Computer and Network Security

Lecture 24: Anonymity & Censorship

COMP-5370/6370
Fall 2025

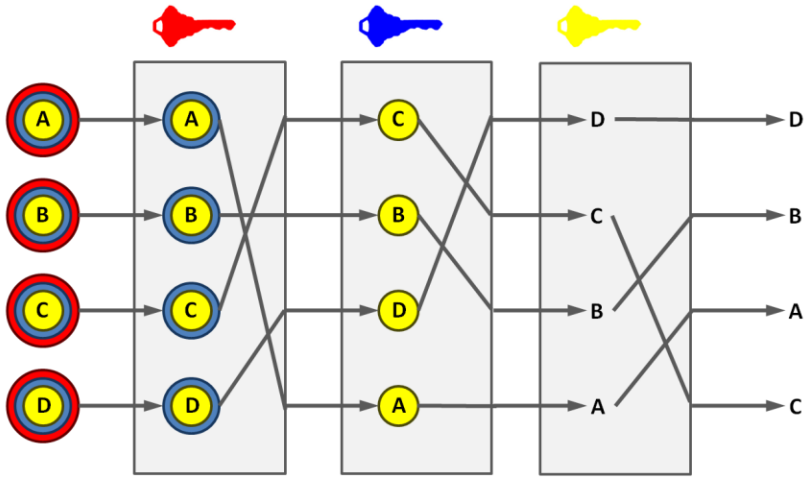
VPNs

A **Virtual Private Network (VPN)** is a *logical* concept through which a remote client appears on the local network by use of a multiplexed secure channel.

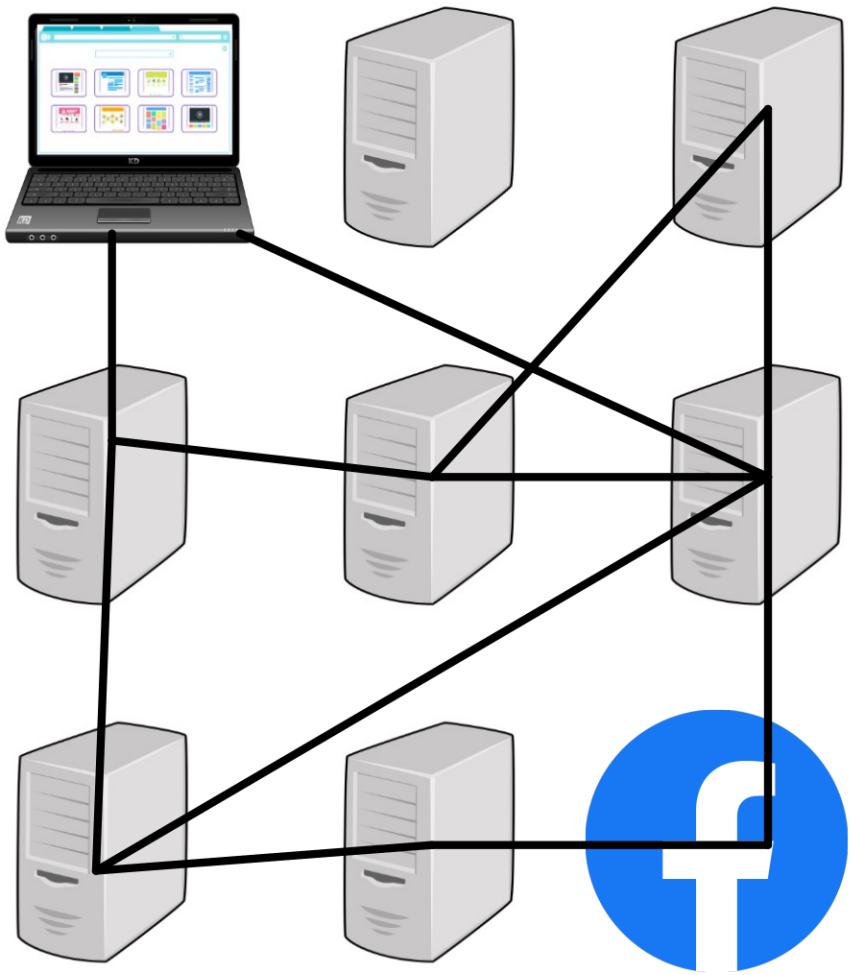
- Many different protocols can be used
- IKE+IPSec is a common implementation
- Can connect two remote-networks as 1
- Can be used on a client-server construction

Mix Networks

Mix Networks (Mix-Nets) are a type of high-latency anonymous network which relies on bounces among nodes with other messages for protections.

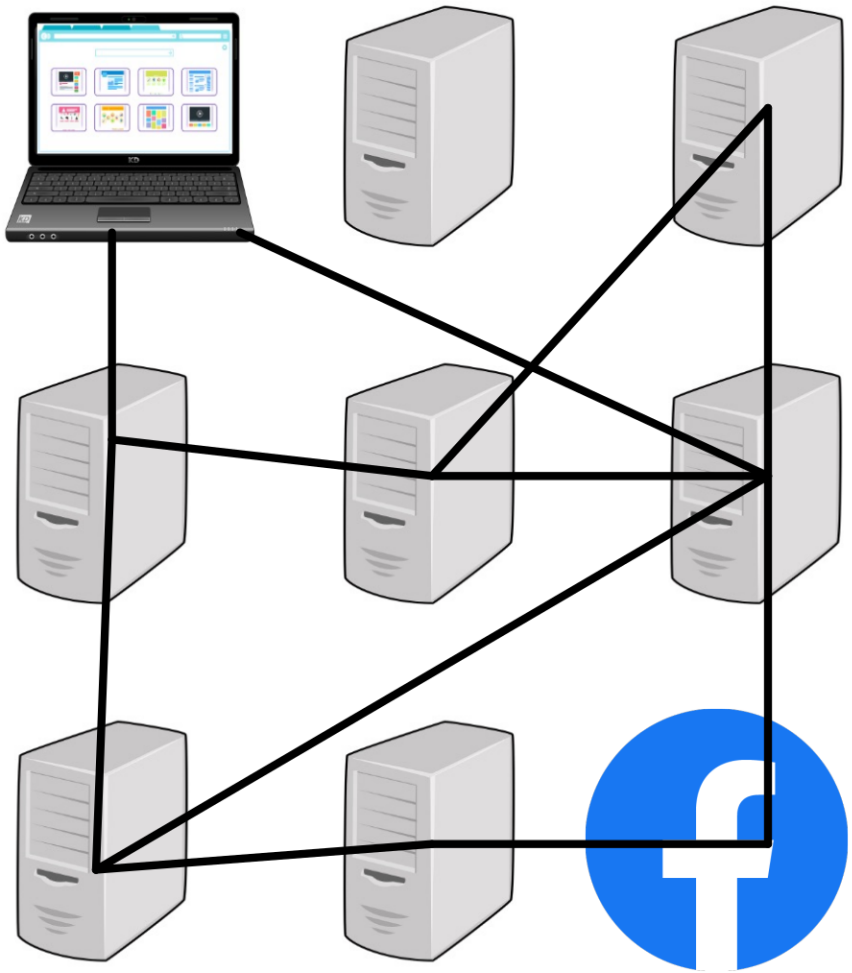


Mix-Nets



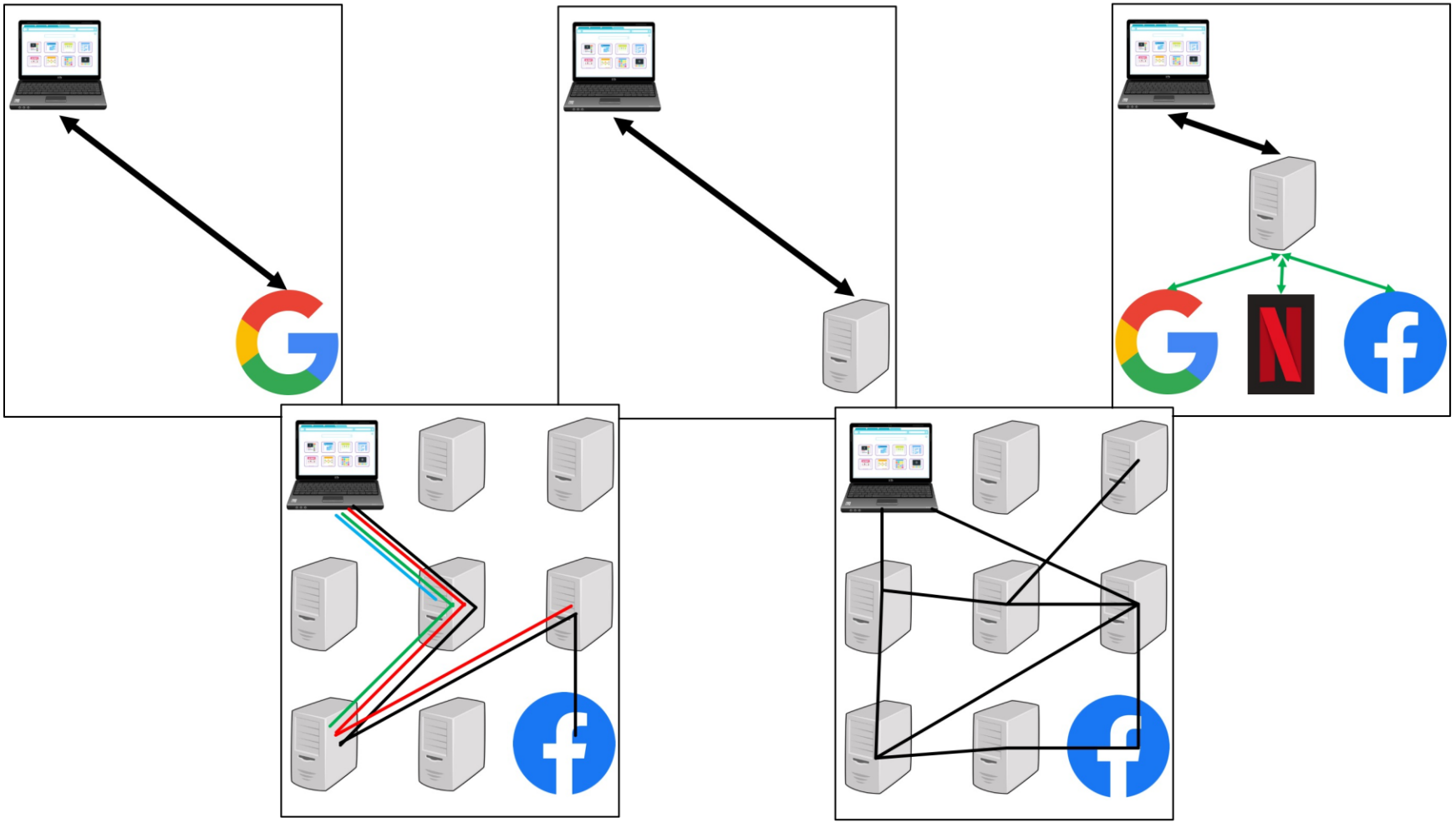
- Client sends message to network
- Nodes delay random amount of time
- Nodes sends random selection of nodes
- Repeat

Mix-Net Downsides



- Extremely Slow
- Require large networks and high through-put
- Non-linear scaling

Different Protocols for Different Needs



Censorship

Censorship is the suppression of access to information that is deemed harmful for the perceived advancement of the *greater good*.

What are examples data/information which SHOULD or SHOULD NOT be censored?

OK to Censor?

