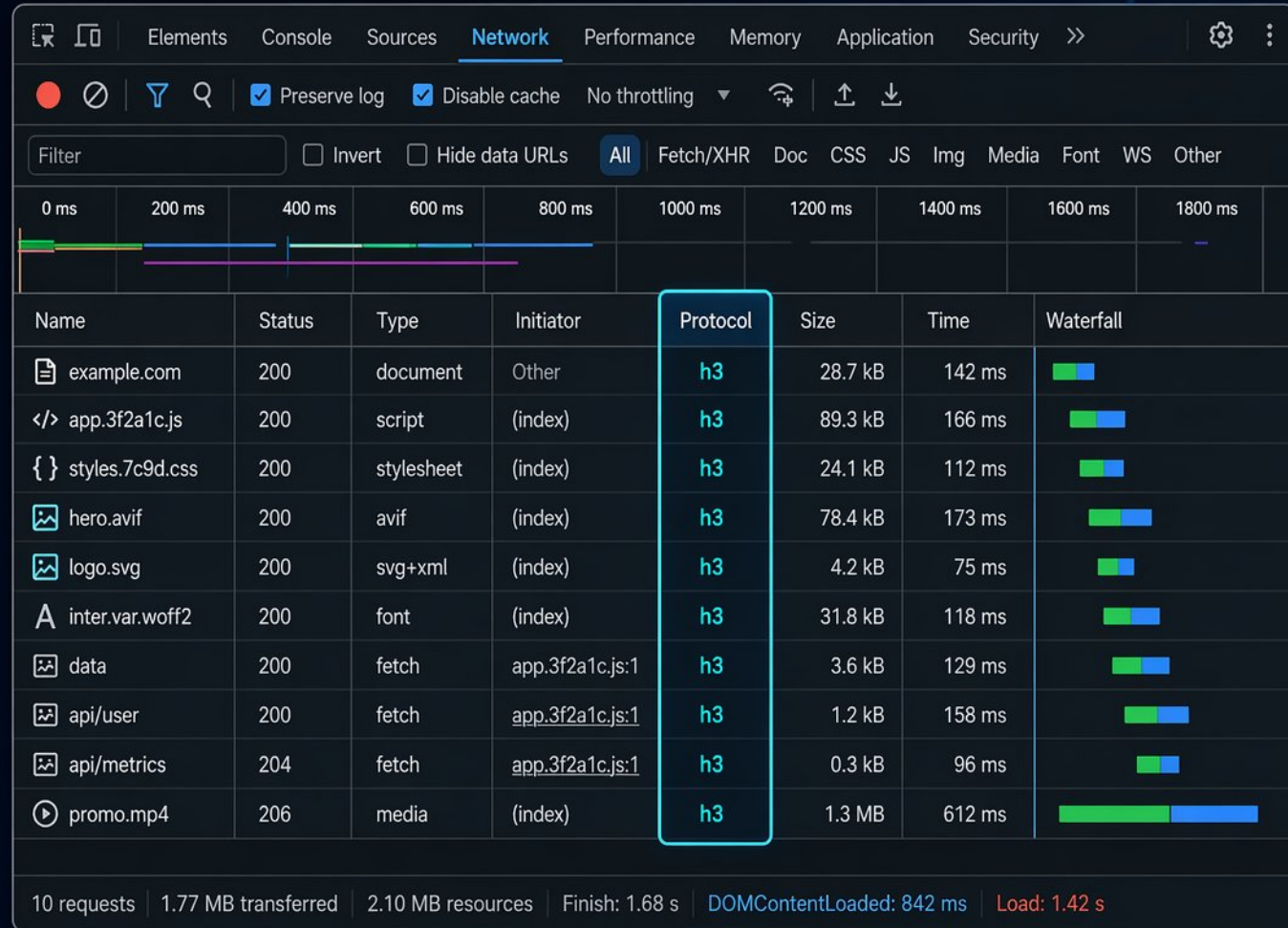
Diagnostic kit: `ping` (connectivity), `traceroute` (path), `dig` (DNS), and browser DevTools (Network tab)



Protocol check: 'h2' (HTTP/2) or 'h3' (HTTP/3) column in DevTools; 'h3' often learned via Alt-Svc header



CDN reality: most traffic is served from nearby edge caches, not the origin; CDN handles HTTP/3 termination



The Internet of Things and Scale



- IoT means billions of connected devices — sensors, wearables, and appliances drive demand for IPv6



- Many IoT devices still use IPv4, forcing reliance on complex NAT and CGNAT workarounds



- Greenfield mobile networks now deploy IPv6-native stacks by default, lowering total cost of ownership



- IPv6 adoption (50% milestone) and QUIC connection migration are critical for IoT reliability



Edge Computing and the Future of Latency



- Moves computation and data storage closer to the user



- Utilizes CDN nodes, 5G MEC, and IoT gateways



- Enables faster content delivery and real-time AI inference



- Reduces backhaul traffic and network congestion



- Evolves the CDN model for next-generation applications

FROM FAR

Higher latency
More backhaul
congestion

TO NEAR

Lower latency
Smarter, faster
experiences

CENTRAL CLOUD
(DATA CENTER)



EDGE NODES
(CLOSER TO USERS)



Review and the Road Ahead



- The Internet is a layered system: physical, logical, transport, and application

KEY METRICS



50%

IPv6 users



21%

HTTP/3 requests



694

subsea cables



93.9%

modern TLS

FUTURE



IPv6-only
networks



QUIC/HTTP/3
default



Edge
computing



IoT
scale



- Enable IPv6 and HTTP/3 on your projects; use diagnostic tools to understand the network



- Follow evolving standards from IETF, RIPE, and APNIC

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