China Communications

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Chapter 3:
Computer Networks

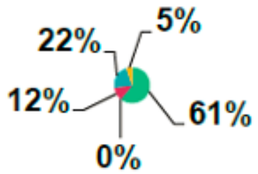
Internet

An example of computer networks

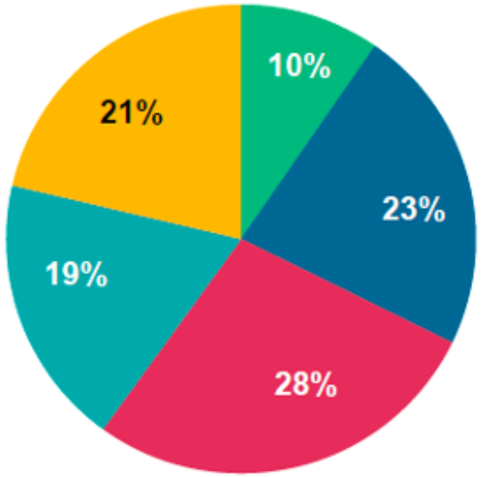
- Internet is the most common computer networks that we use everyday.
    - It is a worldwide system of interconnected computer networks and electronic devices that communicate with each other using an established set of protocols

The Increase of the Internet

1995
35MM+ Internet Users
0.6% Population Penetration



2014
2.8B Internet Users
39% Population Penetration



USA China Asia (ex. China) Europe Rest of World

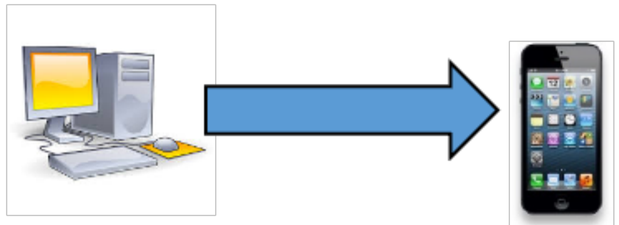
2020

4.8B users

(61% of the world's population)

https://www.broadbandsearch.net/blog/internet-statistics

The Evolvement of the Internet



1992 ftp Web email

1996 chat Games IM Yahoo!