Widely Accepted

- Pornography (setting)
- Abusive Content
- Malicious C2 nodes

Widely Rejected

- Negative publicity
- Scientific research
- Different opinions

More Complicated

- Culturally insensitive content
- Intentionally fake/misleading content
- Anything not yet approved
  - White-list instead of black-list

Censorship

Censorship is the suppression of access to information that is deemed harmful for the perceived advancement of the *greater good*.

- Sometimes called “network interference” to avoid the connotation of “censorship”
- Often associated with *authoritarian* actors but goals and approaches are common

Anonymity

Anonymity is the *concept* that any piece of information can not be tied to a real-world identity which it describes.

- Lots and lots of trade-offs when adding

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Anonymity is the *concept* that any piece of information can not be tied to a real-world identity which it describes.

- Lots and lots of trade-offs when adding
- Lots of techniques but many are far-less useful than they appear

Anonymity

Anonymity is the inability to connect an actor's actions to their identity

Is that a good thing?

- Prevents retaliation for actions
- Prevents holding accountable for actions
- Allows speech that is forbidden

Censorship

Censorship is the suppression of access to information that is deemed harmful for the perceived advancement of the *greater good*.

- Sometimes called “network interference” to avoid the connotation of “censorship”
- Often associated with *authoritarian* actors but goals and approaches are common

Where does censorship exist in the real-world?

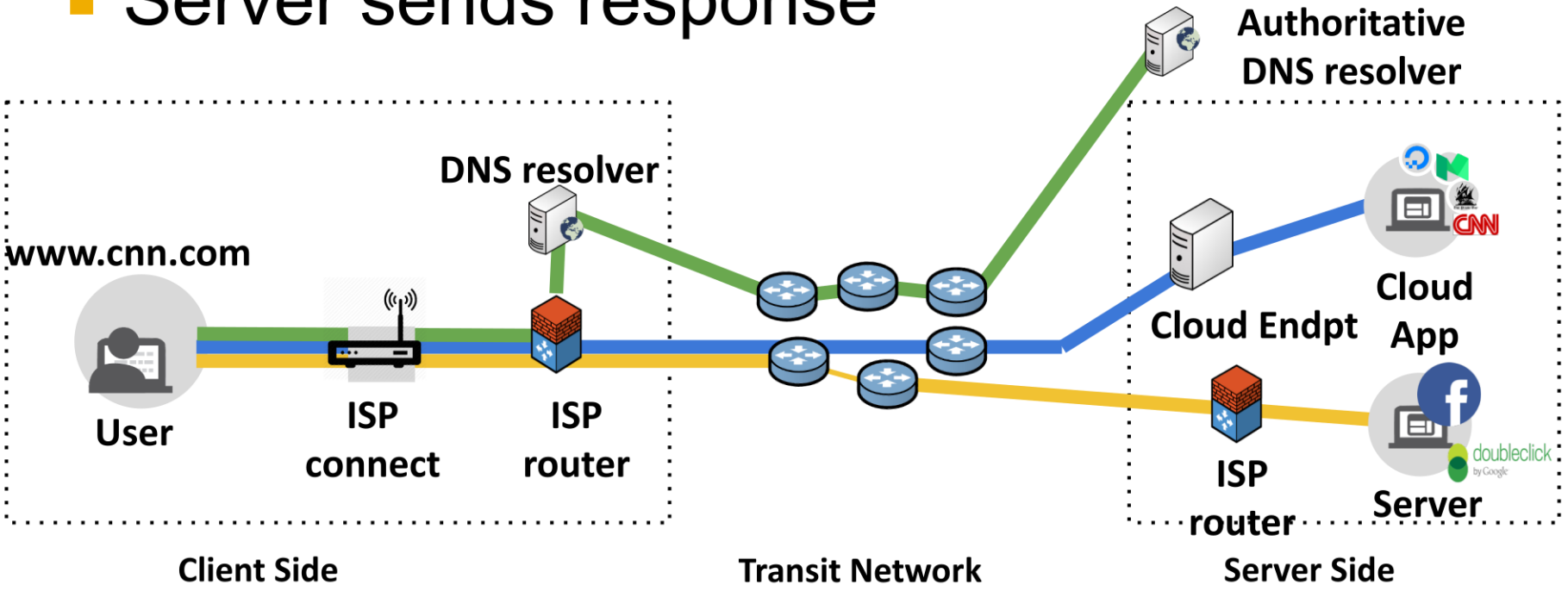
- Who is the censor?
- Who is being censored?
- What is being censored?

Censors are Rational Actors

- In almost all cases, censors understand how their actions will be perceived
  - By those who are censored
  - By the censor's "peers"
- Censorship still exists because the censors decide that the *trade-off* is worth the optics & dislike

How to Fetch a Website

- User types www.cnn.com
- Dereferences to an IP via DNS
- Browser makes request
- Server sends response



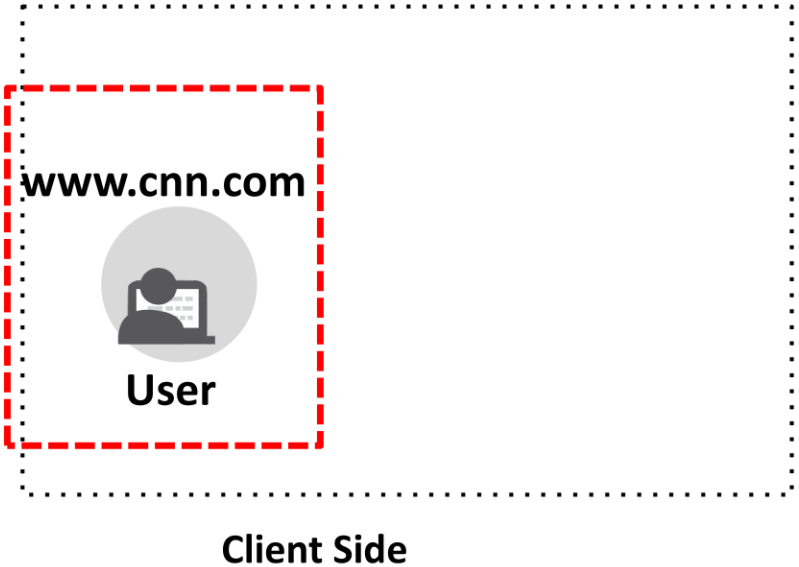
Client-Side Compliance

- Software installed on user-device to block access to content

How to Fetch a Website

- User types www.cn.com
- ~~Dereferences to an IP via DNS~~
- ~~Browser makes request~~
- ~~Server sends response~~

OS rejects



Client-Side Compliance

The New York Times

SUBSCRIBE NOW | LOG IN

China Requires Censorship Software on New PCs

By Andrew Jacobs

June 8, 2009

144

The New York Times

SUBSCRIBE NOW | LOG IN

China Snares Tourists' Phones in Surveillance Dragnet by Adding Secret App

Border authorities routinely install the app on the phones of people entering the Xinjiang region by land from Central Asia, gathering personal data and scanning for material considered objectionable.

- Software installed on user-device to block access to content
- Easy to implement and easy to defeat
  - Don't install
  - Uninstall
  - Mimic
  - …

Infrastructure Compliance

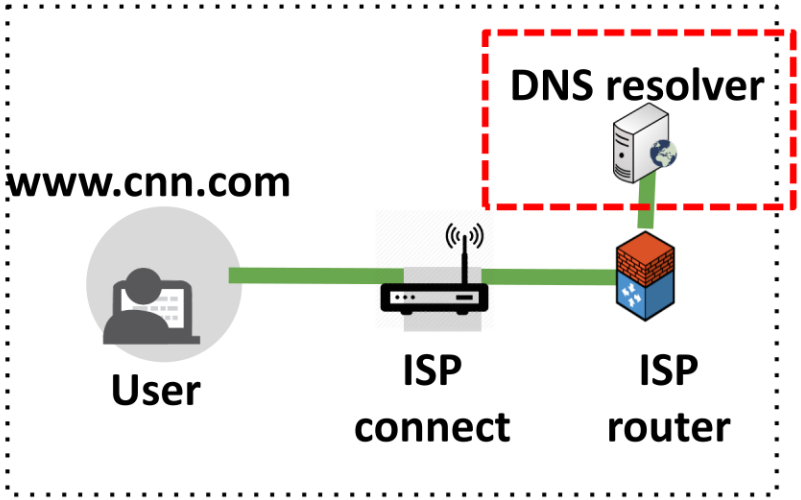
Table 2. ASes that contain filtering devices

AS Number	AS Name	Number of Filtering Interfaces
Border ASes		481
4134	CHINANET-BACKBONE	374
4812	CHINANET-SH-AP	9
4837	CHINA169-BACKBONE CNCGROUP	82
9929	CNCNET-CN	4
4538	ERX-CERNET-BKB	4
9808	CMNET-GD	5
9394	CRNET	3
Non-border ASes		14
23650	CHINANET-JS-AS-AP	4
17785	CHINATELECOM-HA-AS-AP	4
37943	CNNIC-GIANT	3
38356	TIMENET	1
17633	CHINATELECOM-SD-AS-AP	1
4813	BACKBONE-GUANGDONG-AP	1

- Require ISP and telco-providers to censor traffic
- Censor creates requirements and delegate enforcement
  - *I don't care how you do it but you must not allow access to …*

How to Fetch a Website

- User types www.cnn.com
- Dereferences to an IP via DNS ← ISP gives wrong IP
- ~~Browser makes request~~
- ~~Server sends response~~

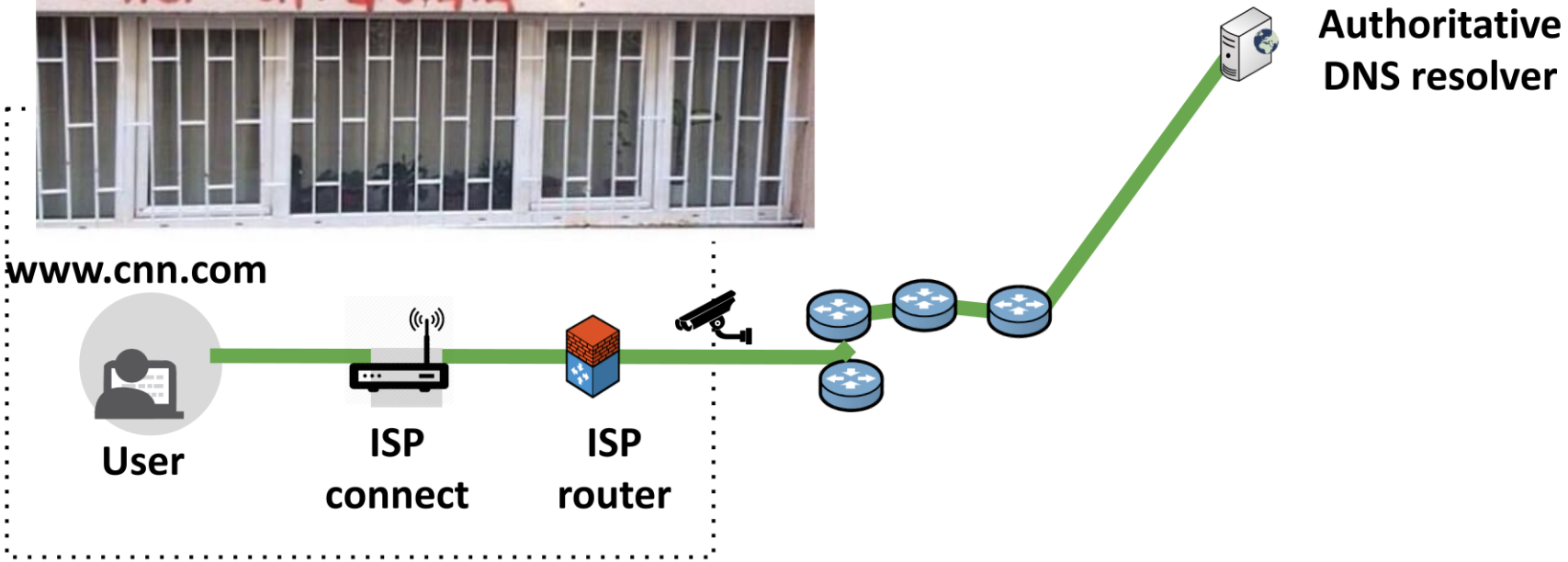


Thou Shalt Not Allow:

