

CS 43: Computer Networks

06: Distributed Systems and DNS

September 21, 2026



Slides adapted from Kurose & Ross, Vasanta Chaganti, Kevin Webb, Laurent Vanbever

Where we are

Application: the application (DNS)

Transport: end-to-end connections, reliability

Network: routing

Link (data-link): framing, error detection

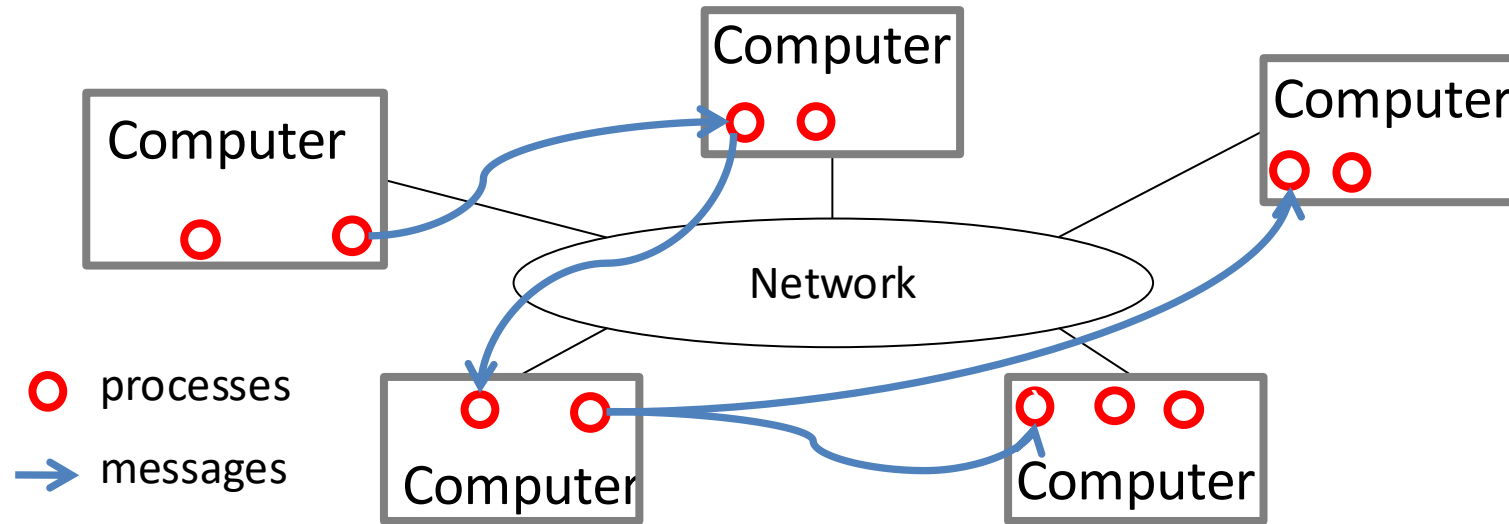
Physical: 1's and 0's/bits across a medium
(copper, the air, fiber)

This week's question:

How does DNS achieve consistency, availability, and high performance? Which of these does it prioritize?