2000 news Blog Search

2004 Music itunes Games search

2008 Wikipedia Craiglist Youtube

2010-2020

2020--

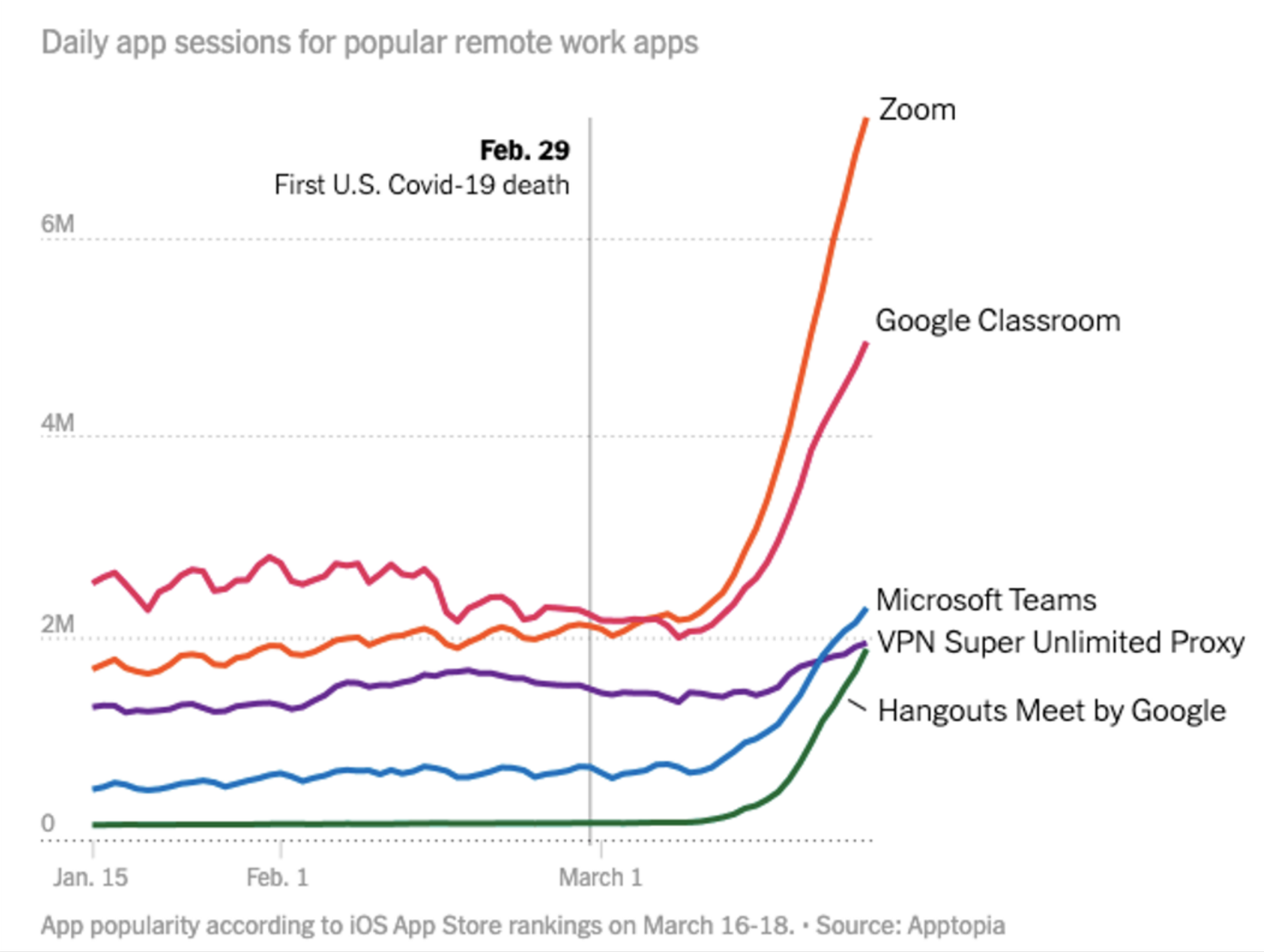
Text content

Multimedia content (Figs)

Multimedia content (videos)