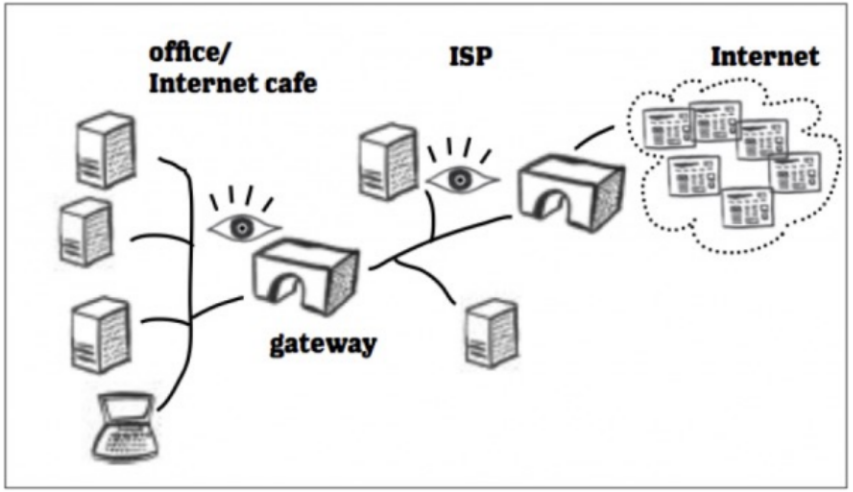
- *.cnn.com
- *.google.com
- *.facebook.com
- …

Trusted DNS Servers

- Manually configure DNS to non-censored server directly

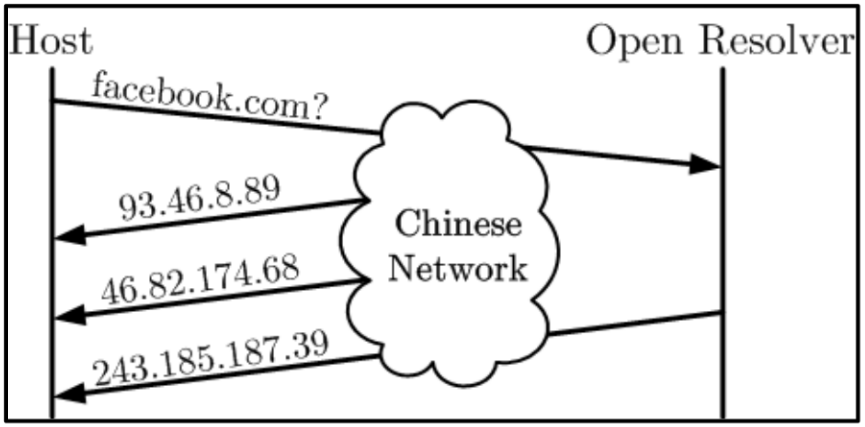


Infrastructure Enforcement

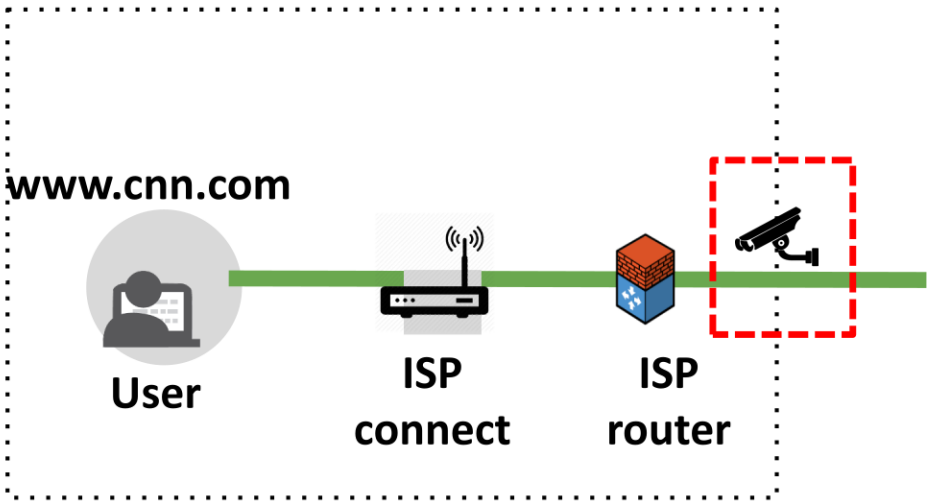


- Require ISP and telco-providers to provide on-path access
- Censor deploys own implementation to block access

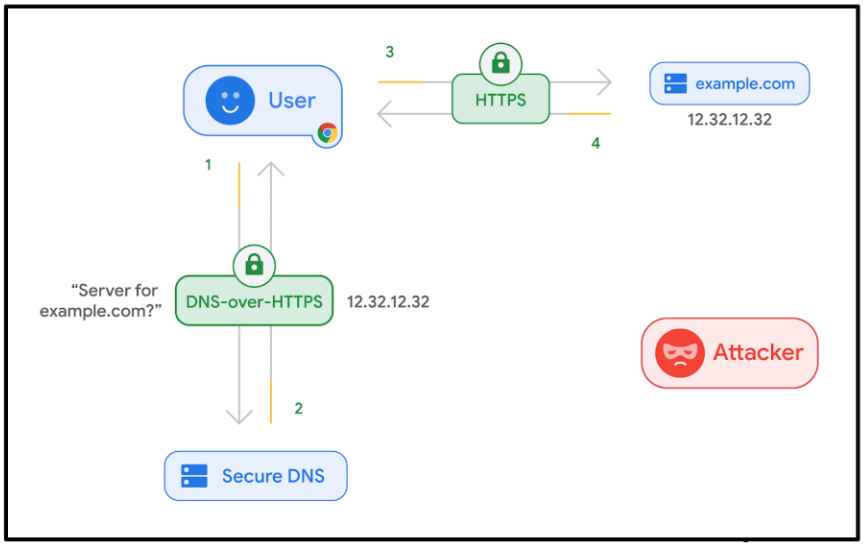
DNS Injection



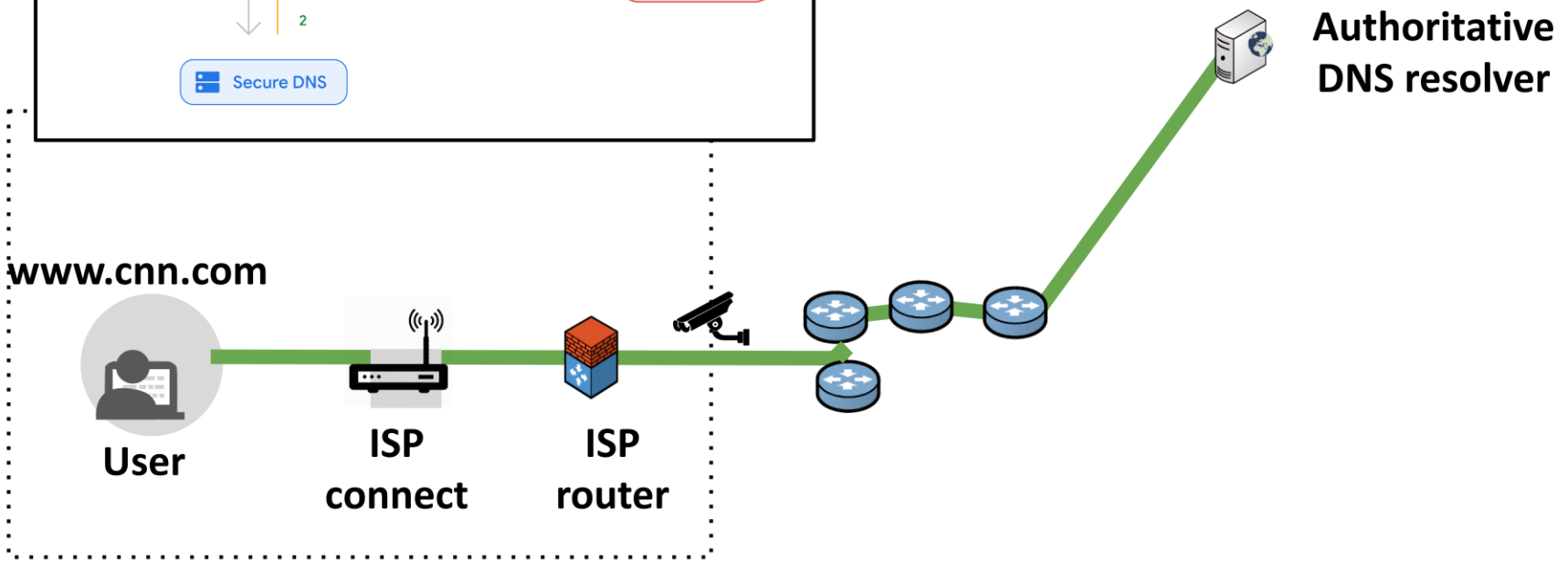
- Censor looks for DNS req in outbound traffic
  - Destined for honest DNS server
- Censor injects fake DNS responses
- Real response is ignored when arrives



DNS over HTTPS



- Wrap DNS protocol inside HTTPS channel



Deep Packet Inspection

Deep Packet Inspection (DPI) is a network component that is able to monitor traffic for signs of *deemed-harmful* content.