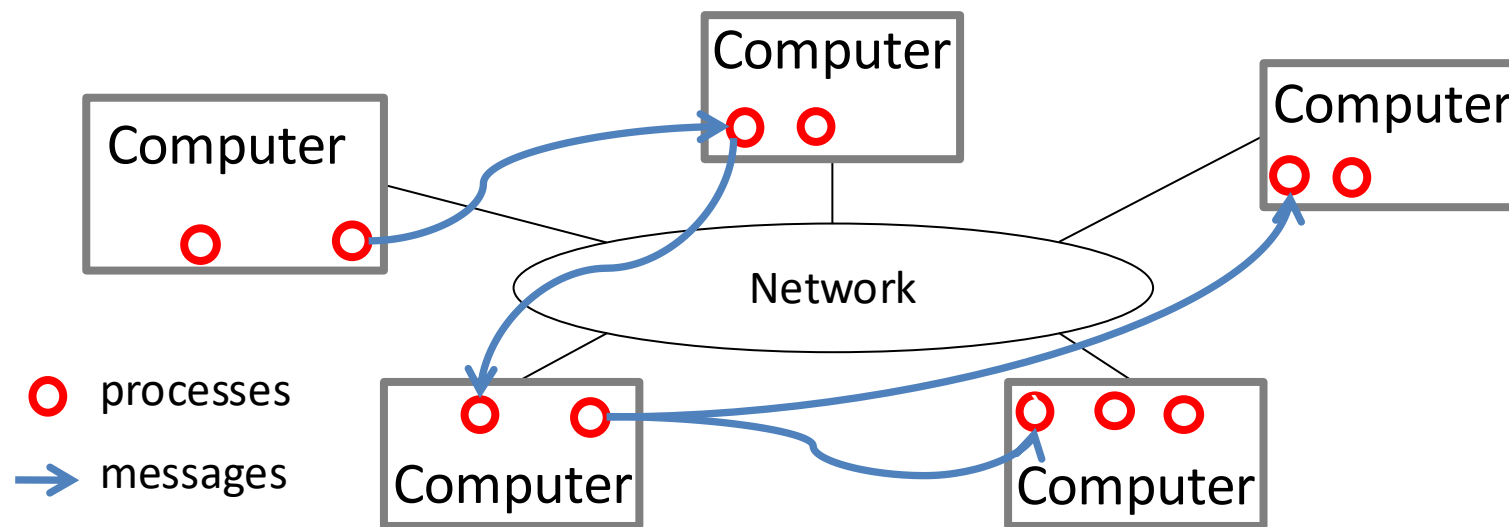
Distributed Network Applications

What is a distributed application?



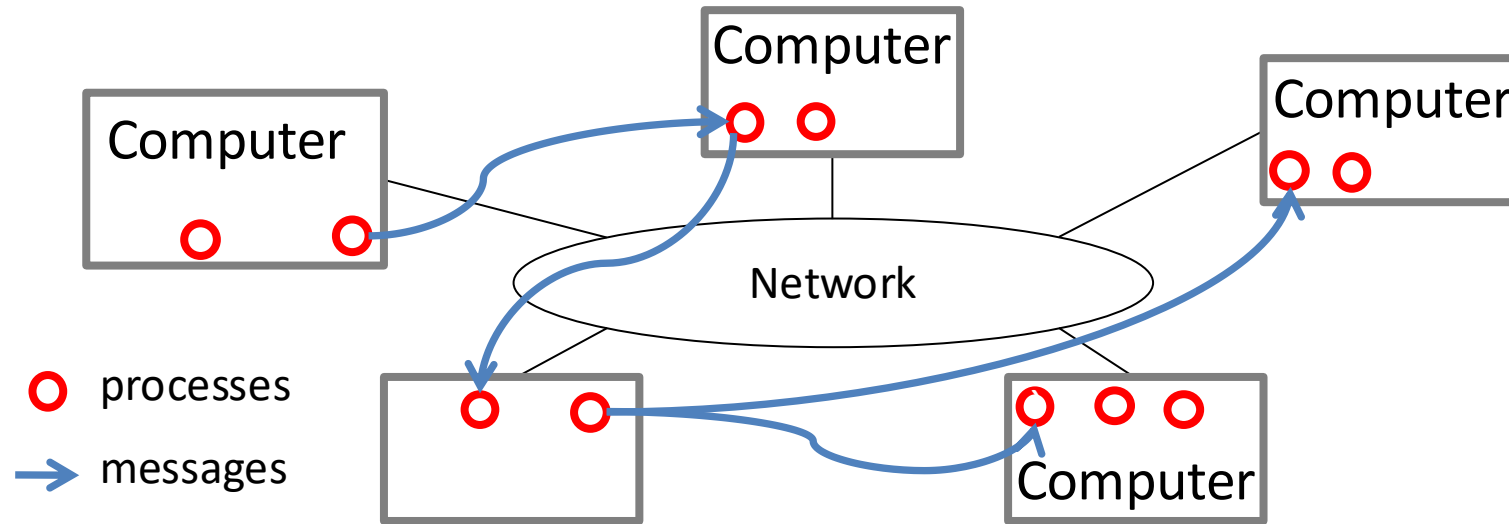
- Cooperating processes in a computer network
- Varying degrees of integration
 - Loose: email, web browsing
 - Medium: chat, Skype, remote execution, remote file systems
 - Tight: process migration, distributed file systems

