CSCI-1680
How to (try) to be anonymous
Wrapup

Nick DeMarinis

Based partly on lecture notes by Rodrigo Fonseca, Scott Shenker and John Jannotti

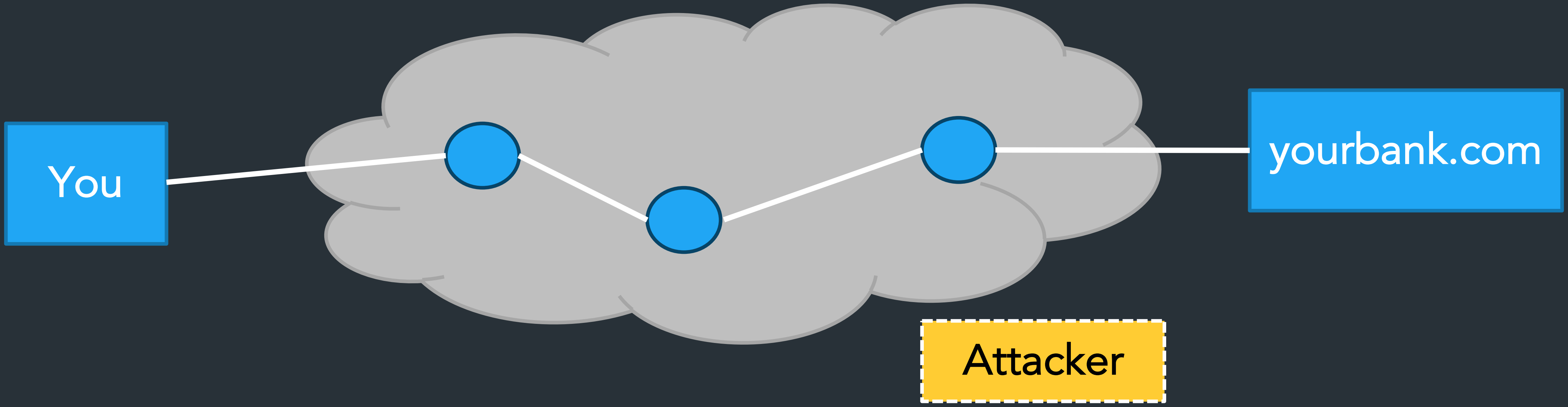
Administrivia

- HW5: Due Monday, 12/9
- Final project: Due 12/16
- SRC problem: Due 12/16 (will be some form of extra credit)
- Office hours: see the calendar

- Course feedback
  - University feedback
  - Critical Review
  - I will send you a form

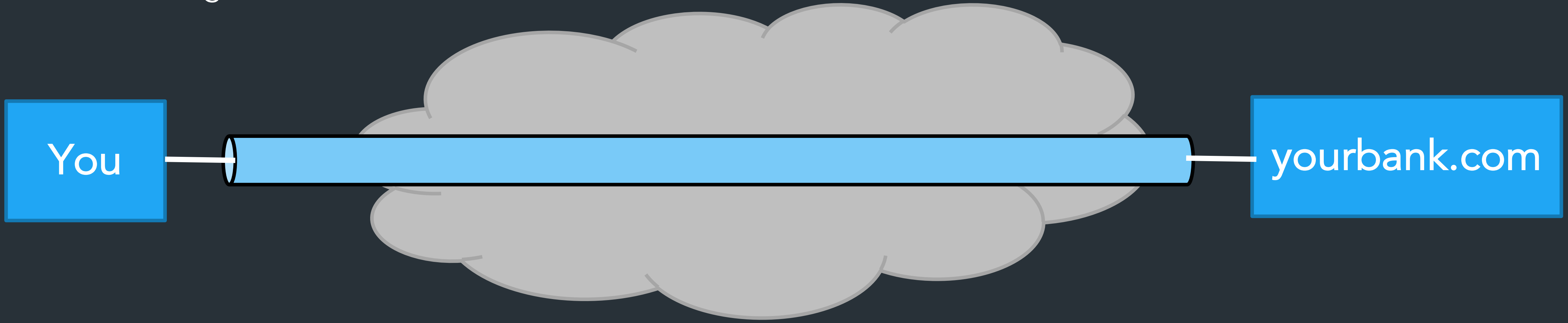
My (major) TODOs

1. I owe you grades on Snowcast, TCP
2. I owe you a bunch of lecture notes
3. I will be watching Ed for final project questions


You
yourbank.com
Attacker

Warmup

With TLS we get this:



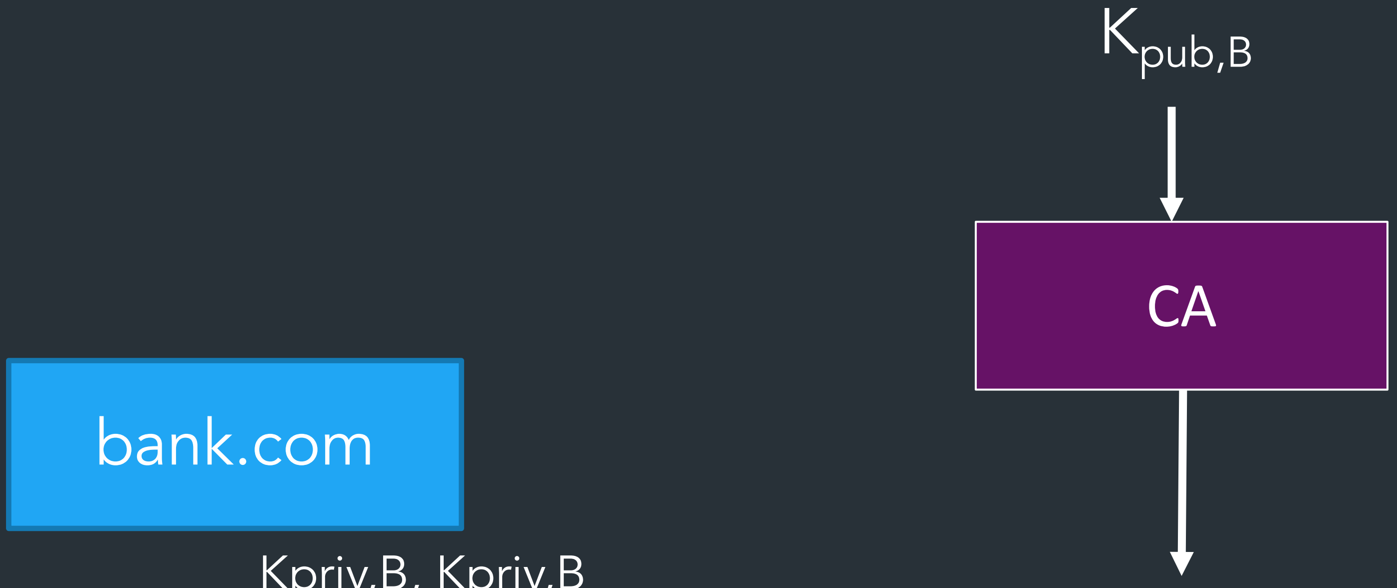
Are we good? Have we solved web security?