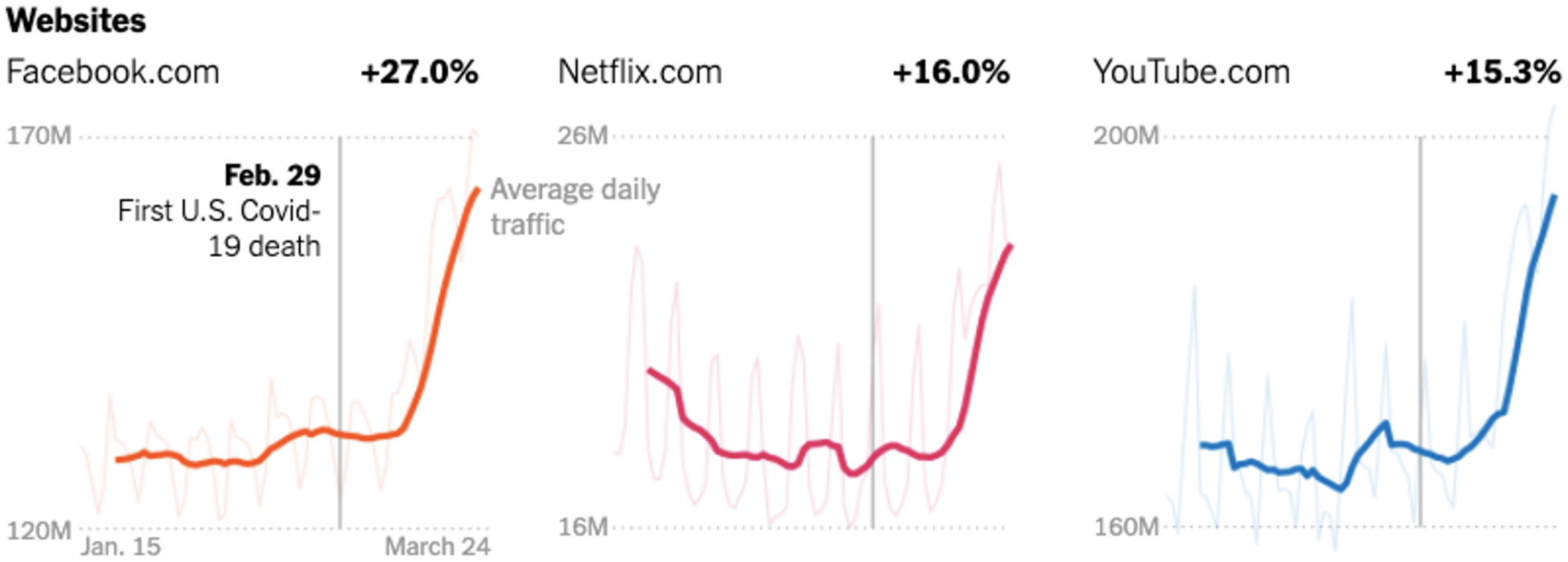
the Metaverse

We Relied on the Internet to Work



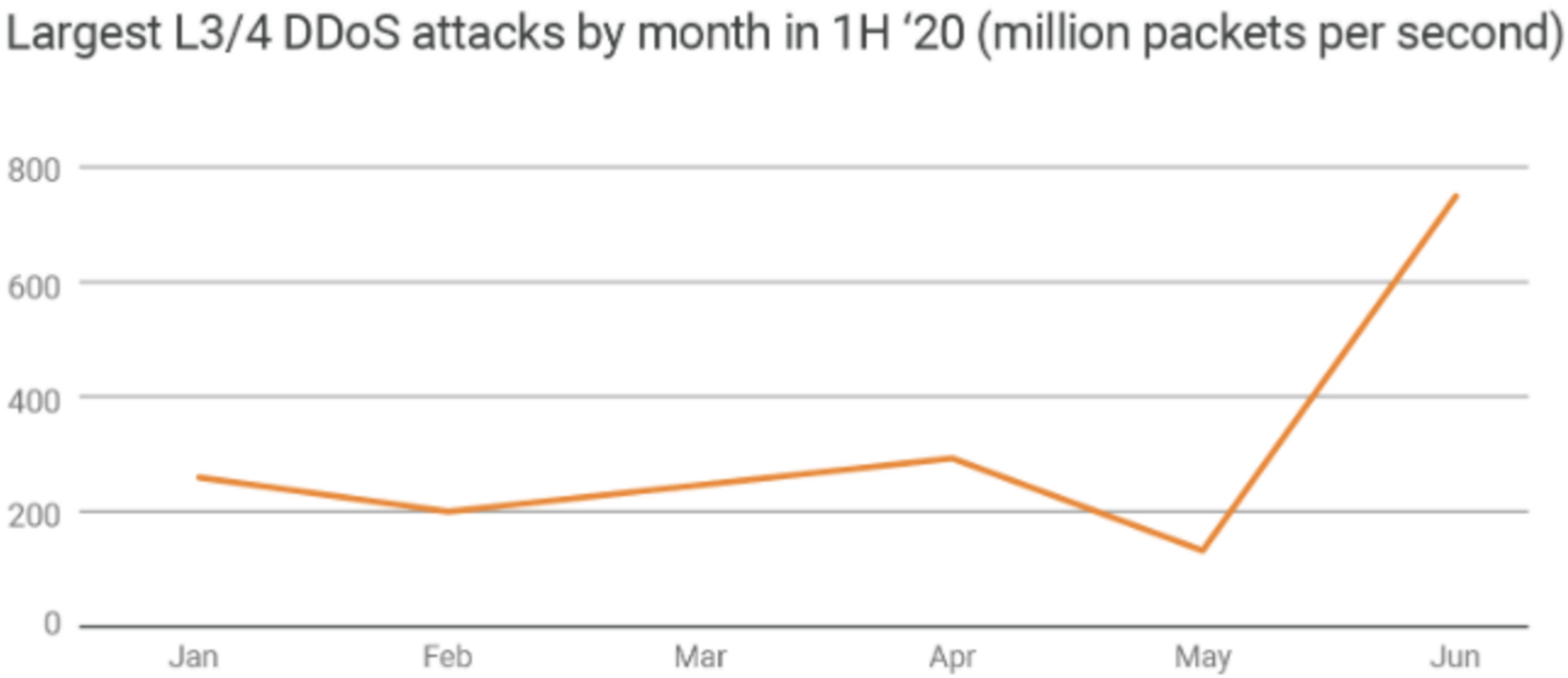
Data shows number of daily sessions in the US over a period in 2020.
Source: nytimes

We Relied on the Internet to “play”!