- DPI is an IDS/IPS used specifically for censorship
- Arbitrarily advanced logic to trigger

Intrusion Detection System (IDS)

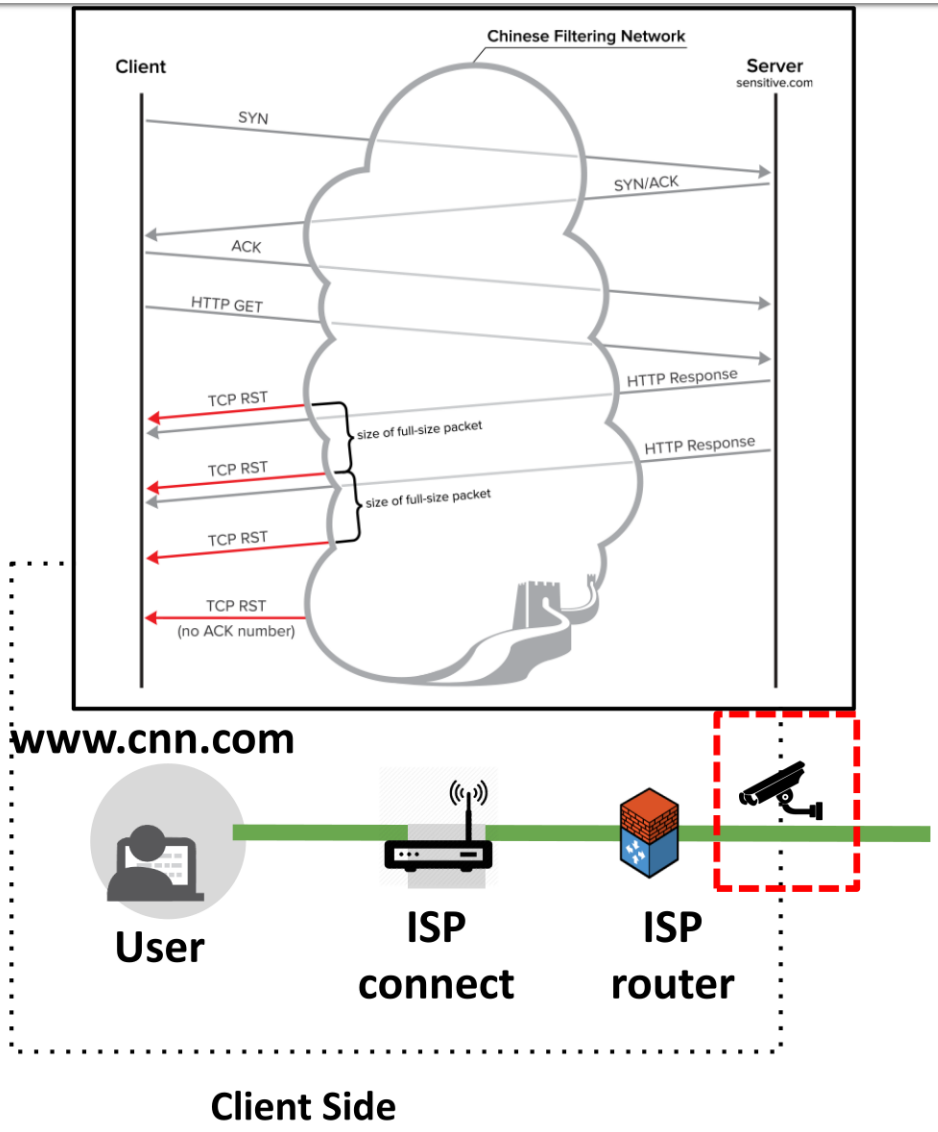
An **Intrusion Detection System (IDS)** is a network *monitoring* component that is able to *watch* for signs of maliciousness.

- Capable of granular and complex rules
  - Beyond L2/L3 (IP/TCP) headers
  - "Deep Packet Inspection" (DPI)
- Capable of pattern/regex matching
- Capable of searching for multi-flow patterns

Common DPI Triggers

- Search for banned domains/IPs
- Search for banned content
  - Words, phrases, images, etc
- Search for traffic fingerprints
  - Timing of requests
  - Packet-flow rate/size
  - Inter-flow correlations (fetching dependencies)
- Search for illogical characteristics
  - Side-channels to fake interactions

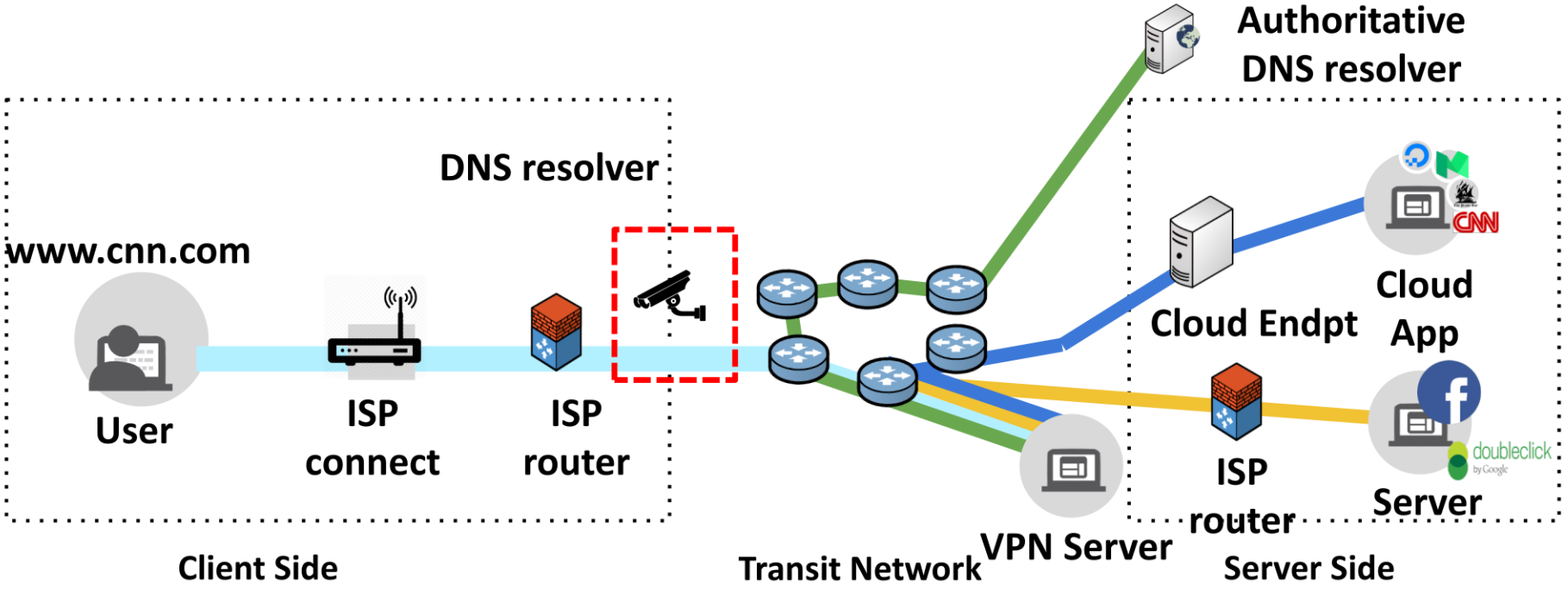
TCP Injection



- Censor looks for DPI triggers in outbound traffic
- Censor injects fake TCP RST packets
- Client thinks RST from server and closes connection

Secure Channel Encapsulation

- DPI much less useful w/ encrypted traffic
  - TLS/VPN/etc.

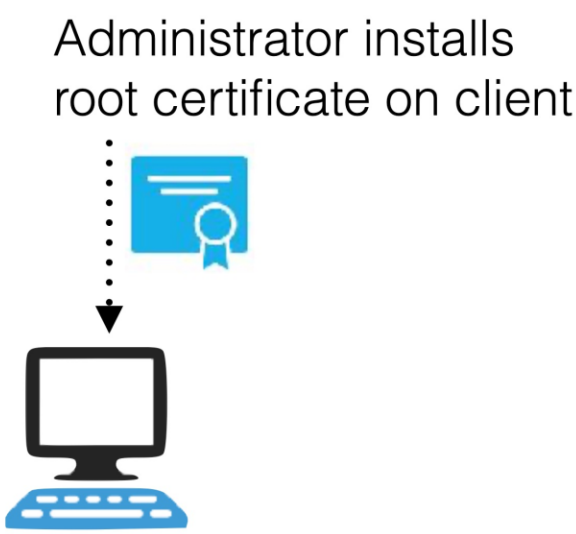


TLS Interception

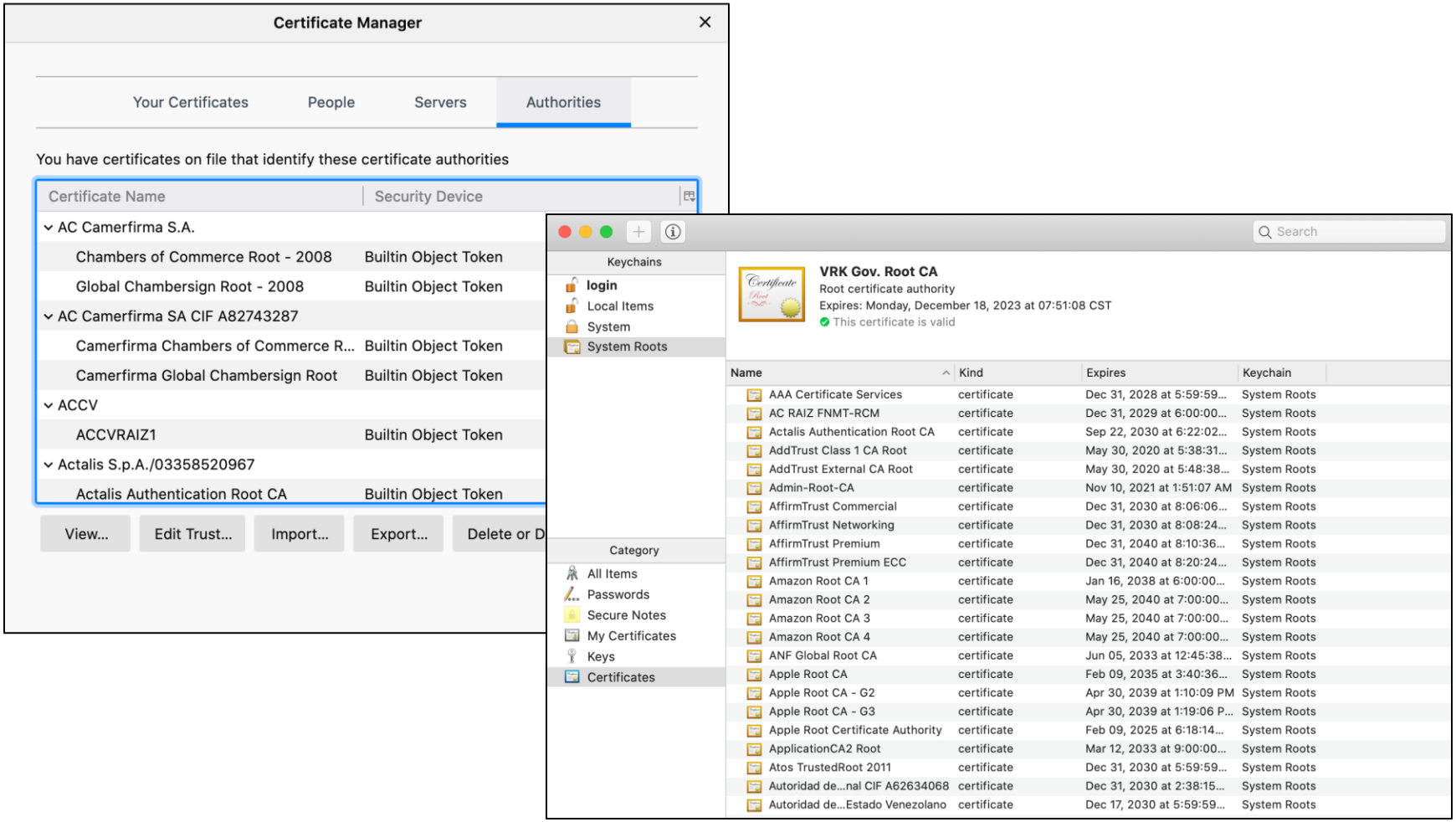
TLS Interception is an *explicit* mechanism to Man-in-the-Middle (MitM) TLS/HTTPS connections in order to monitor contents.