Warmup

bank.com

Kpriv,B, Kpriv,B

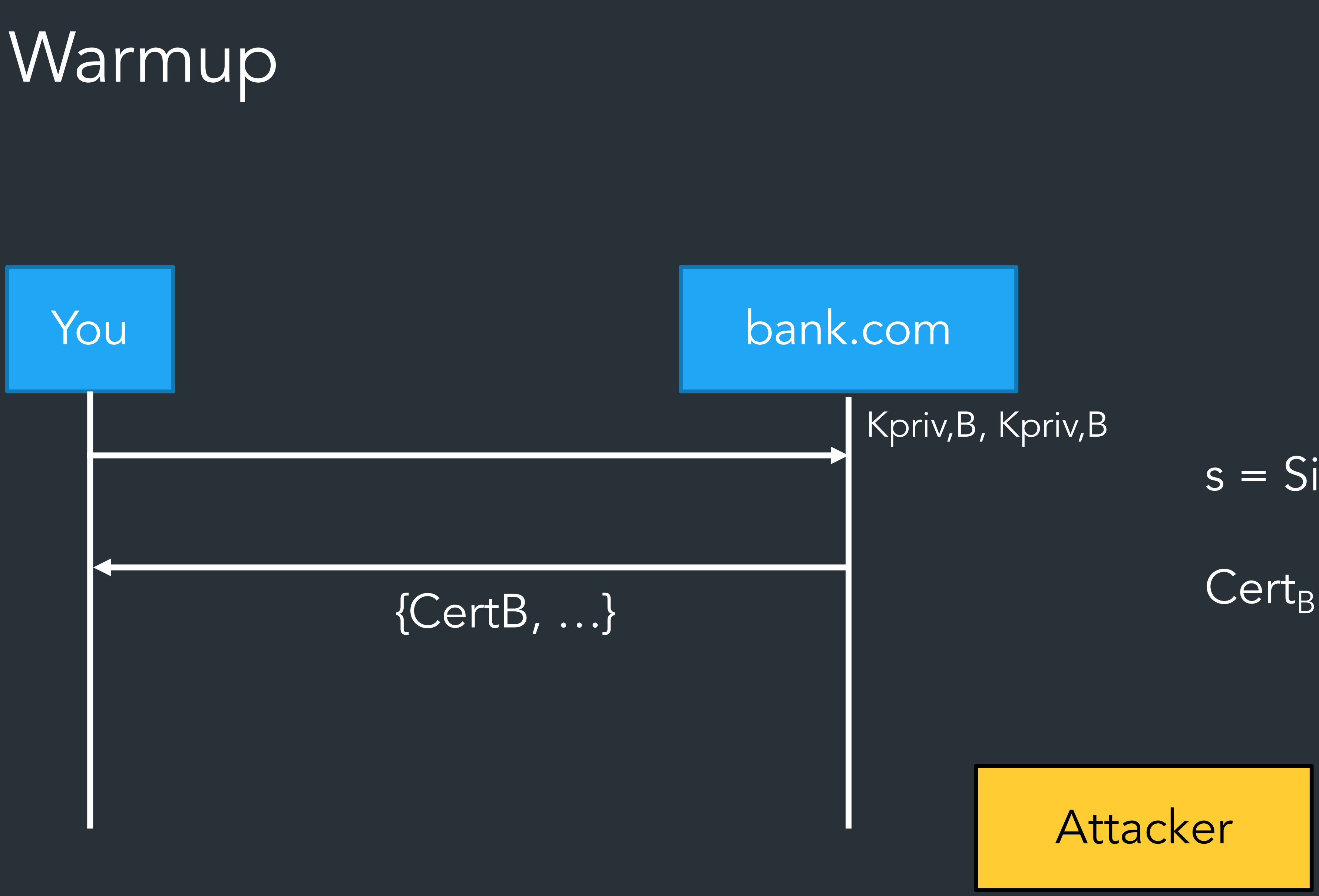
Warmup



$$s = \text{Sign}(K_{priv,CA}, \{K_{pub,B}, \dots\})$$

$$\text{Cert}_B = \{K_{pub,B}, \text{metadata}, s\}$$

Warmup



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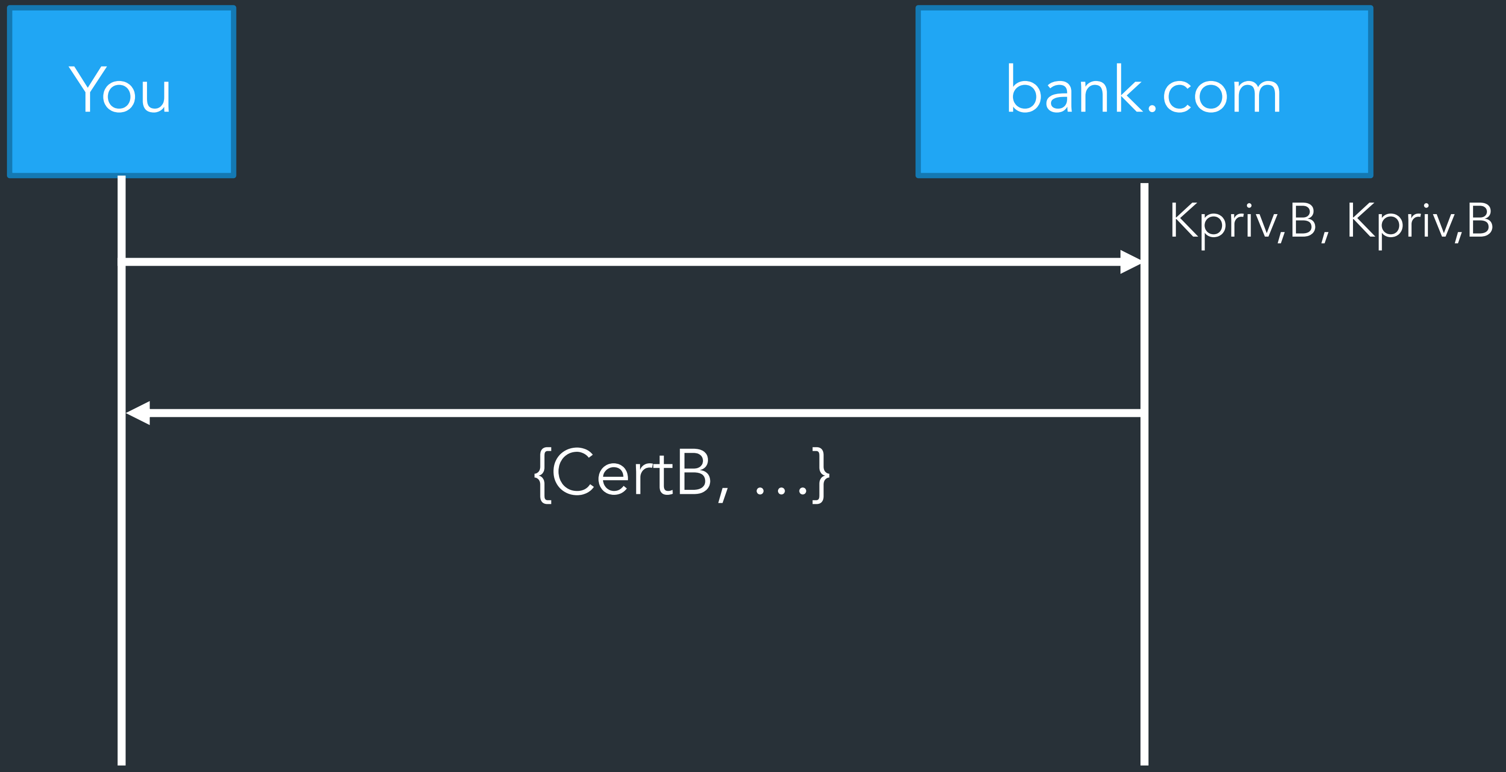
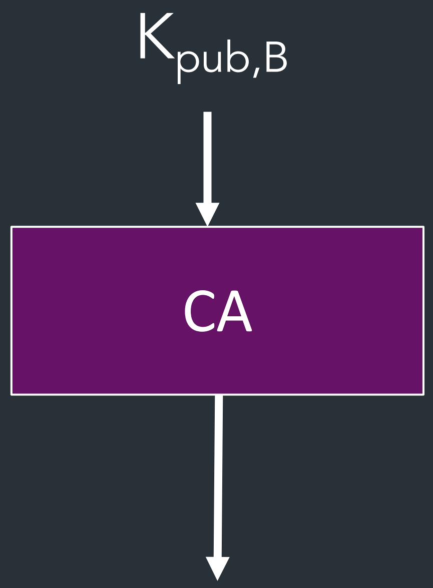
Warmup

What happens if attacker obtains Kpriv,B?
What about Kpriv,CA?





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Today's Lecture

- More about Tor
- Wrapup

Q: If private key is compromised, can attacker decrypt data?

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Not if TLS connection uses forward secrecy

⇒ Cannot recover session key if server private key leaked

⇒ Once optional, now required by TLS 1.3 (2018)