Distributed Systems: Advantages



- Speed: parallelism, less contention
- Reliability: redundancy, fault tolerance
- Scalability: incremental growth, economy of scale
- Geographic distribution: low latency, reliability

Distributed Systems: Disadvantages



- Fundamental problems of decentralized control
 - State uncertainty: no shared memory or clock
 - Action uncertainty: mutually conflicting decisions
- Distributed algorithms are complex

On a single system...

- You have a number of components
 - CPU
 - Memory
 - Disk
 - Power supply
- If any of these go wrong, you're (usually) toast.

On multiple systems...

- New classes of failures (**partial failures**).
 - A link might fail
 - One (of many) processes might fail
 - The network might be partitioned

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Introduces major complexity!

If a process sends a message, can it tell the difference between a slow link and a delivery failure?

A. Yes

B. No

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What should we do to handle a partial failure? Under what circumstances, or what types of distributed applications?

- A. If one process fails or becomes unreachable, switch to a spare.
- B. Pause or shut down the application until all connectivity and processes are available.
- C. Allow the application to keep running, even if not all processes can communicate.
- D. Handle the failure in some other way.

What should we do to handle a partial failure? Under what circumstances, or what types of distributed applications?

- A. If one process fails or becomes unreachable, switch to a spare (not possible if this was a datacenter).
- B. Pause or shut down the application until all connectivity and processes are available. (If it is a critical system: banking, air travel).
- C. Allow the application to keep running, even if not all processes can communicate (non-critical, social network applications)
- D. Handle the failure in some other way.

Desirable Properties

- Consistency
 - Nodes agree on the distributed system's state
- Availability
 - The system is able and willing to process requests
- Partition tolerance
 - The system is robust to network (dis)connectivity

The CAP Theorem

- **Consistency**
 - Nodes agree on the distributed system's state
- **Availability**
 - The system is able and willing to process requests
- **Partition tolerance**
 - The system is robust to network (dis)connectivity
- **Choose Two**
- “CAP prohibits only a tiny part of the design space: **perfect availability and consistency in the presence of partitions, which are rare.**”*

* Brewer, Eric. "CAP twelve years later: How the " rules" have changed." Computer 45.2 (2012): 23-29.

Consistency: Event Ordering

- It's very useful if all nodes can agree on the order of events in a distributed system
- For example: Two users trying to update a shared file across two replicas

If two events occur (digitally or in the “real world”), can we always tell which happened first?

A. Yes

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“Relativity of simultaneity”

- Example: observing car crashes
- Exception: causal relationship

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- For example: Two users trying to update a shared file across two replicas
- “Time, Clocks, and the Ordering of Events in a Distributed System” by Leslie Lamport (1978)
 - Establishes causal orderings
 - Cited > 8000 times

Summary

- Distributed systems are hard to build!
 - Partial failures
 - Ordering of events
- Take CS 87 for more details!

DNS: Domain Name System

People: many identifiers:

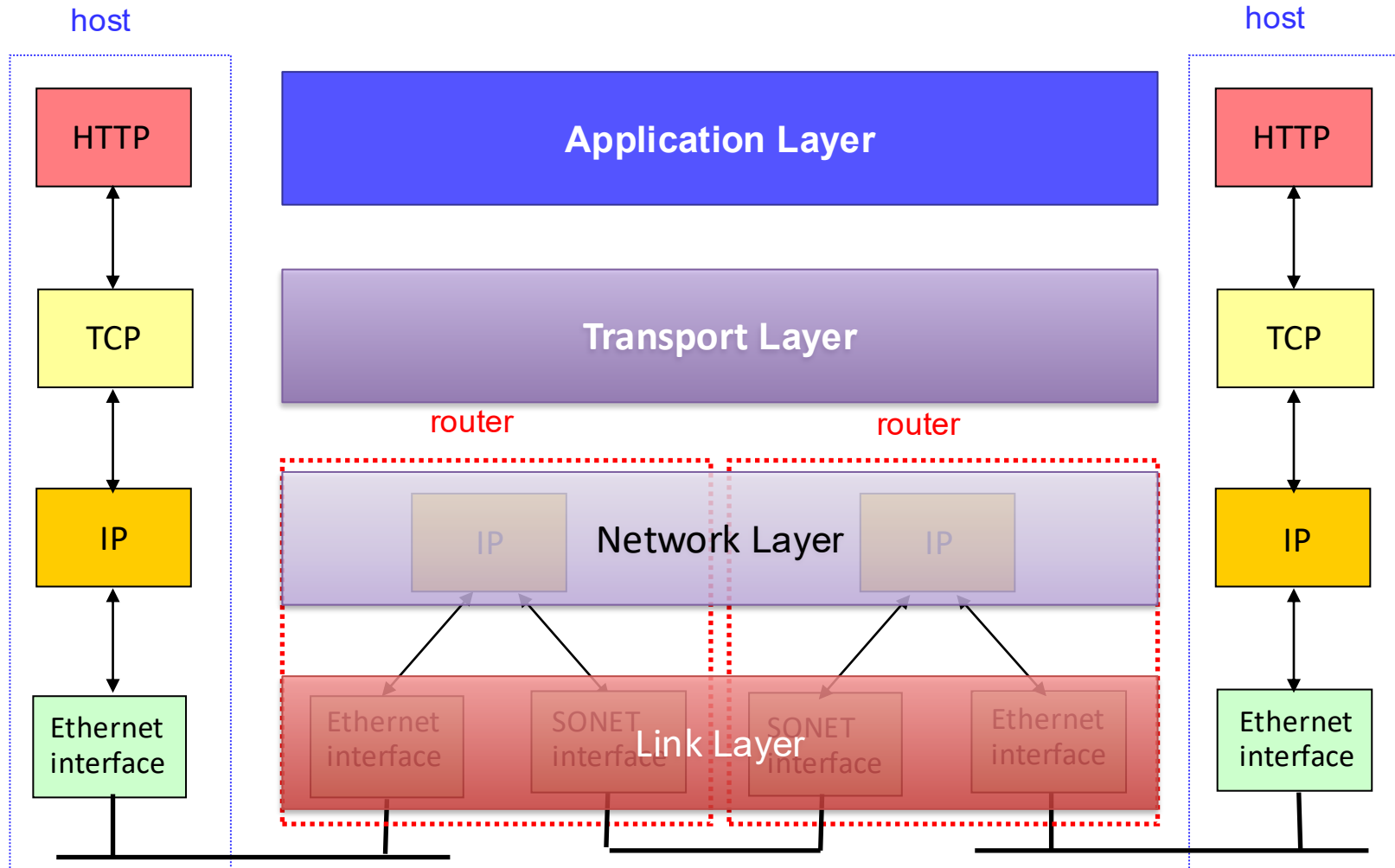
- name, swat ID, SSN, passport #

Internet hosts (endpoints), routers (devices inside a n/w):