- Estimated 5-10% of TLS connections

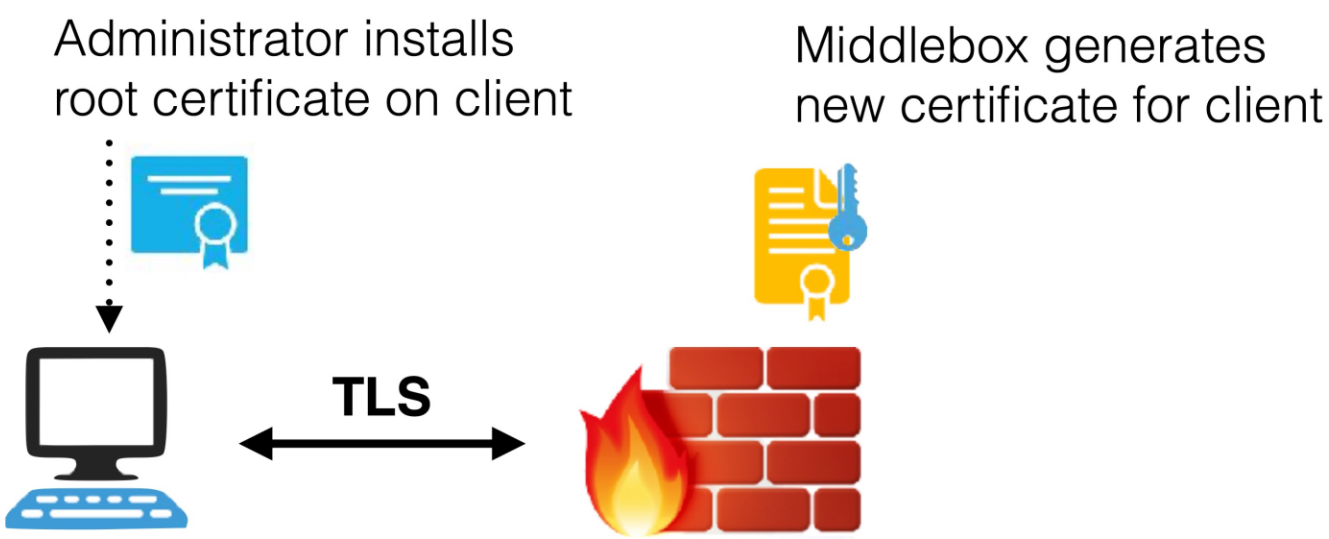
TLS Interception



TLS Interception

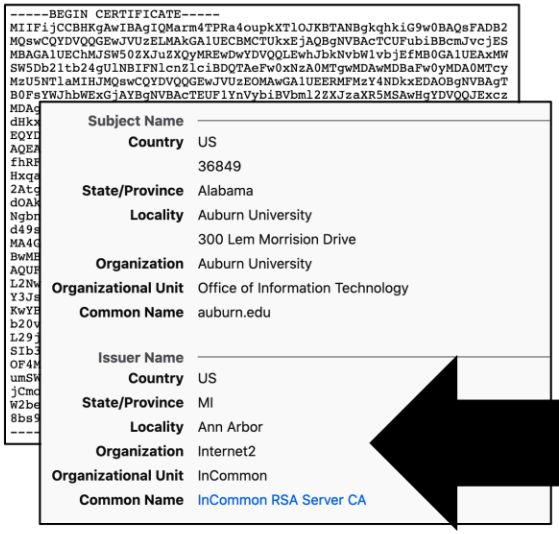


TLS Interception

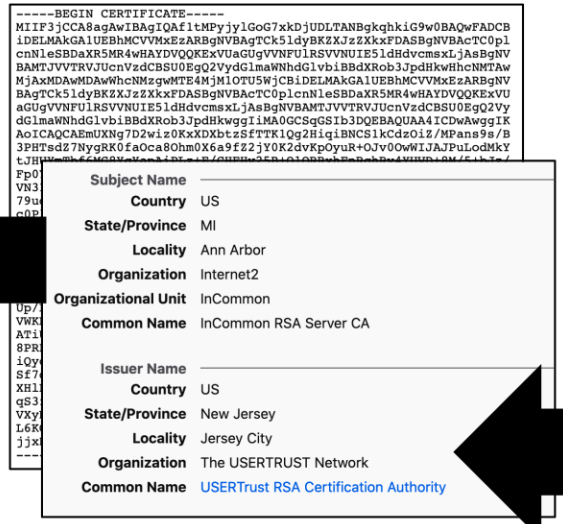


Certificate Chaining

Leaf Certificate



Intermediate Certificate

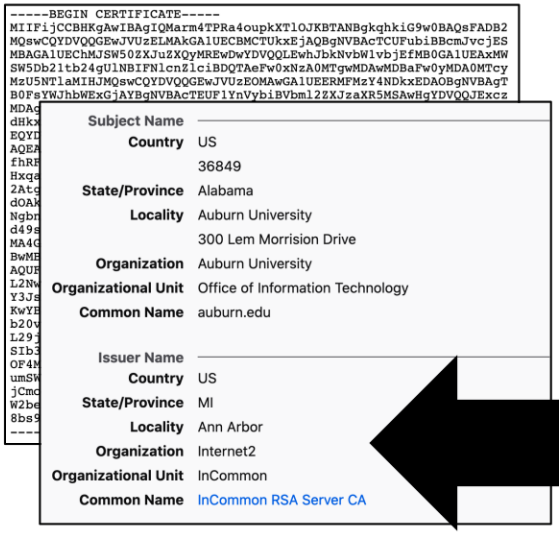


Root Certificate

Compromised Root CA

Compromised Root Chain

Leaf Certificate

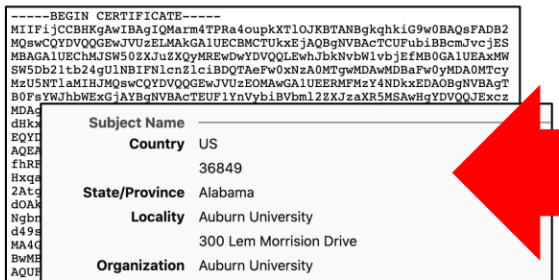


Intermediate Certificate

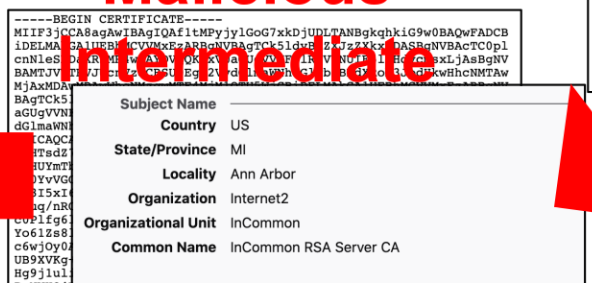
Root Certificate

COMPROMISED

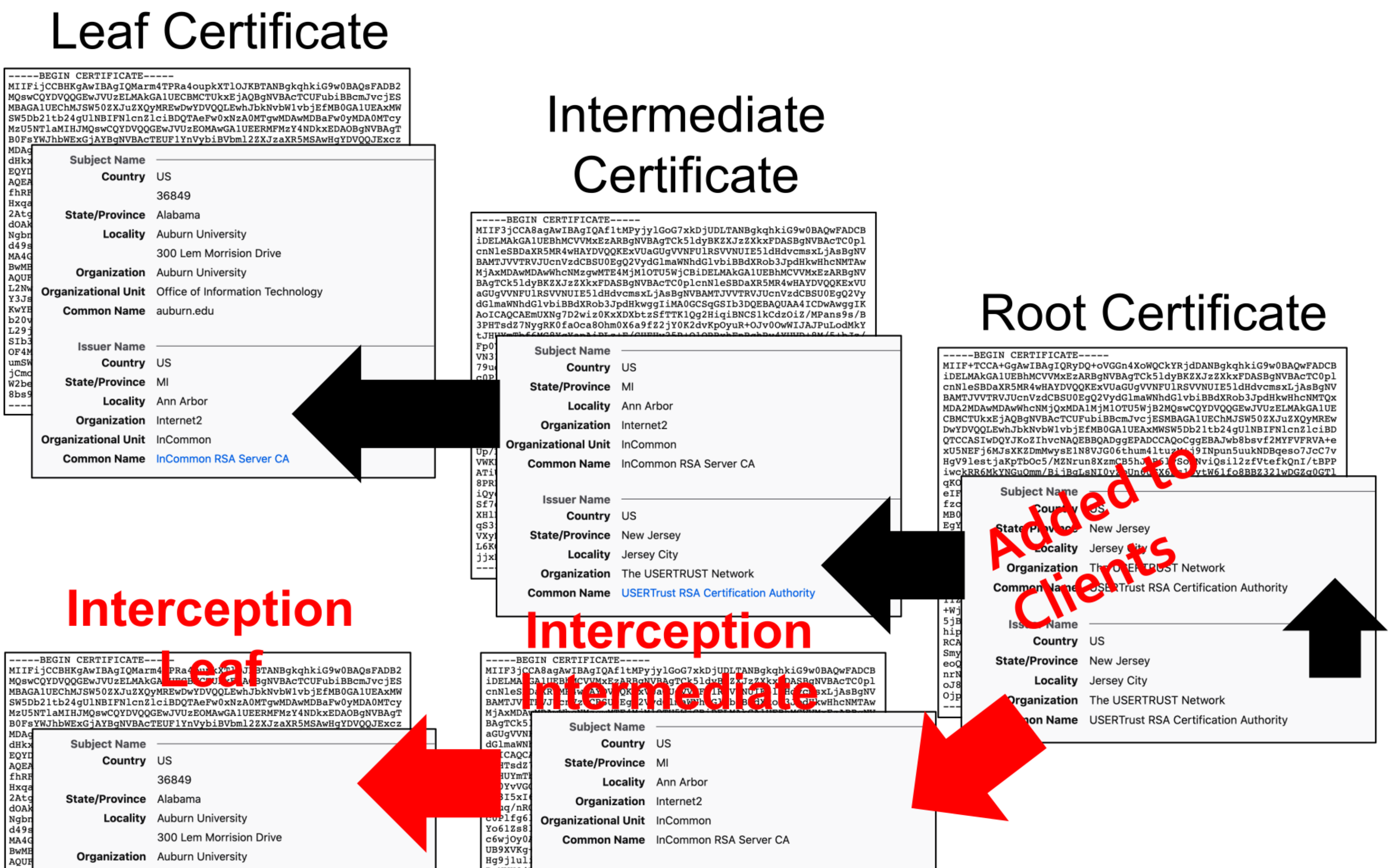
Malicious Leaf



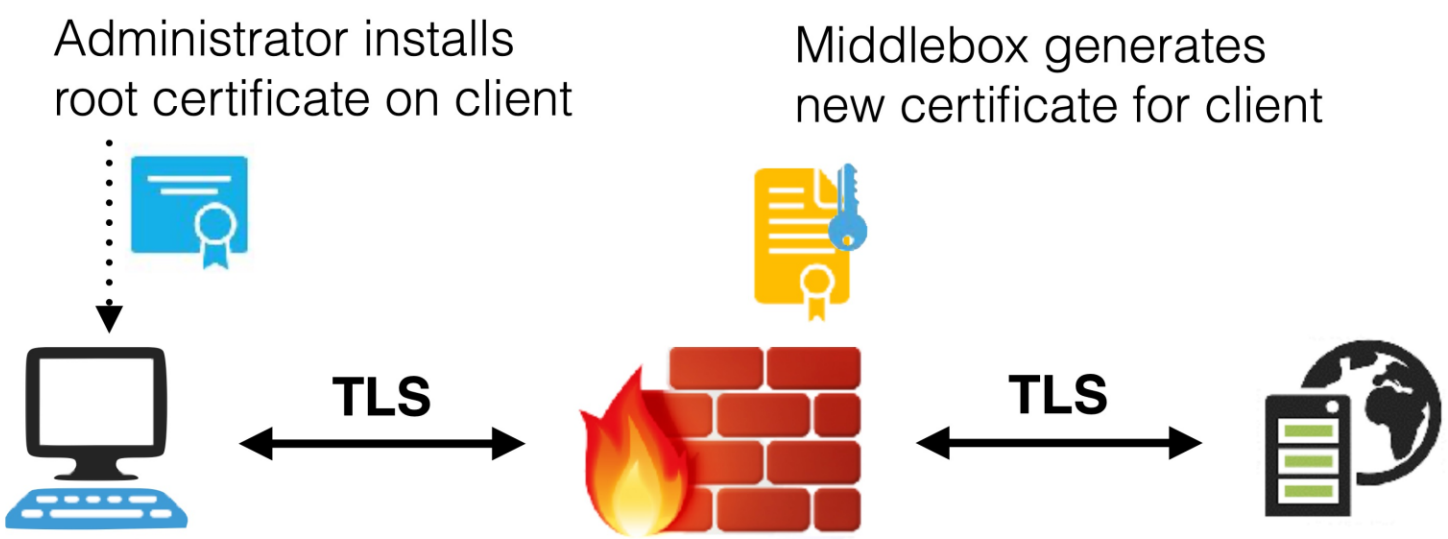
Malicious Intermediate



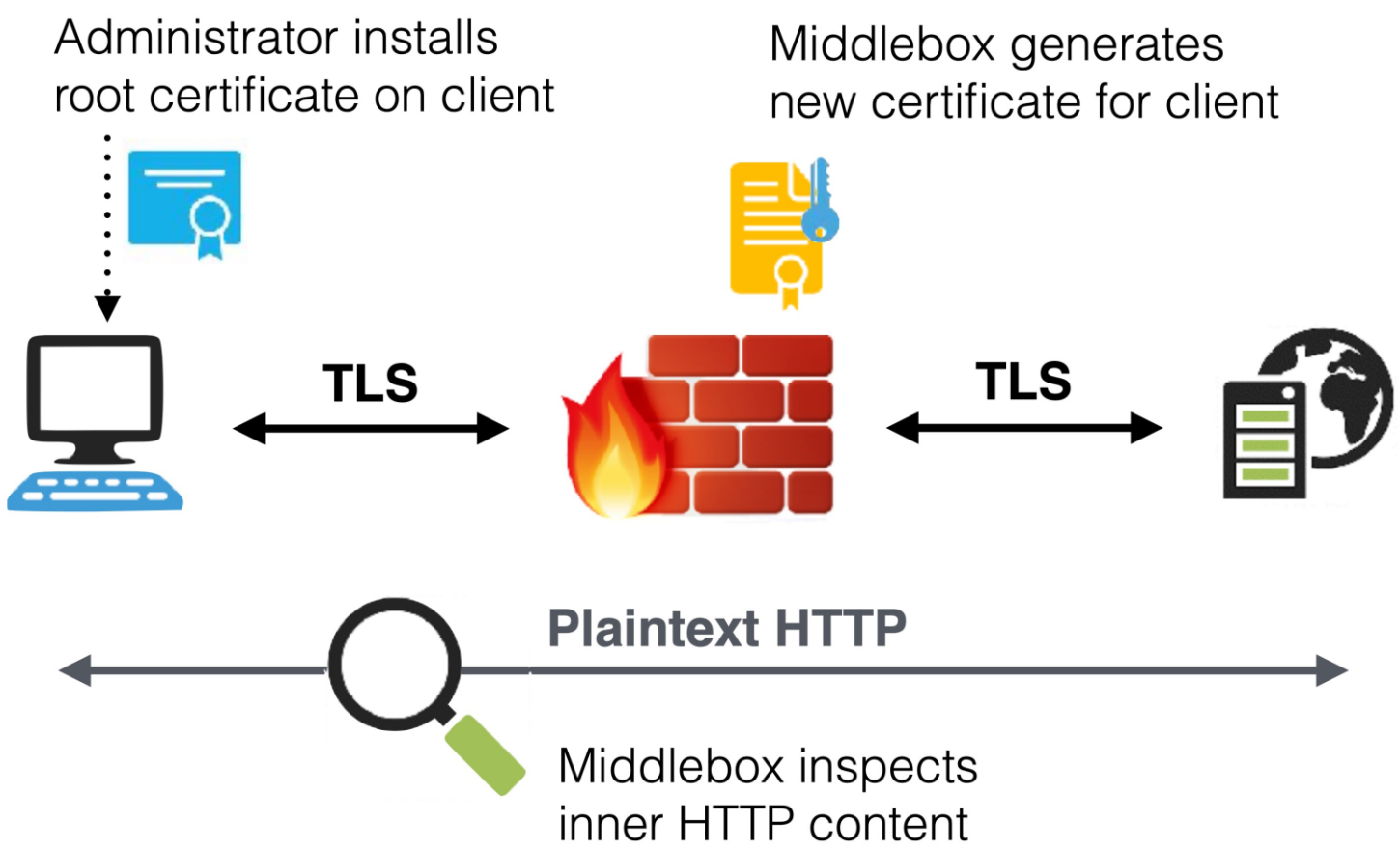
TLS Interception Chain



TLS Interception



TLS Interception



TLS Interception

TLS Interception is an *explicit* mechanism to Man-in-the-Middle (MitM) TLS/HTTPS connections in order to monitor contents.

- Estimated 5-10% of TLS connections
- Often ***claims*** to be a security defense
- More often it ***creates vulnerabilities*** in otherwise secure interactions

Impact of TLS Interception

TLS Security	Increased Security	Same Security	Decreased Security	Severely Broken
Client Security Products	0/20	2/20	18/20	10/20
Middleboxes	0/12	1/12	6/12	5/12

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The Security Impact of HTTPS Interception

Zakir Durumeric[*∨], Zane Ma[†], Drew Springall[*], Richard Barnes[‡], Nick Sullivan[§], Elie Bursztein[¶], Michael Bailey[†], J. Alex Halderman[*], Vern Paxson[‖∨]

[*] University of Michigan [†] University of Illinois Urbana-Champaign [‡] Mozilla [§] Cloudflare [¶] Google [‖] University of California Berkeley [∨] International Computer Science Institute

Impact of TLS Interception

Product	OS	Browser MITM: IE	Chrome	Firefox	Safari	Grade	Validates Certificates	Modern Ciphers	TLS Version	Grading Notes
Avast …										
AV 11	Win	●	○	○		A*	✓	✓	1.2	Mirrors client ciphers
AV 11.7	Mac		●	●	●	F	✓	✓	1.2	Advertises DES
AVG …										
Internet Security 2015–6	Win	●	●	○		C	✓	✓	1.2	Advertises RC4
Bitdefender …										
Internet Security 2016	Win	●	●	●		C	✓	○	1.2	RC4, 768-bit D-H
Total Security Plus 2016	Win	●	●	●		C	✓	○	1.2	RC4, 768-bit D-H
AV Plus 2015–16	Win	●	●	●		C	✓	○	1.2	RC4, 768-bit D-H
Bullguard …										
Internet Security 16	Win	●	●	●		A*	✓	✓	1.2	Mirrors client ciphers
Internet Security 15	Win	●	●	●		F	✓	✗	1.0	Advertises DES
CYBERsitter …										
CYBERsitter 11	Win	●	●	●		F	✗	✗	1.2	No cert. validation, DES
Dr. Web …										
Security Space 11	Win	●	●	●		C	✓	○	1.2	RC4, FREAK
Dr. Web 11 for OS X	Mac		●	●	●	F	✓	✗	1.0	Export ciphers, DES, RC2
ESET …										
NOD32 AV 9	Win	●	●	●		F	○	○	1.2	Broken cert. validation
Kaspersky …										
Internet Security 16	Win	●	●	●		C	✓	✓	1.2	CRIME vulnerability
Total Security 16	Win	●	●	●		C	✓	✓	1.2	CRIME vulnerability
Internet Security 16	Mac		●	●	●	C	✓	✓	1.2	768-bit D-H
KinderGate …										