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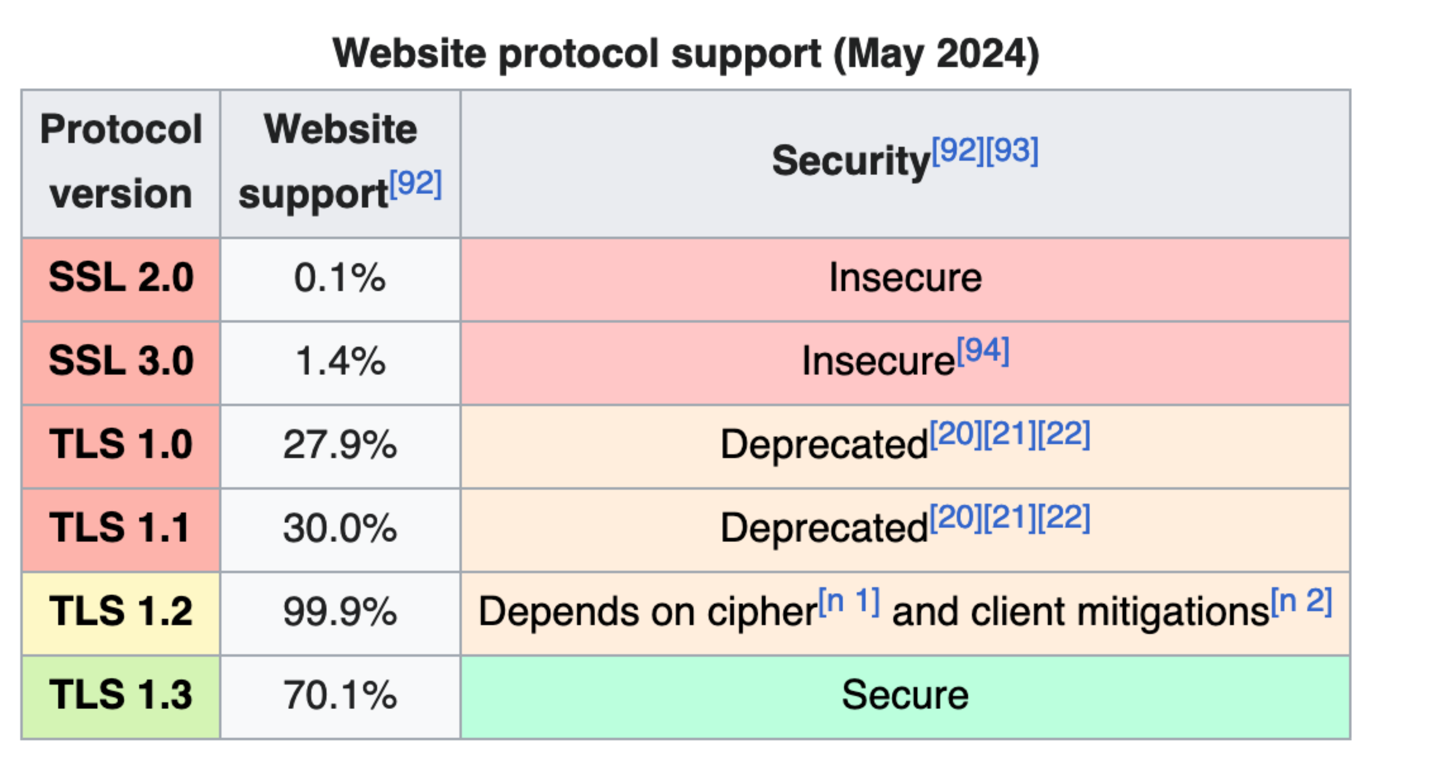
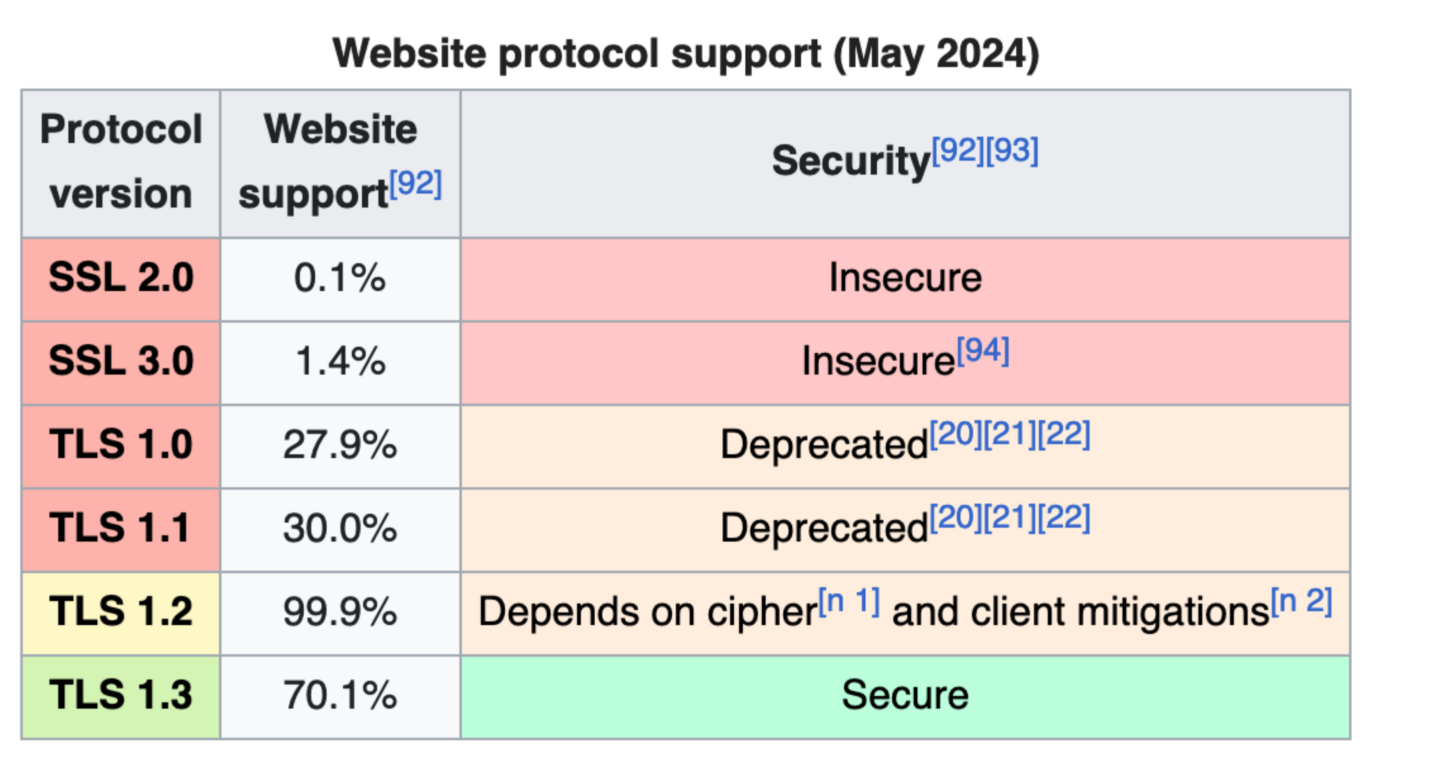


Website protocol support (May 2024)

Protocol version	Website support[92]	Security[92][93]
SSL 2.0	0.1%	Insecure
SSL 3.0	1.4%	Insecure[94]
TLS 1.0	27.9%	Deprecated[20][21][22]
TLS 1.1	30.0%	Deprecated[20][21][22]
TLS 1.2	99.9%	Depends on cipher[n 1] and client mitigations[n 2]
TLS 1.3	70.1%	Secure

In practice, TLS 1.3 rollout delayed by many broken TLS implementations (eg. in-network middleboxes/proxies) …



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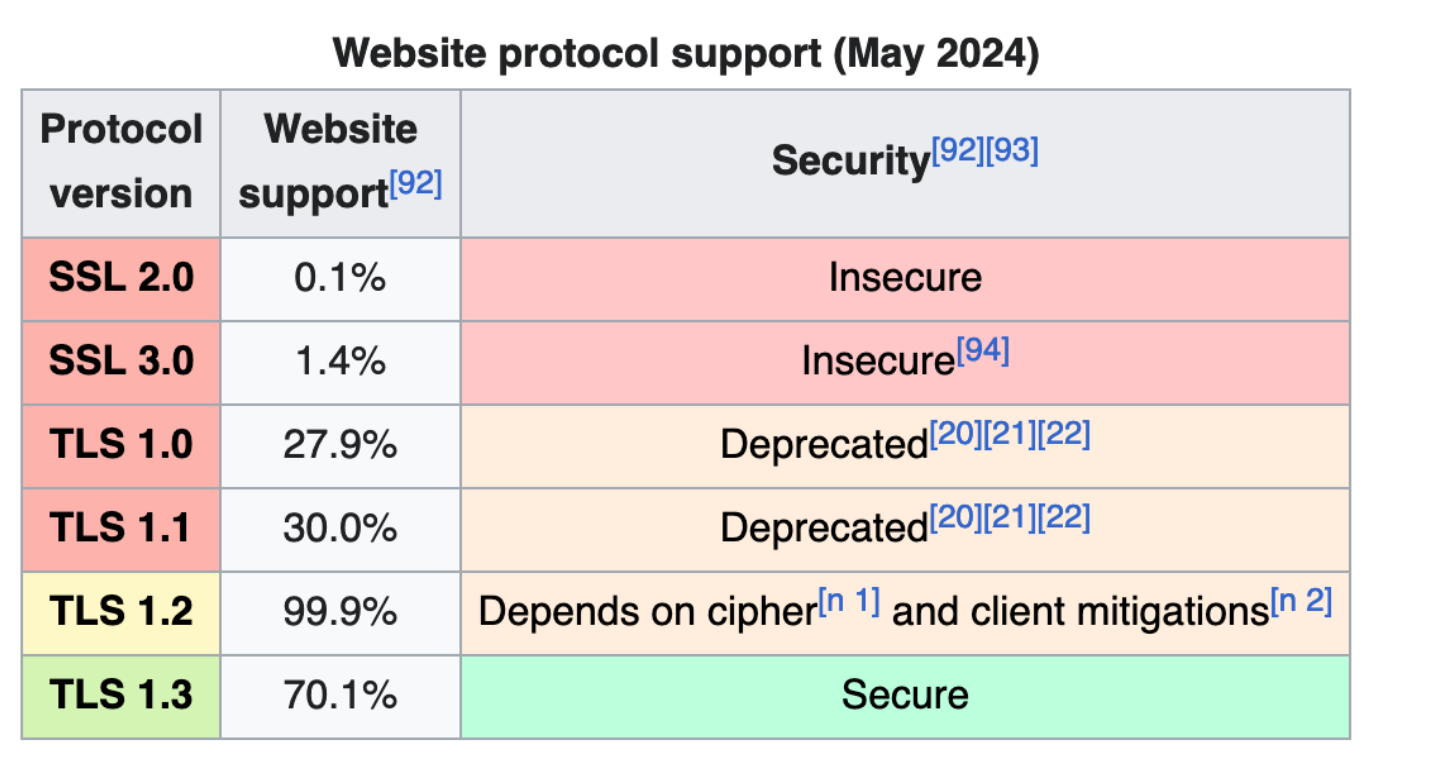