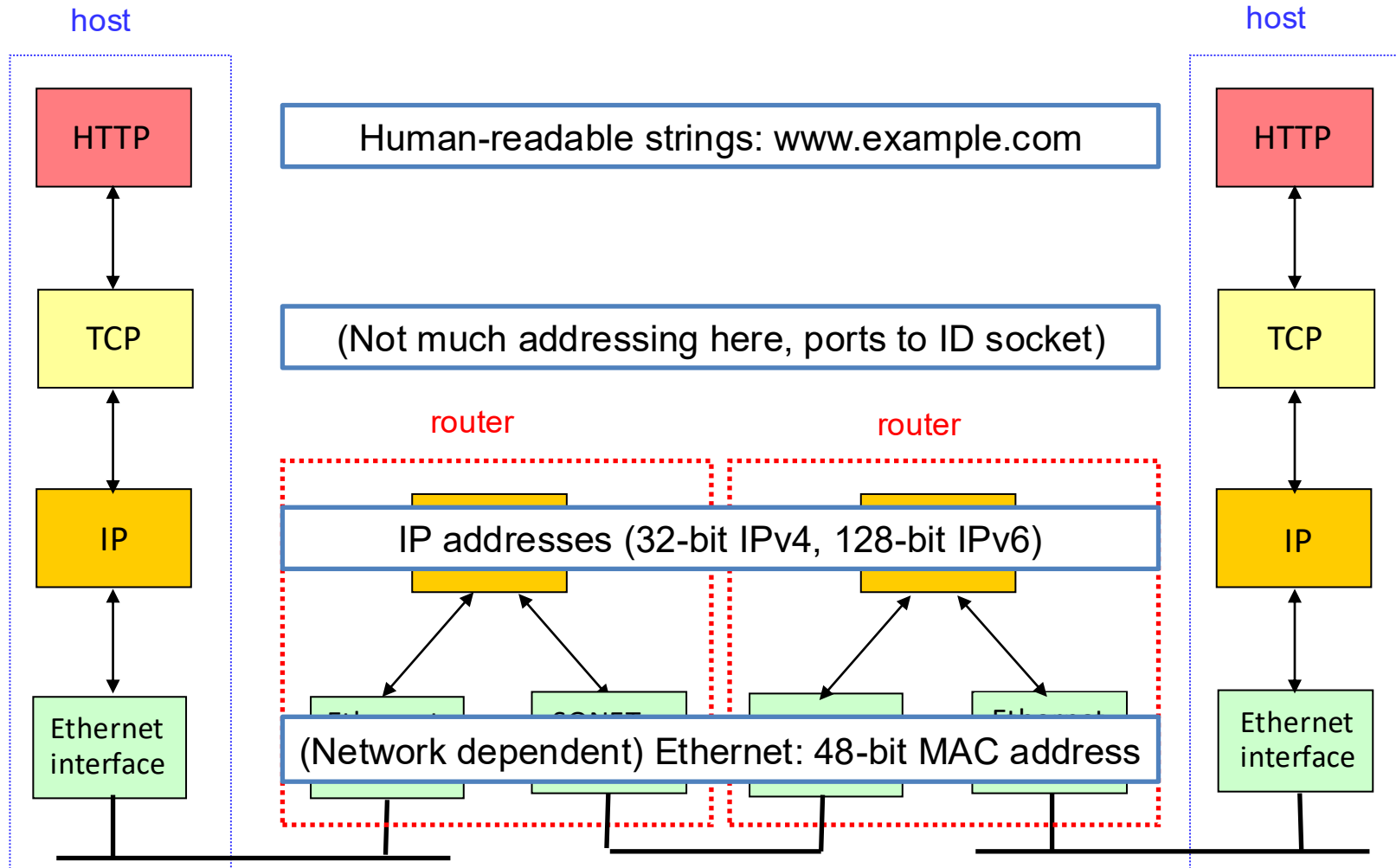
- “name”, e.g., www.google.com - used by humans
- IP address (32 bit) - used for addressing packets

How do we map between IP address and name, and vice versa ?

Where



Recall: TCP/IP Protocol Stack



Why do we need to map names to IP addresses? Why not route on names at the network layer?

- A. Domain names are hierarchical, so we can route on domain names too.
- B. Domain names are variable length, vs IP are fixed length, some changes will be required to switch.
- C. With domain names we wouldn't know where to route to geographically.
- D. Some other reason.

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- B. Domain names are variable length, vs IP are fixed length, some changes will be required to switch.
- C. With domain names we wouldn't know where to route to geographically (mostly true).
- D. Some other reason.

Identifiers

- **Host name** (e.g., www.swarthmore.edu)
 - Used by humans to specify host of interest
 - Unique, selected by host administrator
 - Hierarchical, **variable-length string** of alphanumeric characters
- **IP address** (e.g., 130.58.68.164)
 - Used by routers to forward packets
 - Unique, **topologically meaningful** locator
 - Hierarchical namespace of **32 bits**

Mapping Between Identifiers

- Domain Name System (DNS)
 - Given a host name, provide the IP address
 - Given an IP address, provide the host name

Is a hostname to IP address mapping always permanent?