Parental Control 3	Win	●	●	●		F	○	✗	1.0	Broken cert. validation
Net Nanny …										
Net Nanny 7	Win	●	●	●		F	✓	✓	1.2	Anonymous ciphers
Net Nanny 7	Mac		●	●	●	F	✓	✓	1.2	Anonymous ciphers
PC Pandora …										
PC Pandora 7	Win	●	◐	◐		F	✗	✗	1.0	No certificate validation
Qustodio …										
Parental Control 2015	Mac		●	●	●	F	✓	✓	1.2	Advertises DES

Interception: ○ No Interception (conn. allowed) ◐ Connections Blocked ● Connections Intercepted

Certificate Validation: ✗ No Validation ○ Broken Validation ✓ Correct Validation

Modern Ciphers: ✗ No Support ○ Non- ✓ Prefe

Fig. 4: **Security of Client-side Interception Software**—We evaluate and fingerprint popu products, finding that products from twelve vendors intercept connections.[5] In all but two ca security. *Mirrors browser ciphers.

	Same Security	Decreased Security	Severely Broken
	2/20	18/20	10/20
	1/12	6/12	5/12

Product	Grade	Validates Certificates	Modern Ciphers	Advertises RC4	TLS Version	Grading Notes
A10 vThunder SSL Insight	F	✓	✓	Yes	1.2	Advertises export ciphers
Blue Coat ProxySG 6642	A*	✓	✓	No	1.2	Mirrors client ciphers
Barracuda 610Vx Web Filter	C	✓	✗	Yes	1.0	Vulnerable to Logjam attack
Checkpoint Threat Prevention	F	✓	✗	Yes	1.0	Allows expired certificates
Cisco IronPort Web Security	F	✓	✓	Yes	1.2	Advertises export ciphers
Forcepoint TRITON AP-WEB Cloud	C	✓	✓	No	1.2	Accepts RC4 ciphers
Fortinet FortiGate 5.4.0	C	✓	✓	No	1.2	Vulnerable to Logjam attack
Juniper SRX Forward SSL Proxy	C	✓	✗	Yes	1.2	Advertises RC4 ciphers
Microsoft Threat Mgmt. Gateway	F	✗	✗	Yes	SSLv2	No certificate validation
Sophos SSL Inspection	C	✓	✓	Yes	1.2	Advertises RC4 ciphers
Untangle NG Firewall	C	✓	✗	Yes	1.2	Advertises RC4 ciphers
WebTitan Gateway	F	✗	✓	Yes	1.2	Broken certificate validation

Fig. 3: **Security of TLS Interception Middleboxes**—We evaluate popular network middleboxes that act as TLS interception proxies. We find that nearly all reduce connection security and five introduce severe vulnerabilities. *Mirrors browser ciphers.

Why would censors inject traffic (DNS responses/TCP RSTs/etc) instead of intercepting traffic?

Inline DPI+blocking is expensive and delays *approved* content.

Censors are Rational Actors

- In almost all cases, censors understand how their actions will be perceived
  - By those who are impacted
  - By other governments/companies
- Censorship still exists because the censors decide that the negative aspects are acceptable due to the advantages.

Censorship Avoidance

Censorship avoidance is intentionally designing, building, using, and maintaining systems whose goal is explicitly to give users ability to bypass local censorship.

- Attempts to modify the censor's trade-off
  - Increase the negative impacts of blocking
  - Decrease the user-effort to avoid

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Censorship avoidance is intentionally designing, building, using, and maintaining systems whose goal is explicitly to give users ability to bypass local censorship.