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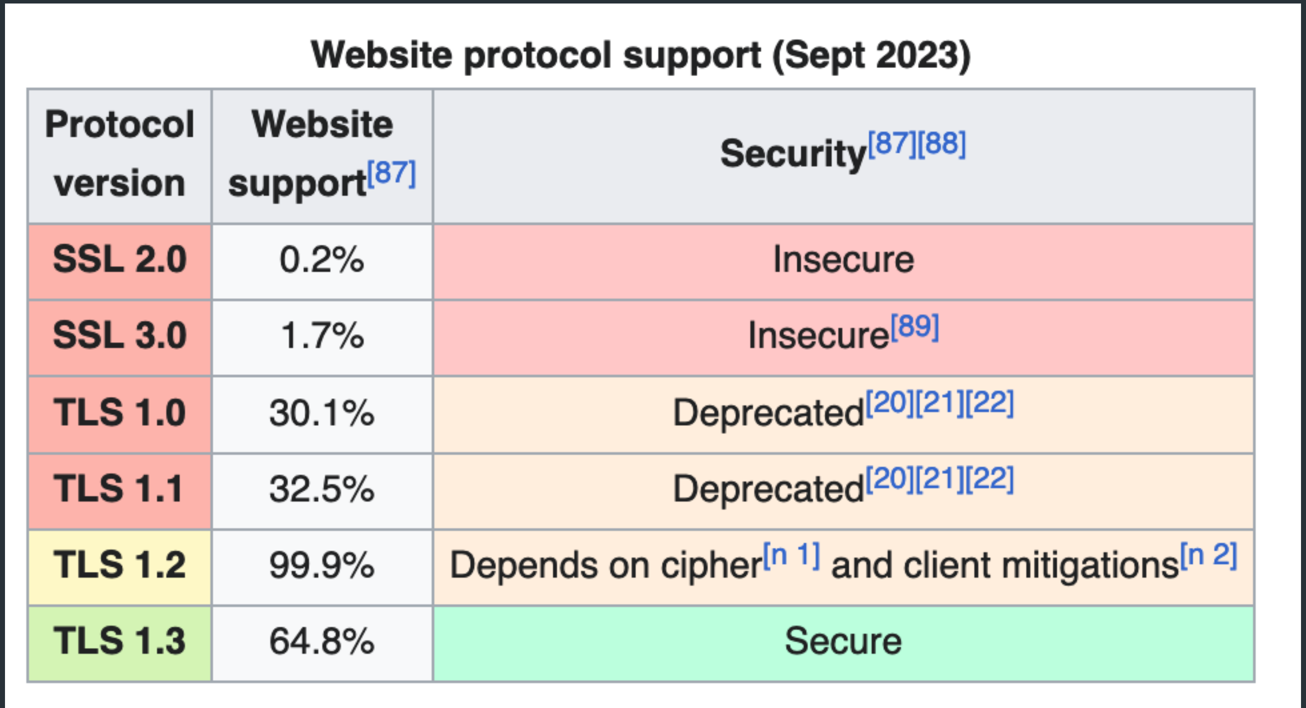
Remember how we said don’t propagate buggy behavior in TCP?



Website protocol support (Sept 2023)

Protocol version	Website support[87]	Security[87][88]
SSL 2.0	0.2%	Insecure
SSL 3.0	1.7%	Insecure[89]
TLS 1.0	30.1%	Deprecated[20][21][22]
TLS 1.1	32.5%	Deprecated[20][21][22]
TLS 1.2	99.9%	Depends on cipher[n 1] and client mitigations[n 2]
TLS 1.3	64.8%	Secure

In general, implementing security protocols is hard to get right

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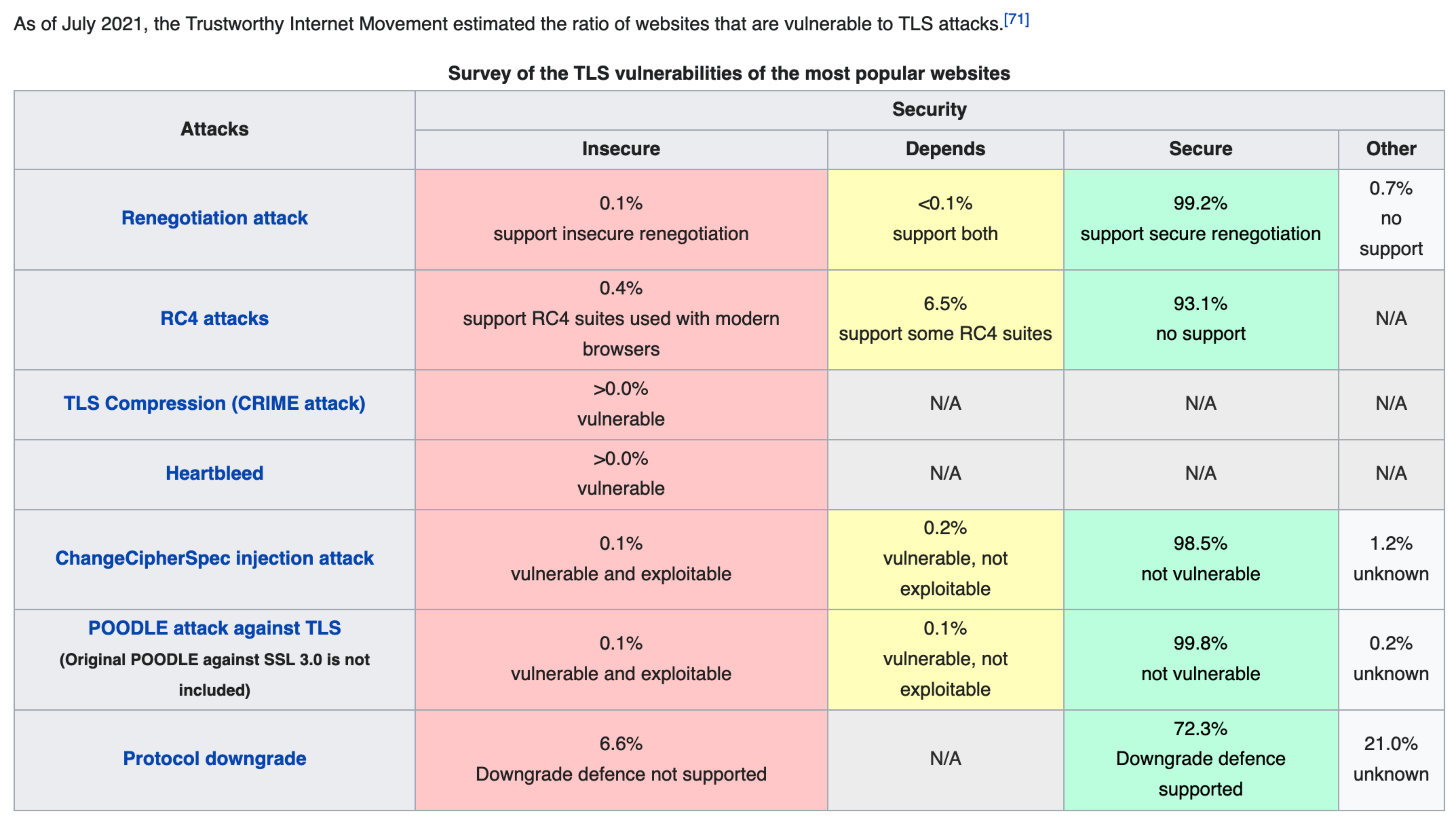
=> TLS libraries are very critical and need lots of oversight/auditing

=> Servers (and clients) need to be updated with latest standards/fixes

Se



As of July 2021, the Trustworthy Internet Movement estimated the ratio of websites that are vulnerable to TLS attacks.[71]

Survey of the TLS vulnerabilities of the most popular websites

Attacks	Security			
	Insecure	Depends	Secure	Other
Renegotiation attack	0.1% support insecure renegotiation	<0.1% support both	99.2% support secure renegotiation	0.7% no support
RC4 attacks	0.4% support RC4 suites used with modern browsers	6.5% support some RC4 suites	93.1% no support	N/A
TLS Compression (CRIME attack)	>0.0% vulnerable	N/A	N/A	N/A
Heartbleed	>0.0% vulnerable	N/A	N/A	N/A
ChangeCipherSpec injection attack	0.1% vulnerable and exploitable	0.2% vulnerable, not exploitable	98.5% not vulnerable	1.2% unknown
POODLE attack against TLS (Original POODLE against SSL 3.0 is not included)	0.1% vulnerable and exploitable	0.1% vulnerable, not exploitable	99.8% not vulnerable	0.2% unknown
Protocol downgrade	6.6% Downgrade defence not supported	N/A	72.3% Downgrade defence supported	21.0% unknown

Wikipedia table, source: https://www.ssllabs.com/ssl-pulse/

So, are we good?

If we use TLS, is it enough?

Overall, depends on your threat model…

- Server still knows who you are, even if connection is encrypted

- Even encrypted traffic leaks information!

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- Server still knows who you are, even if connection is encrypted

=> IPs can be traced to location (to varying levels of precision)

=> Your browser may leak info (cookies, mouse usage, etc.)

- Even encrypted traffic leaks information!

=> Name of server: DNS, Server Name Indicator (SNI)

=> Traffic patterns (timing of packets, protocols, …)

Securing the transport layer not enough => info leaks based on other layers

Why?

- Avoiding censorship
- Avoiding surveillance (by person, or an organization)
- Anonymous reporting (journalists, whistleblowers)

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Room 641A: alleged wiretapping room in a datacenter for an Internet backbone…
https://en.wikipedia.org/wiki/Room_641A

How can we deal with this?

Mechanisms to provide more security at the network layer

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Mechanisms to provide more security at the network layer

⇒ Security for all your network traffic => not just one 5-tuple

⇒ Can (try to) provide more anonymity

VPN: secure tunnel for network traffic

=> Connect a host to a private network

Virtual Private Network (VPN)

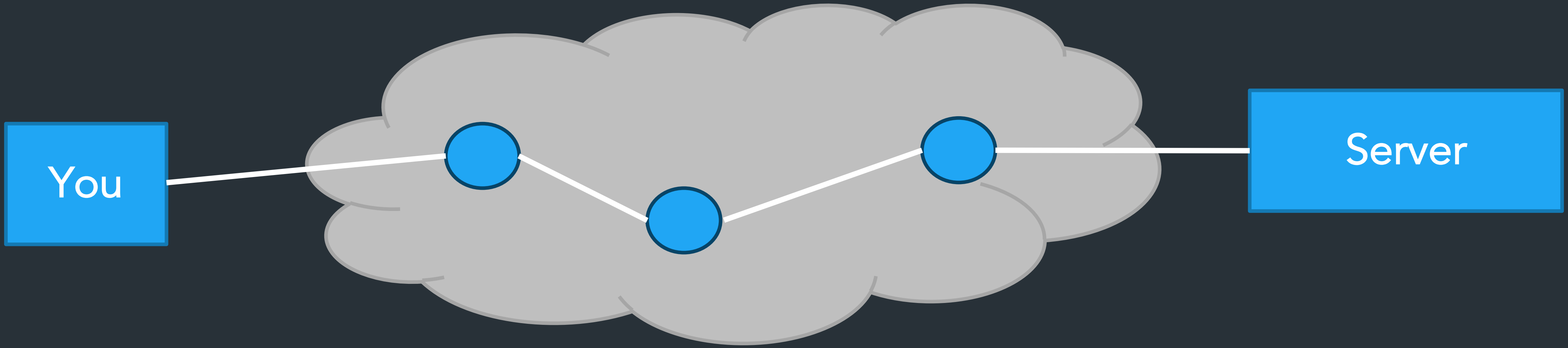
Secure tunnel for arbitrary network traffic (any IP packets)

Use for

=> Accessing a private network (remote access internal network)

=> Secure proxy for your traffic: traffic appears to originate from VPN server

Problems?