- A. Yes
- B. No
- C. I don't know



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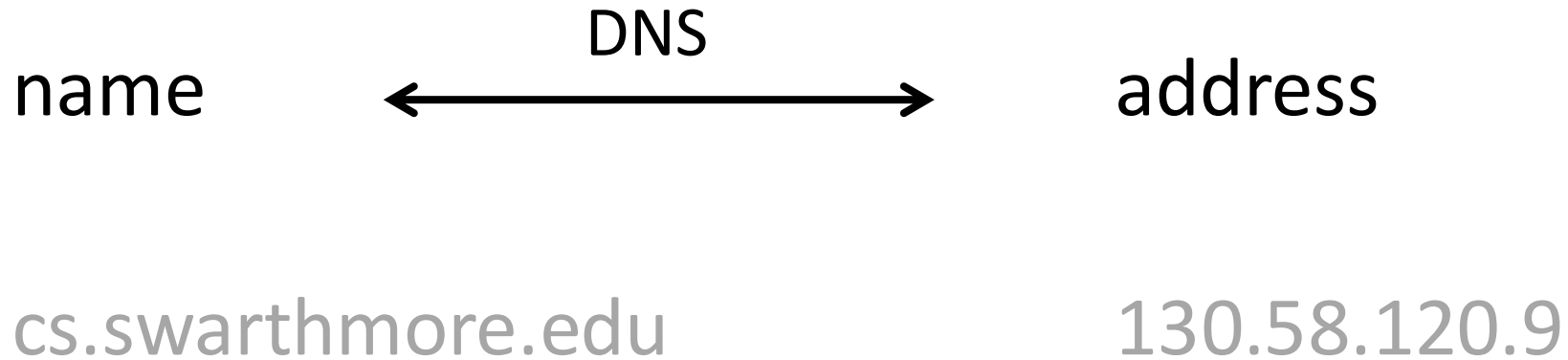
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B. No