- Attempts to modify the censor's trade-off
  - Increase the negative impacts of blocking
  - Decrease the user-effort to avoid
- Will never be 100% successful but that's OK
  - **Just need to cross trade-off boundary**

VPNs

A **Virtual Private Network (VPN)** is a *logical* concept through which a remote client appears on the local network by use of a multiplexed secure channel.

- Many different protocols can be used
- IKE+IPSec is a common implementation
- Can connect two remote-networks as 1
- Can be used on a client-server construction

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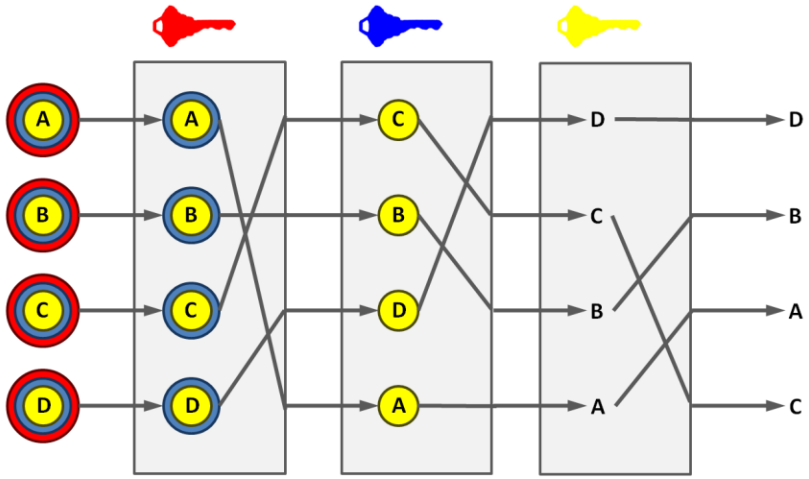
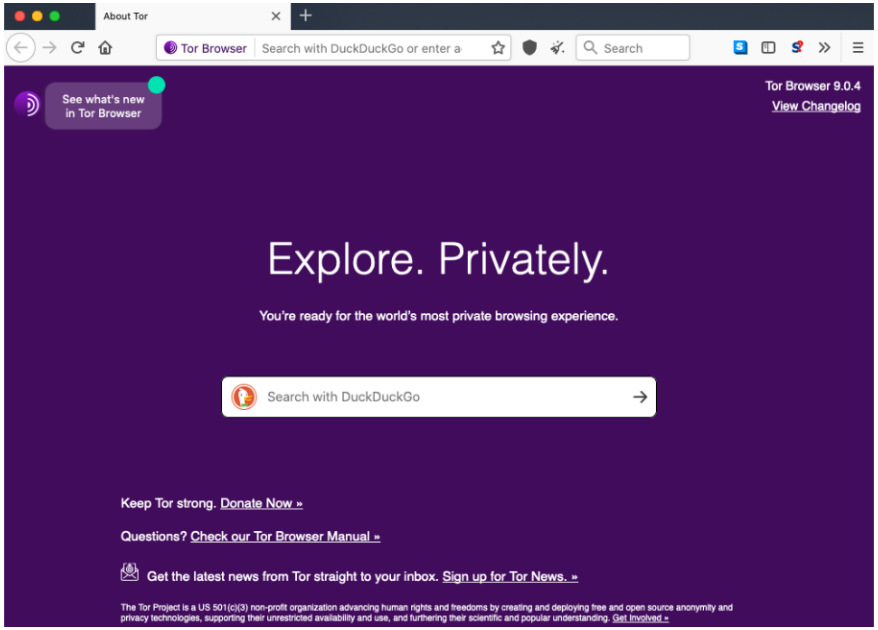
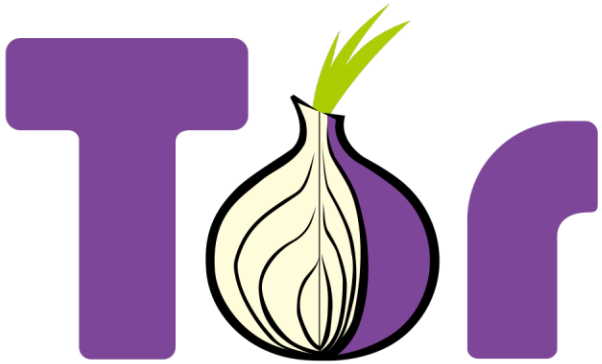


The Onion Router (Tor)

The Onion Router (Tor) network is a privacy- and anonymity-centric, volunteer-run communications network.

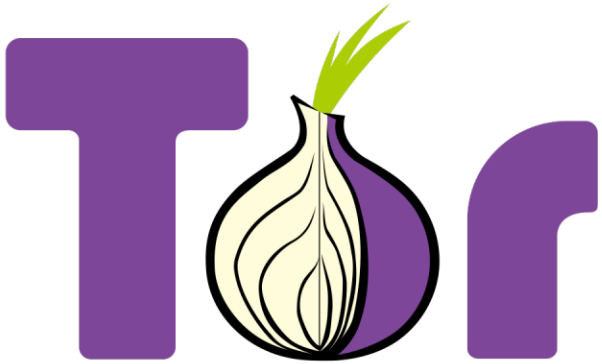


Tor



- Started by DoD's Naval Research Lab
- "Low-latency" Secure Channel
- *Overlay network*

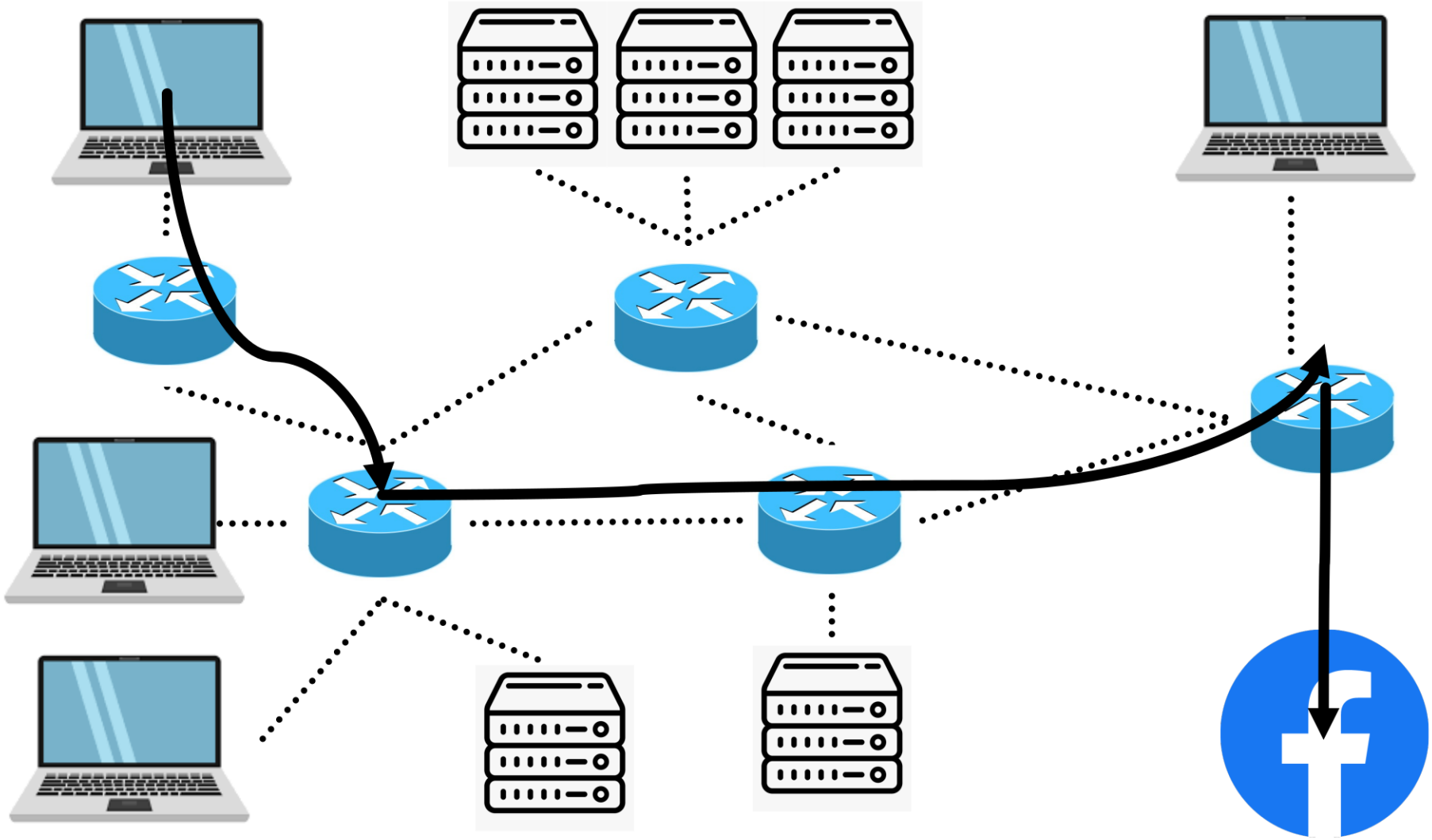
Tor



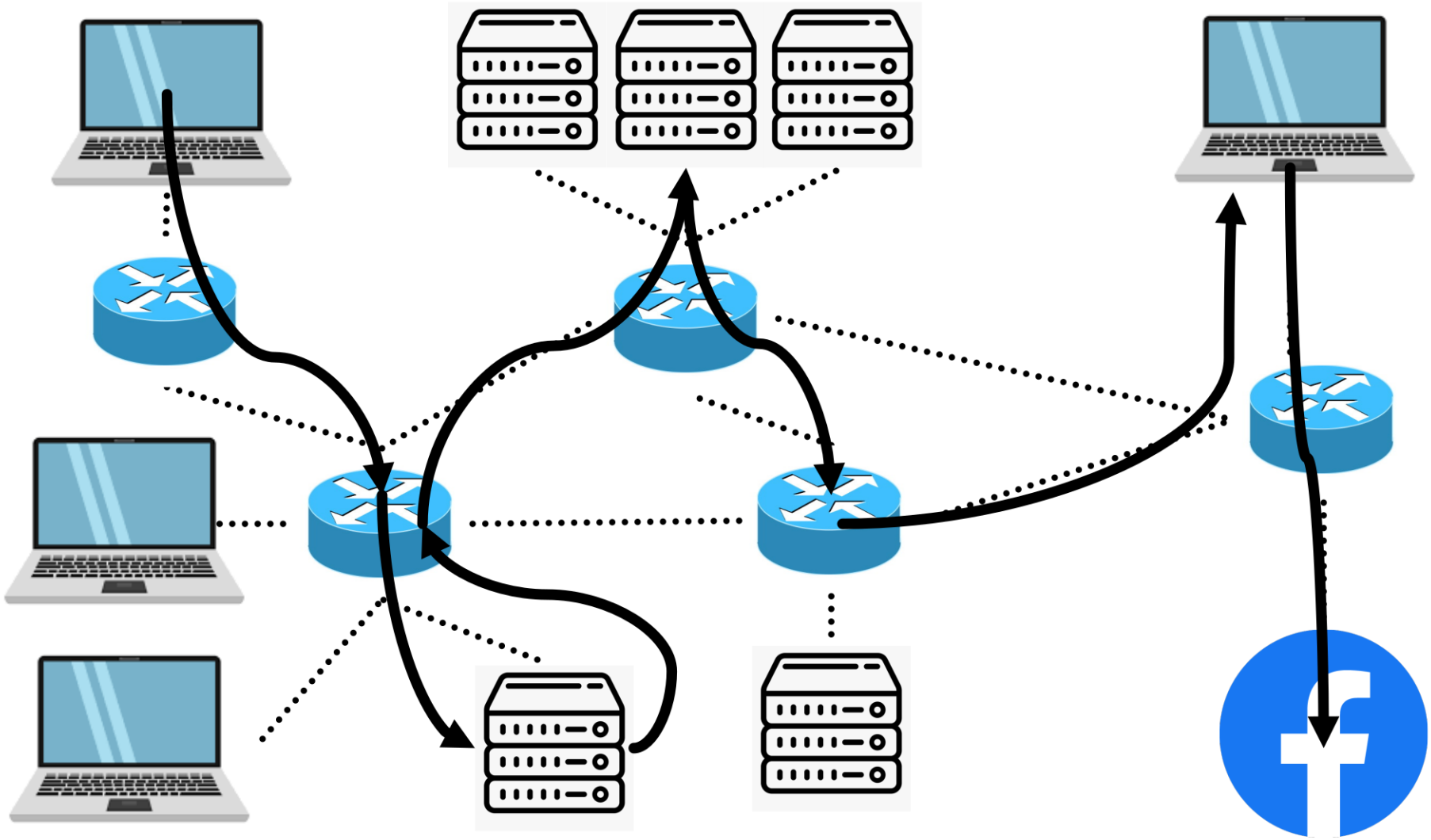
- Started by DoD's Naval Research Lab
- "Low-latency" Secure Channel
- *Overlay network*
- Used by *good guys*
- Used by *bad guys*