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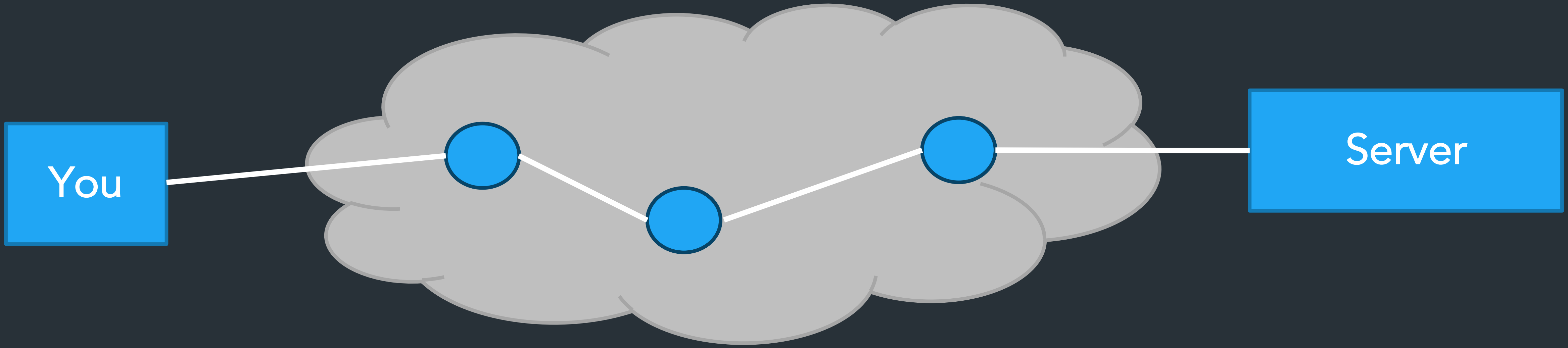
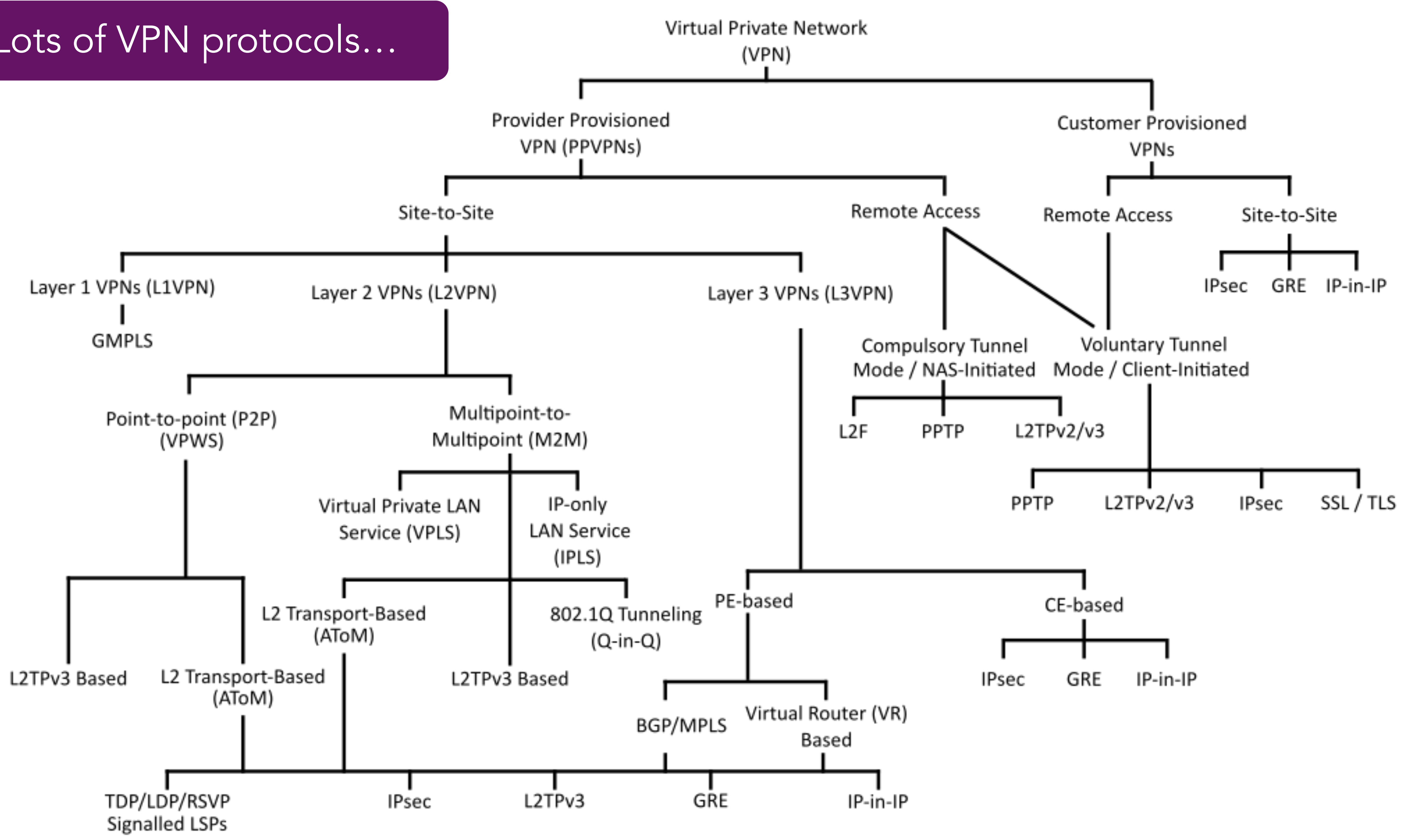


Lots of VPN protocols…


Virtual Private Network (VPN)
Provider Provisioned VPN (PPVPNs)
Customer Provisioned VPNs
Site-to-Site
Remote Access
Remote Access
Site-to-Site
IPsec
GRE
IP-in-IP
Layer 1 VPNs (L1VPN)
Layer 2 VPNs (L2VPN)
Layer 3 VPNs (L3VPN)
GMPLS
Compulsory Tunnel Mode / NAS-Initiated
Voluntary Tunnel Mode / Client-Initiated
L2F
PPTP
L2TPv2/v3
PPTP
L2TPv2/v3
IPsec
SSL / TLS
Point-to-point (P2P) (VPWS)
Multipoint-to-Multipoint (M2M)
Virtual Private LAN Service (VPLS)
IP-only LAN Service (IPLS)
L2 Transport-Based (AToM)
802.1Q Tunneling (Q-in-Q)
PE-based
CE-based
L2TPv3 Based
L2 Transport-Based (AToM)
L2TPv3 Based
IPsec
GRE
IP-in-IP
BGP/MPLS
Virtual Router (VR) Based
TDP/LDP/RSVP Signalled LSPs
IPsec
L2TPv3
GRE
IP-in-IP