Data shows number of daily sessions in the US over a period in 2020. Source: nytimes

Threats on the Internet Are Growing, too



Source:
CloudFlare
blog

CLOUDFLARE

What is a Computer Network

Definition

- A computer network is a collection of interconnected devices that communicate with each other to share resources and information.

- Key components:
  - Link
    - Communication links for transmission
  - Host/Endpoint
    - Computer running applications of end user
  - Router
    - Computer for routing packets from input link to another output link
  - Network
    - A group of hosts, links, routers capable of sending packets among its members

Types of Computer Networks

Based on coverage

- PAN (Personal Area Network)
- LAN (Local Area Network)
- MAN (Metropolitan Area Network)
- WAN (Wide Area Network)

Types of Computer Networks

Based on transmission medium

- Wired networks:
  - copper wire, lasers over optic fiber, coax cables
- Wireless networks:
  - Wi-Fi, bluetooth

In General, Networks Give No Guarantees

Best effort

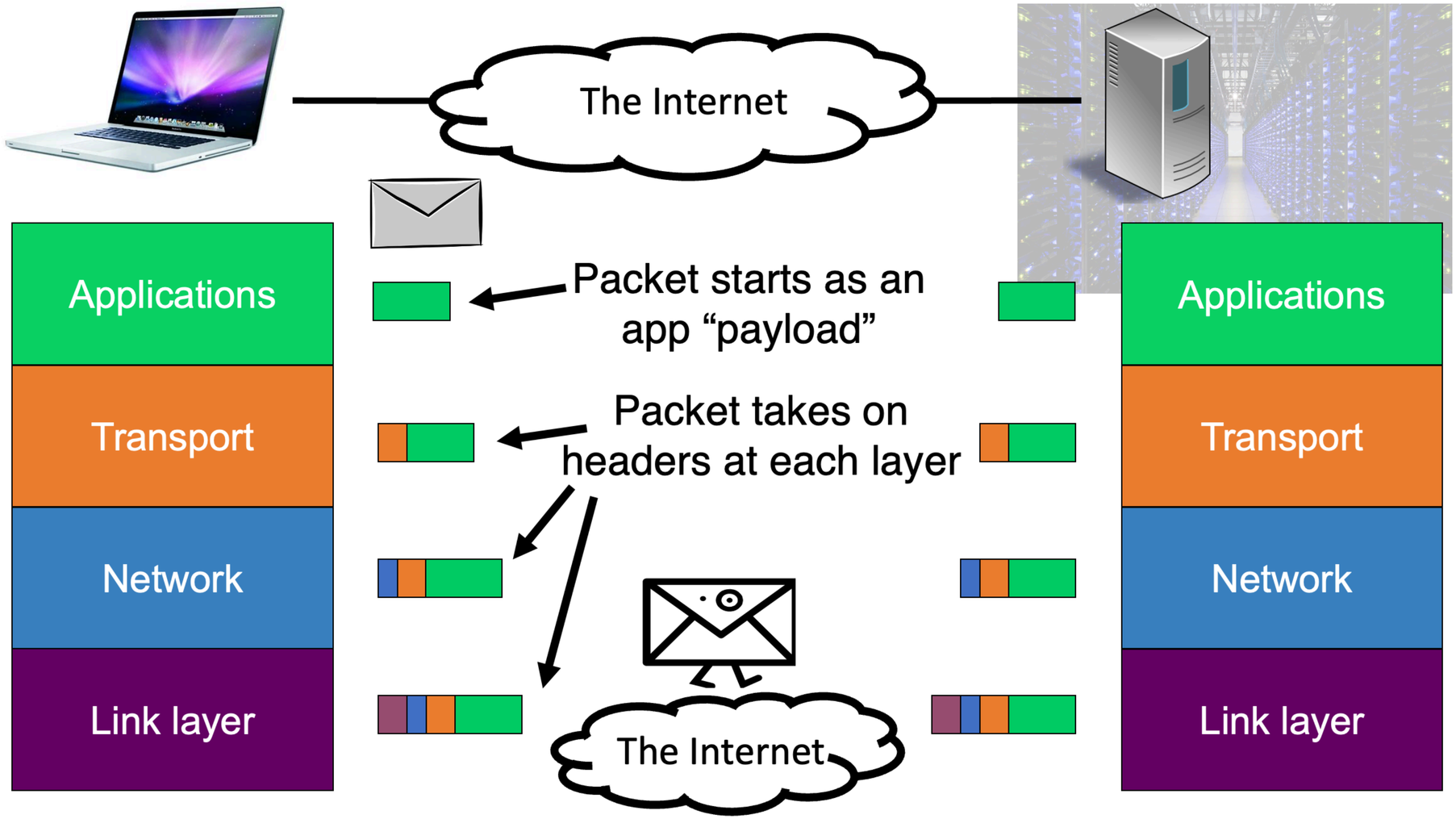
- Packets may be lost, corrupted, reordered, on the way to the destination.
  - Best effort delivery
- Advantage: The network becomes very simple to build.
  - Don’t have to make it reliable
  - Don’t need to implement any performance guarantees
  - Don’t need to maintain packet ordering
  - Almost any medium can deliver individual packets