Journalists	Drug Dealers
Hackers	Terrorists
Activists	Researchers
Whistleblowers	Mil/Intel Agents
Pedophiles	Normal People

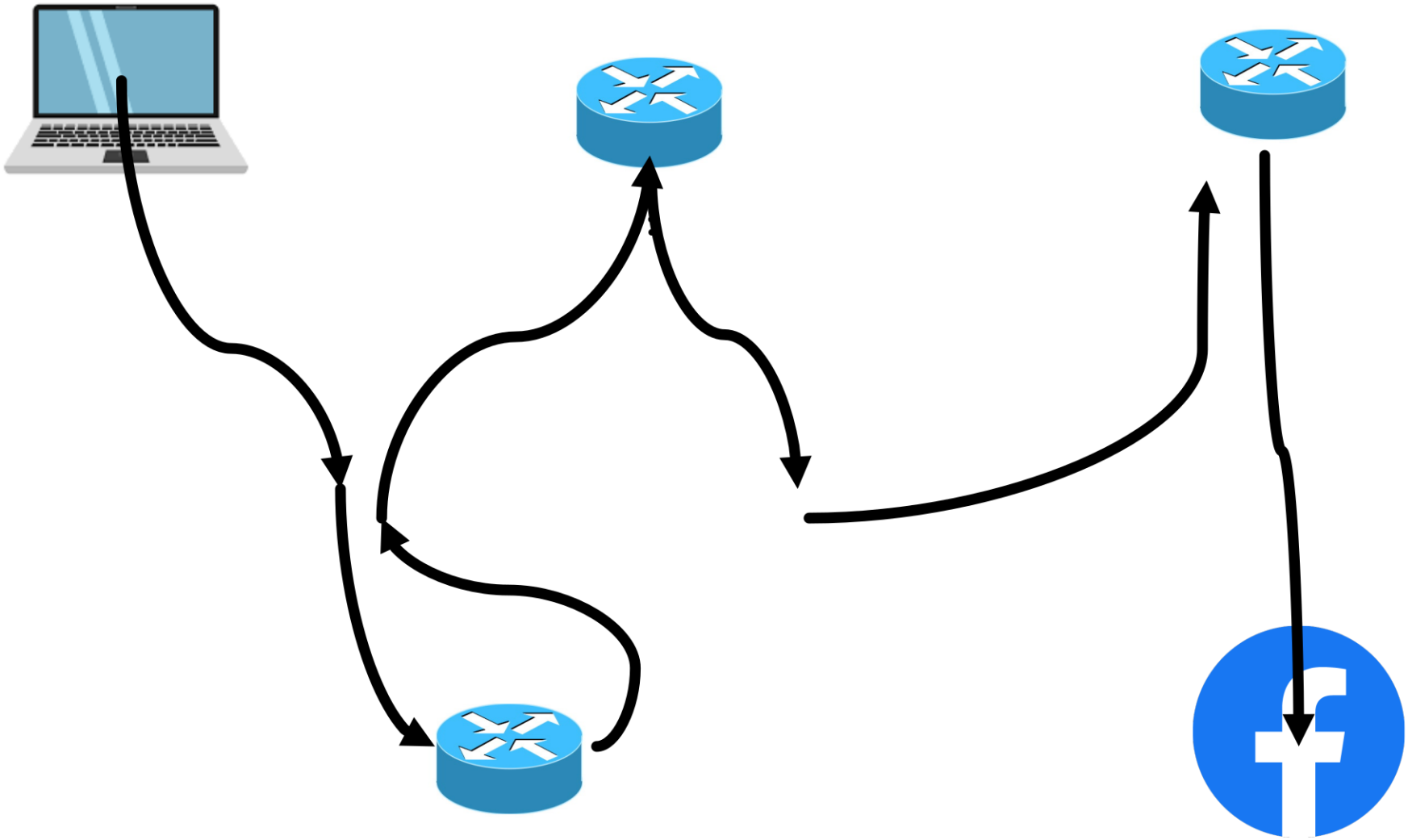
"Normal" Network



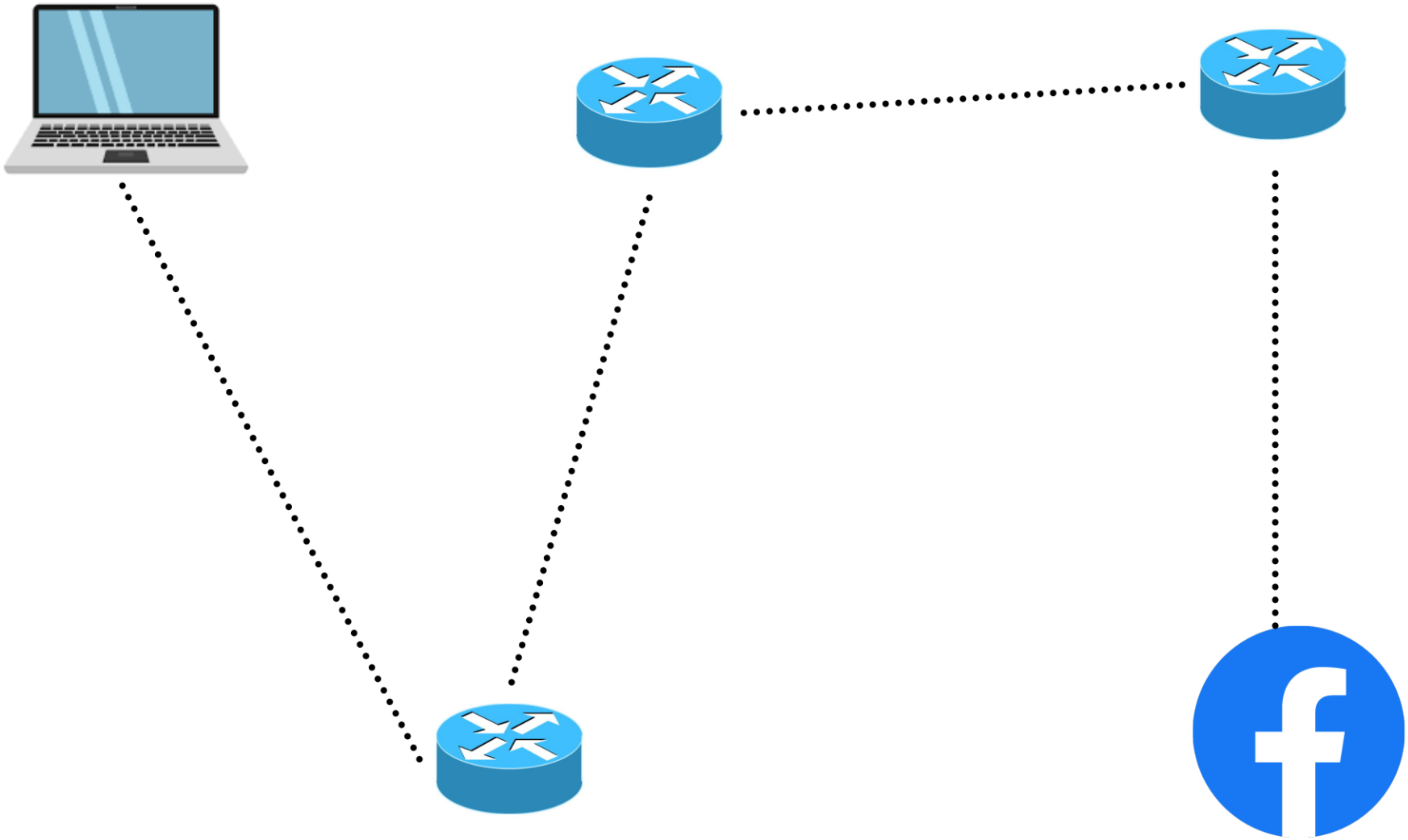
"Overlay" Network



"Overlay" Network



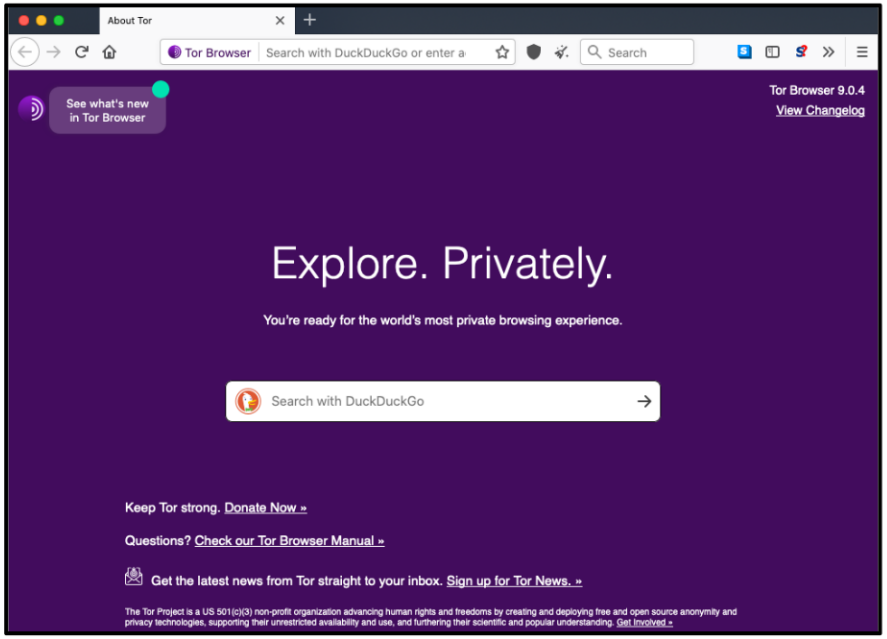
"Overlay" Network



Tor Browser

By default, users access Tor through a forked version of the Firefox web browser with numerous special-purpose patches.

- Use exactly as would Firefox/Chrome/etc
- 100% traffic routed over Tor network
- Cutting-edge privacy protections



Computer and Network Security

Lecture 24: Anonymity & Censorship

COMP-5370/6370
Fall 2025