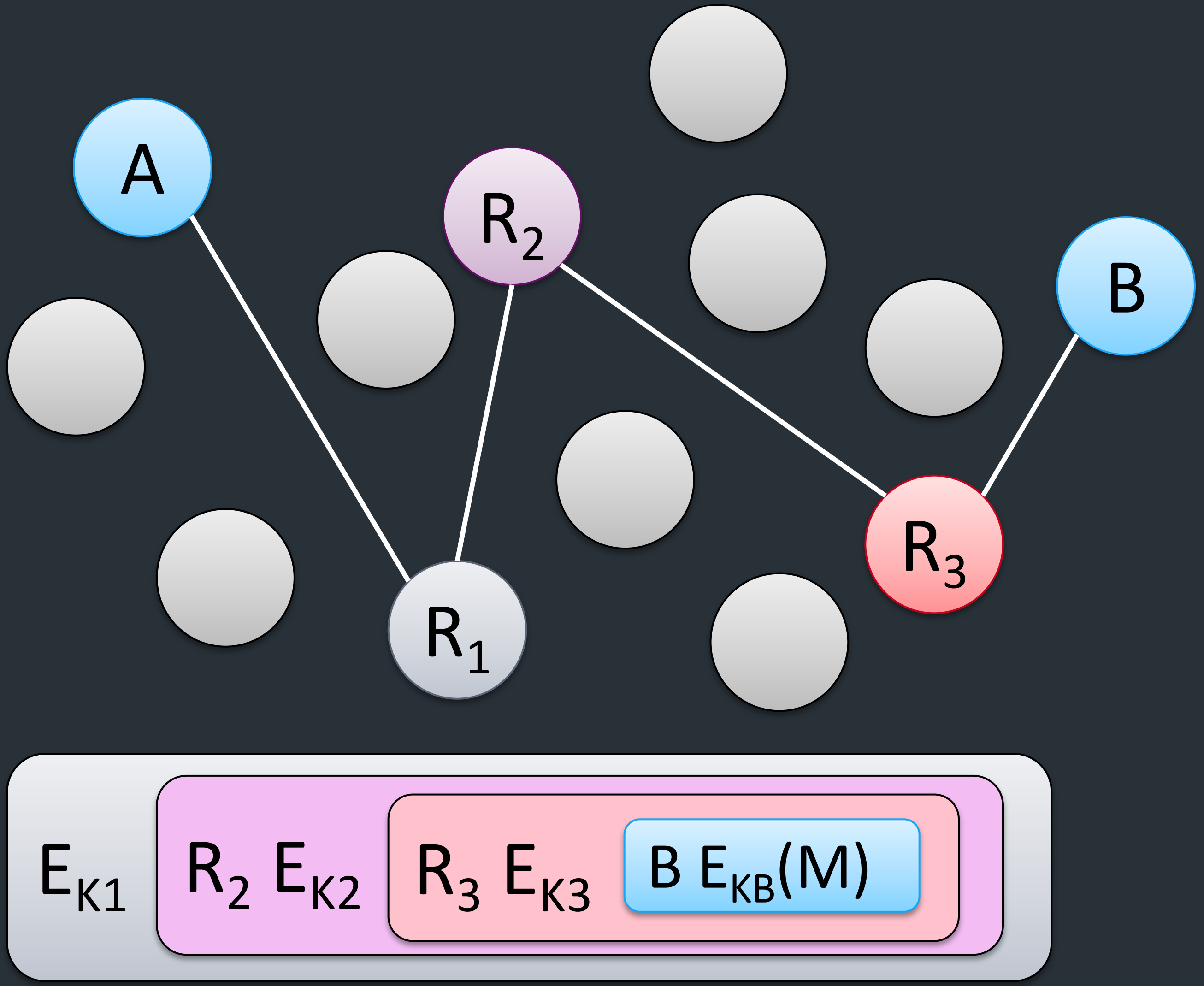
Can we do better?

Tor

- Onion routing service: build encrypted circuit on tor relay network
- Network of relays, mainly operated by volunteers
- Started in 1990s from Naval Research Lab, now maintained by The Tor Project (a non-profit)

Onion Routing

- Layered encryption
  - Build onion inside out
- Routing
  - Peel onion outside in
- Each router knows only previous and next



E_{K1} R_2 E_{K2} R_3 E_{K3} B $E_{KB}(M)$

What if the server wants to help?

Onion services: server connects to tor directly => no need for an exit node!

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Examples

- *New York Times:*
  `https://www.nytimesn7cgmftshazwhfgzm37qxb44r64ytbb2dj3x62d2lljsciiyd.onion`
- Facebook
  `https://facebookwkhpilnemxj7asaniu7vnjjbiltxjqhye3mhbshg7kx5tfyd.onion`
- Cloudflare public DNS
  `dns4torpnlfs2ifuz2s2yf3fc7rdmsbhm6rw75euj35pac6ap25zgqad.onion`

Wrapping up

- This is our last formal lecture
- From here: work on final project

What I hope you have learned

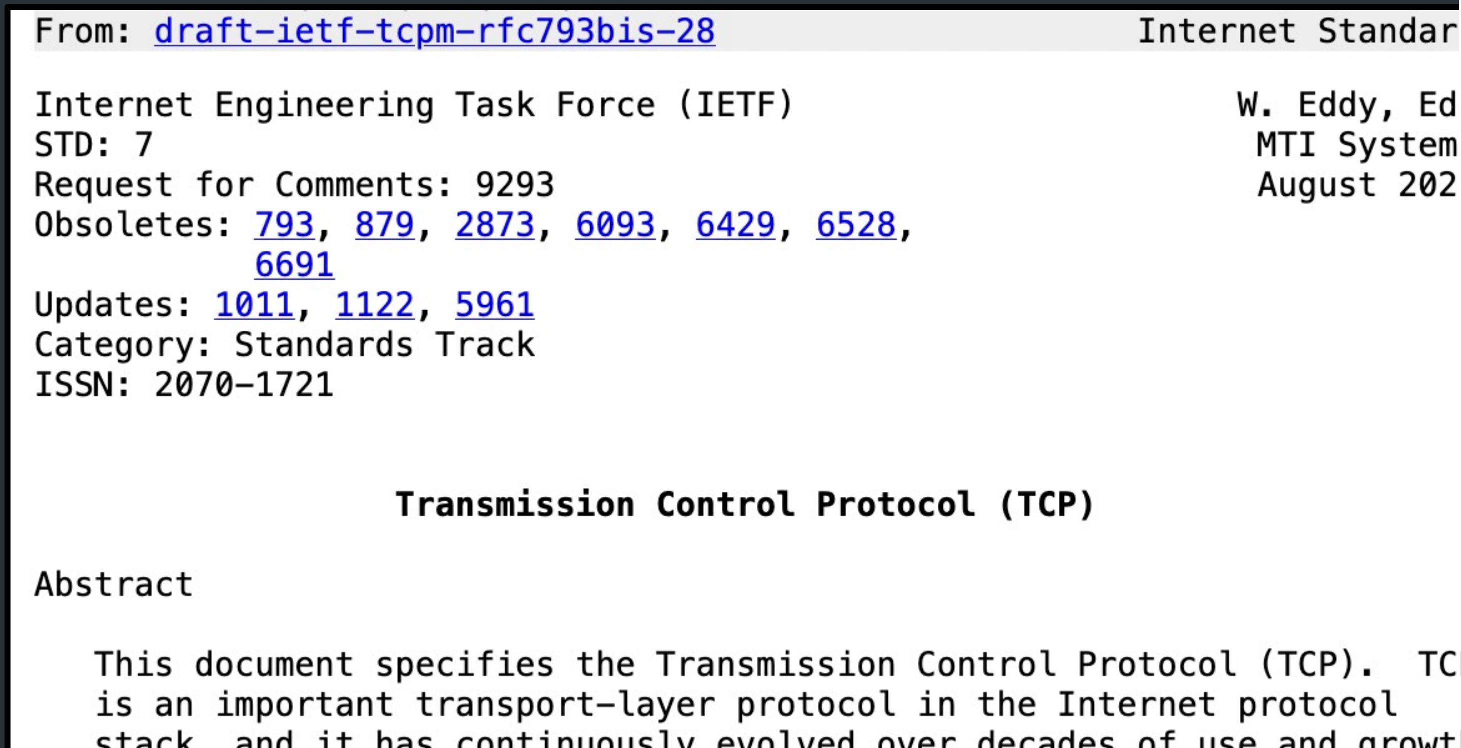
We can't cover (or remember) everything

Hope you learn important tools/principles to understand networking challenges you encounter

Protocols Ways to communicate between *heterogeneous* systems

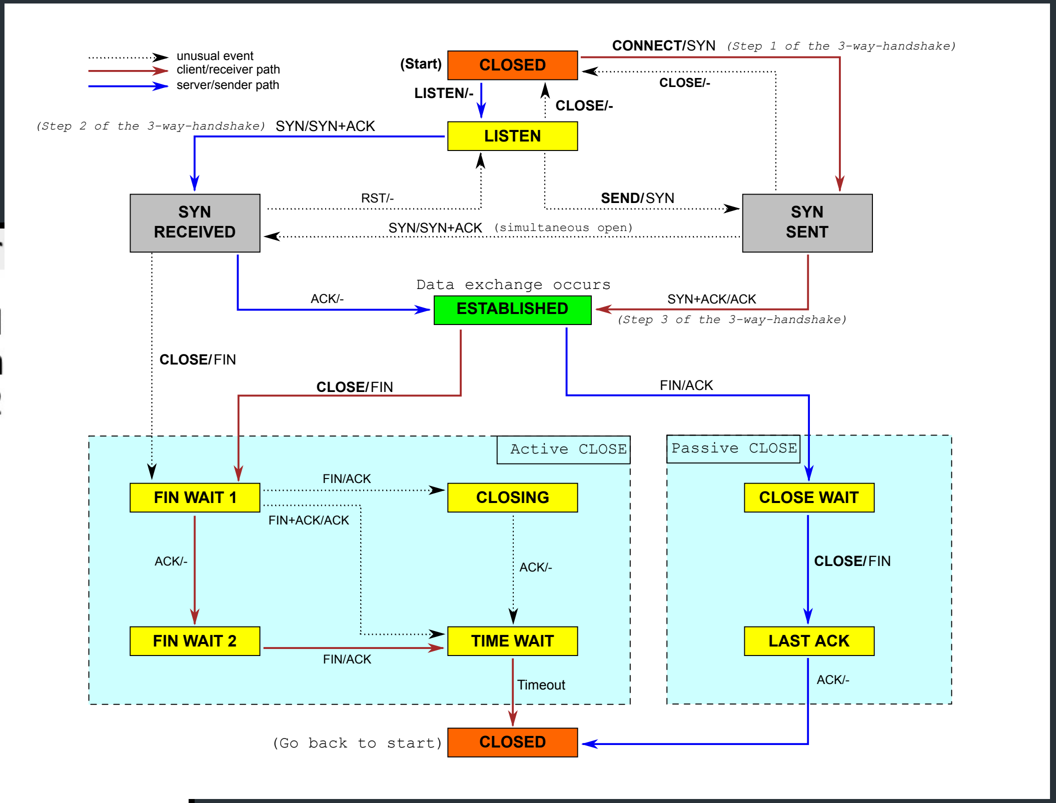
Network programming

```
conn, err :=  net.Dial(“tcp”, “10.0.0.1:80”)
. . .

someBuf := make([]byte, . . .)
conn.Write(someBuf)
```