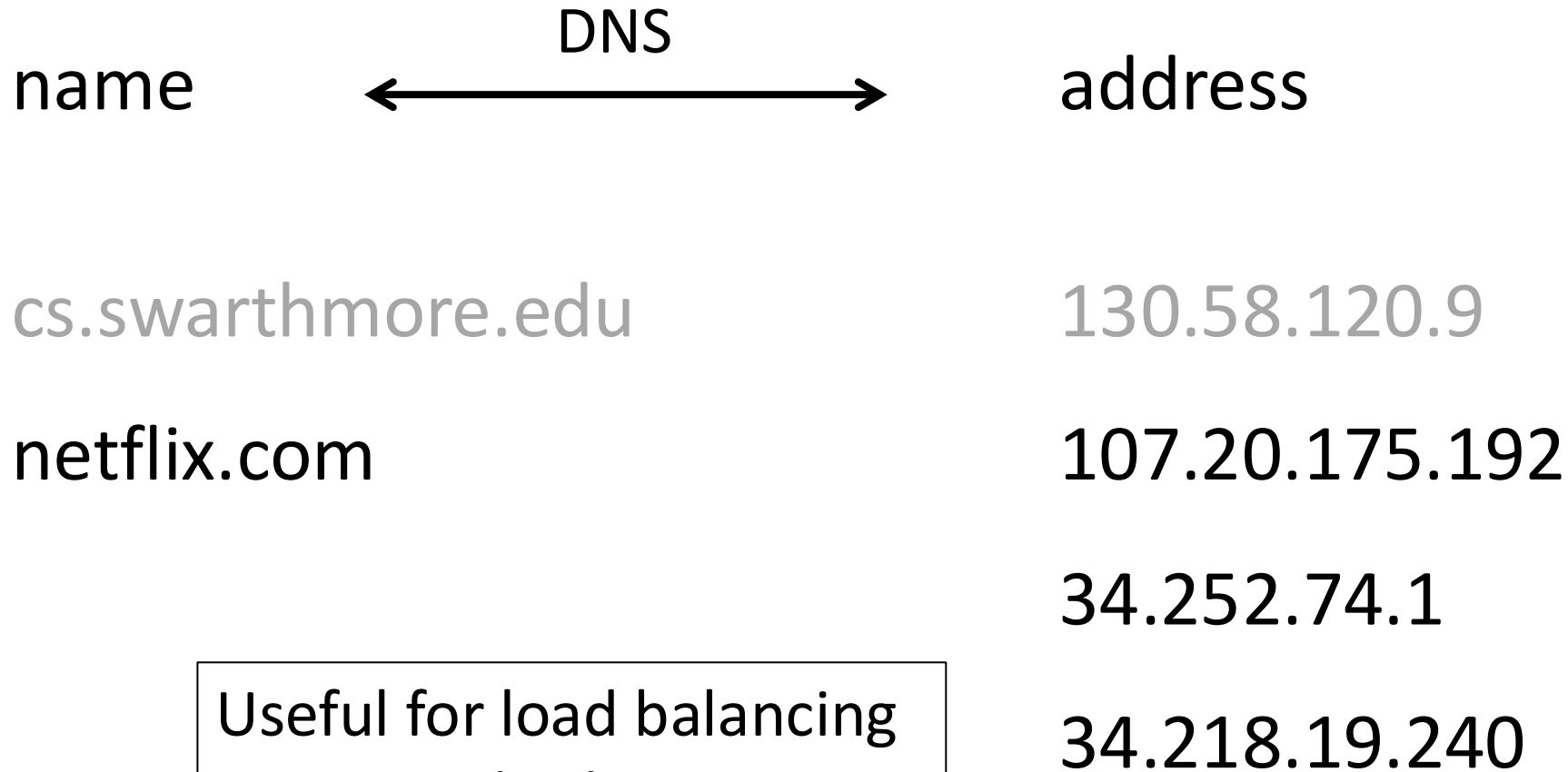
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In practice, names can be mapped to more than one IP



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Useful for load balancing
across multiple servers.

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name ↔ DNS

address

The same IP addresses can also map to different names!

cs.swarthmore.edu

130.58.120.9

netflix.com

107.20.175.192

34.252.74.1

34.218.19.240

Useful for load balancing
across multiple servers.

What's the biggest challenge for DNS?

- A. It's old.
- B. The fact that the Internet is global.
- C. The fact that DNS is now critical infrastructure.
- D. The sheer number of name lookups happening at any given time.
- E. How and when the name -> IP address mapping should change.

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In the old days...

- Pre-1982, everyone downloads a “hosts.txt” file from SRI
- Pre-1998, Jon Postel, researcher at USC, runs the **Internet Assigned Numbers Authority (IANA)**
 - RFCs 882 & 883 in 1983
 - RFCs 1034 & 1035 in 1987



Emailed 8/12 root DNS servers, asked change to his authority. They did.

<http://www.wired.com/wiredenterprise/2012/10/joe-postel/>

Who should control DNS?

- A. US government
- B. UN / International government
- C. Private corporation
- D. Someone else

Since 1998...

- Control of Internet Assigned Numbers Authority (IANA) transferred to **Internet Corporation for Assigned Names and Numbers (ICANN)**
 - ICANN is a private non-profit (formerly) blessed by US DOC
 - Global advisory committee for dealing with international issues
 - 2000's: Many efforts for UN control, US resisted
 - 2016: ICANN no longer partnered with DOC

DNS Root Server and Politics



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REVOKE .RU DOMAIN, UKRAINE SAYS —

Ukraine asks ICANN to revoke Russian domains and shut down DNS root servers

Expert: Cutting DNS links would harm Russian people but have little impact on gov't.

JON BRODKIN - 3/2/2022, 2:33 PM



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THE INTERNET MUST KEEP WORKING —

ICANN won't revoke Russian Internet domains, says effect would be "devastating"

ICANN's mission: Make sure the Internet works "regardless of the provocations."

JON BRODKIN - 3/4/2022, 1:13 PM