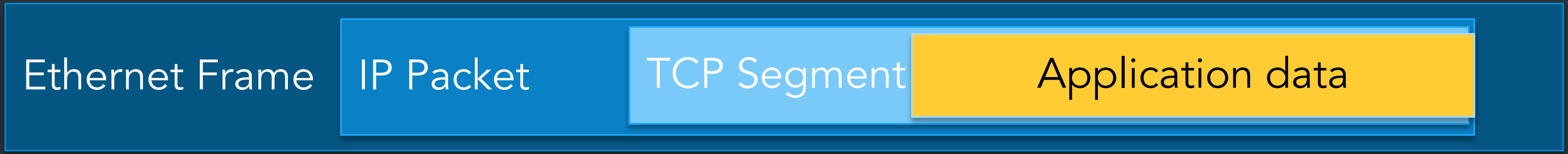
From: draft-ietf-tcpm-rfc793bis-28 Internet Standar

```
Internet Engineering Task Force (IETF)                    W. Eddy, Ed
STD: 7                                                    MTI System
Request for Comments: 9293                                August 202
Obsoletes: 793, 879, 2873, 6093, 6429, 6528,
           6691
Updates: 1011, 1122, 5961
Category: Standards Track
ISSN: 2070-1721


                Transmission Control Protocol (TCP)

Abstract

   This document specifies the Transmission Control Protocol (TCP).  TCP
   is an important transport-layer protocol in the Internet protocol
   stack, and it has continuously evolved over decades of use and growth
```



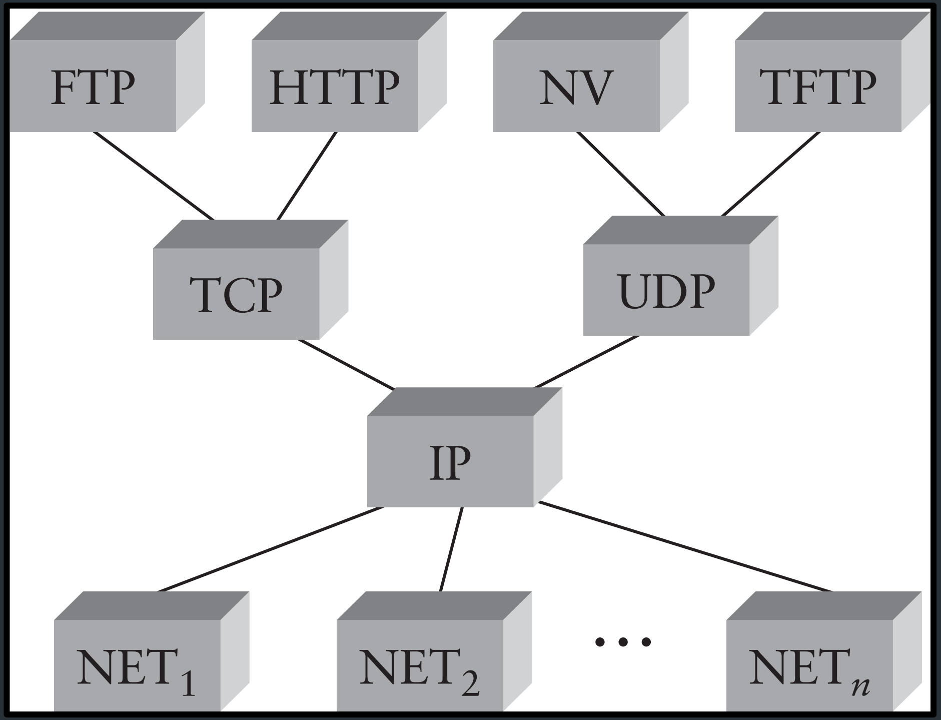
Layering / Encapsulation

Building abstractions and interfaces to hide lower-level details from “higher” layers



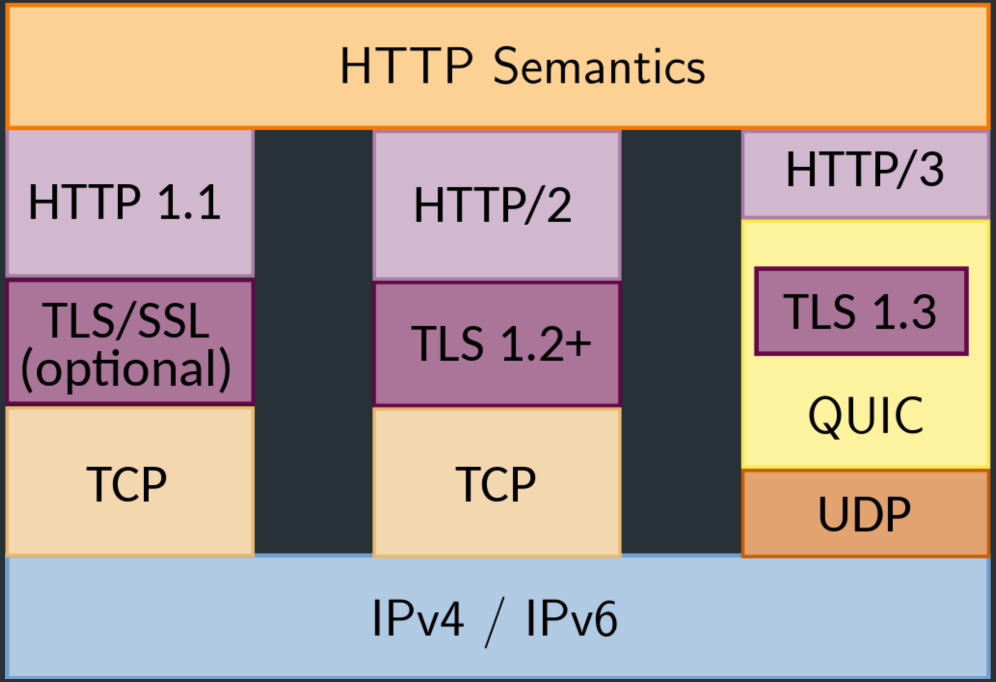
Abstractions are great!

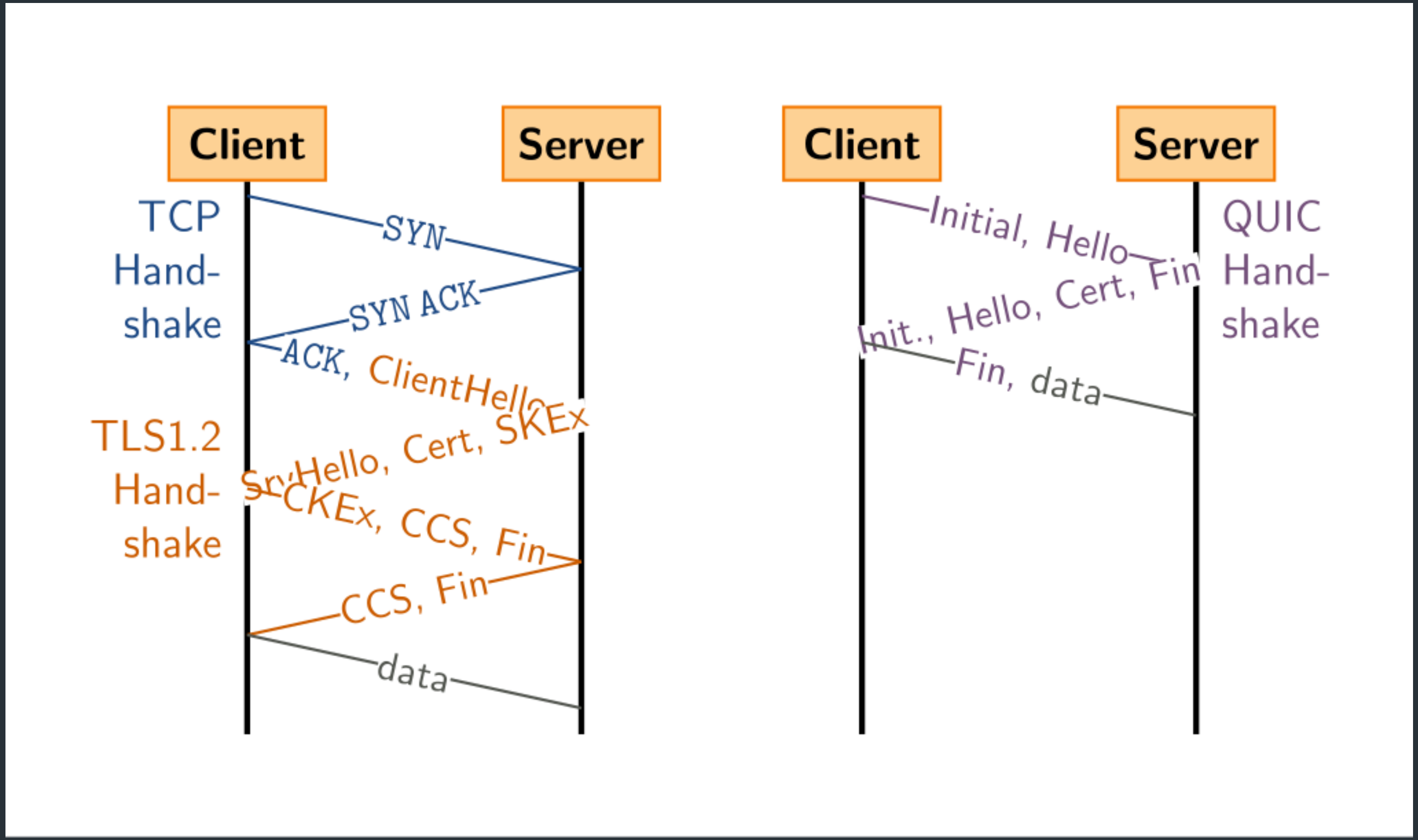
- Can support huge variety of devices, protocols
- Allows independent evolution => new protocols!



… until they aren’t

Sometimes, need to break them





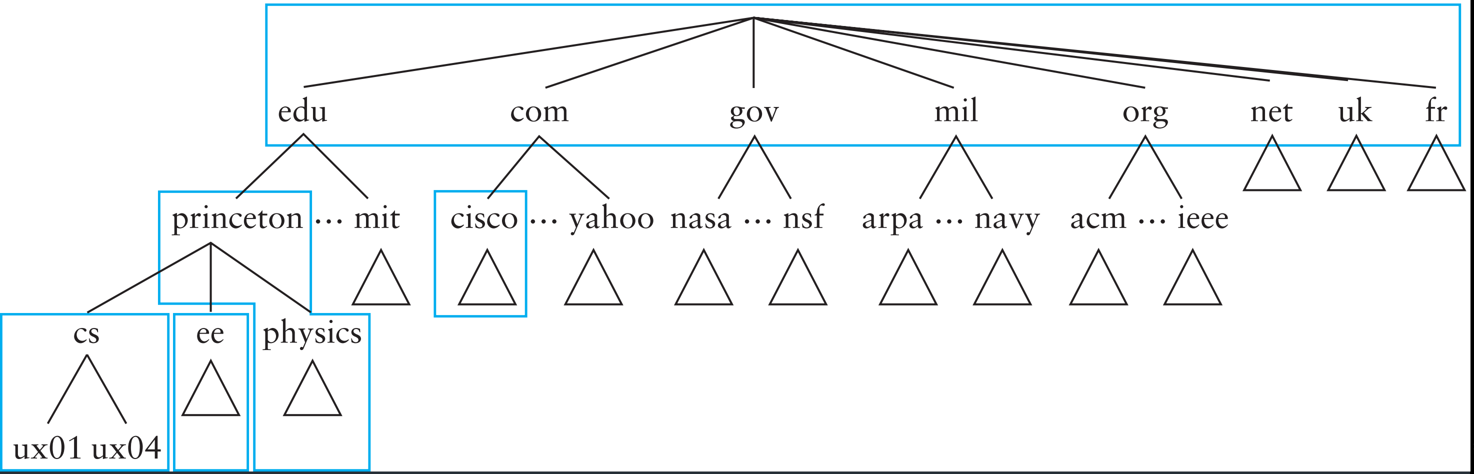
Naming

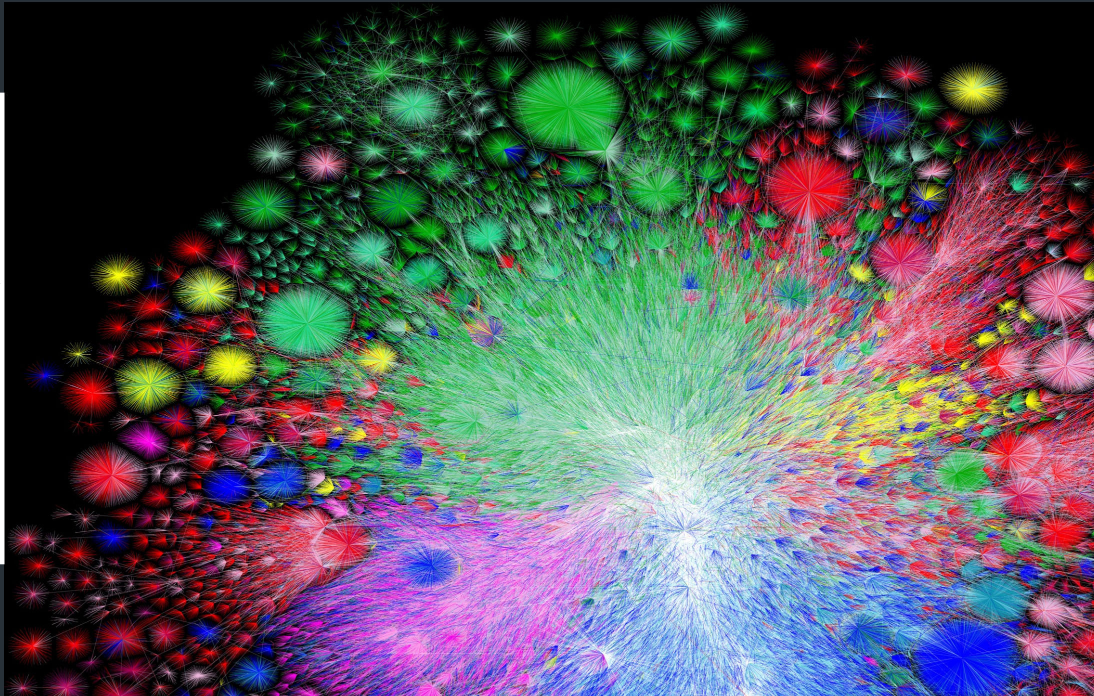
Indirection: abstract low-level info with a higher-level name

=> Human-readable DNS names

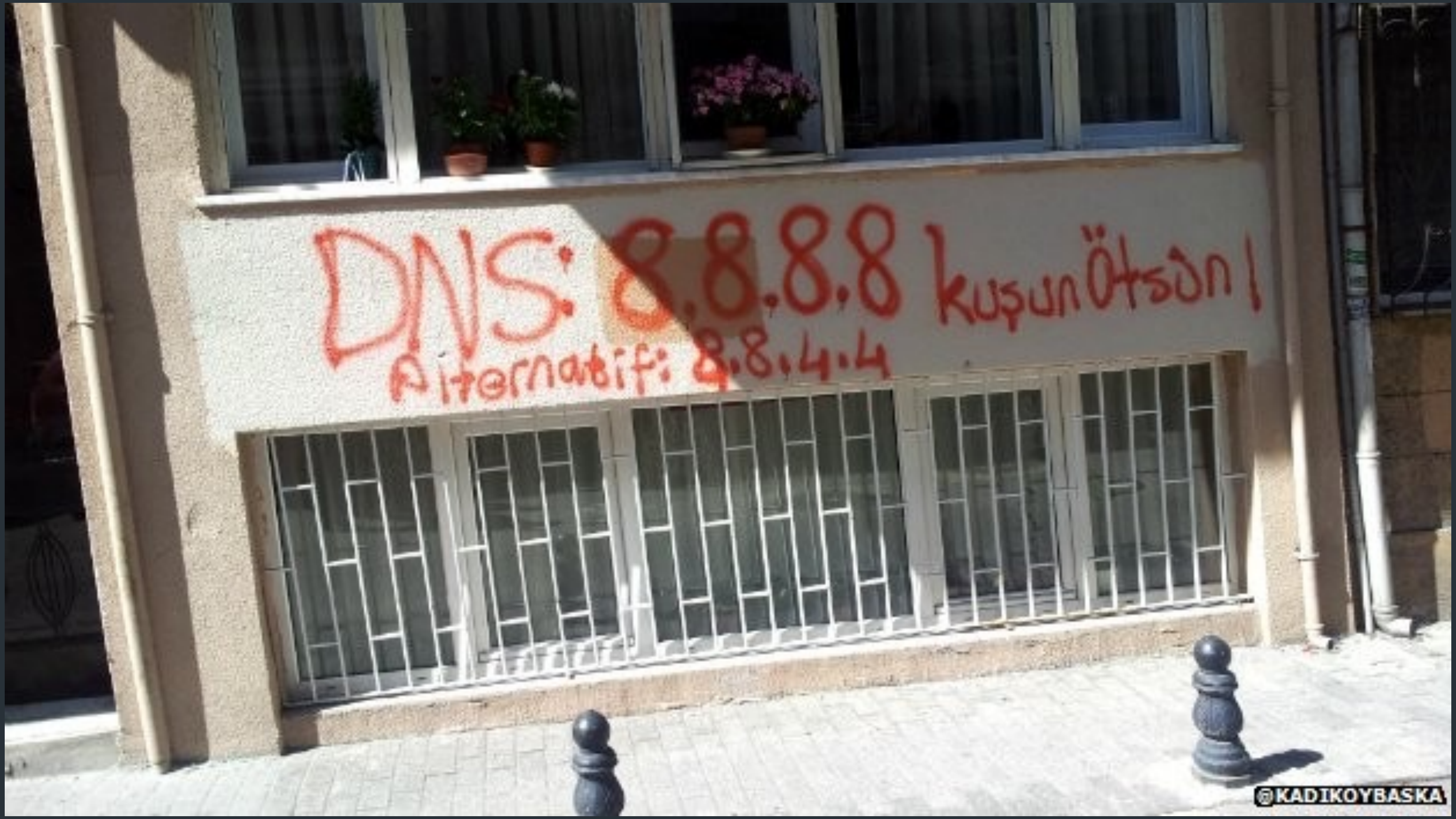
=> Scalability: redundancy, proxies, load balancing

Can leverage hierarchy of naming => scalability (IP, DNS, …)





How naming, etc. can be controlled…



Changing DNS servers in response to blocking of Twitter in Turkey (2014)

Writeup, with more links: https://www.thousandeyes.com/blog/internet-censorship-around-the-world

Lots of challenges out there

Our Internet architecture was designed in the 1980s, where modern scale and complexity was unimaginable

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Now…

- No one knows how big the Internet is
- No one is in charge
- Anyone can add any application
- Packets traverse many paths, countries, regulatory domains

Thank you!
Please stay in touch!