Network Protocols

- What are protocols?
  - Rules and conventions for communication in a network
- Common protocols:
  - TCP/IP: fundamental protocol suite for the Internet and most networks
  - HTTP: protocol for transferring web pages
  - FTP: file transfer protocol for exchanging files
  - SMTP: protocol for sending email

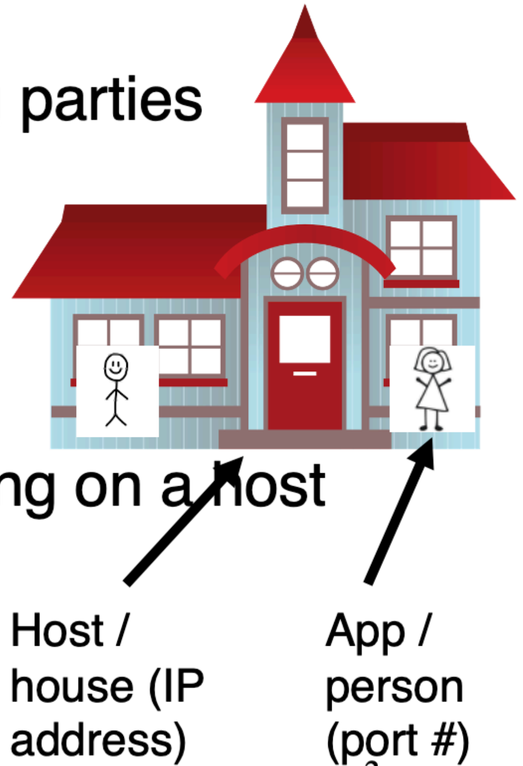
TCP/IP Model

Overview of TCP/IP layers



Application Addressing

- We usually think of an application executing on a single endpoint
- However, applications can reside on, say, 2 different endpoints connected by a network
- In order to communicate, need to identify the communicating parties
  - Telephone network: phone number (10 digits)
- Computer network: IP address
  - IPv4 (32 bits) 128.6.24.78
  - IPv6 (128 bits) 2001:4000:A000:C000:6000:B001:412A:8000
- Suppose there is more than one networked program executing on a host
  - In addition to host address, we need one more address
  - "Which Program to talk to?"
- Identity for an application: port number + IP addr



Why IPv6?

Why do we need IPv6

- IPv4 exhaustion: The number of available IPv4 addresses is running out (limited to 4.3 billion addresses).
- IoT growth: The increasing number of devices that need unique IP address, such as smart home devices and autonomous vehicles.
- Improved security: IPv6 has built-in features such as IPsec for better security in communication.

IPv6

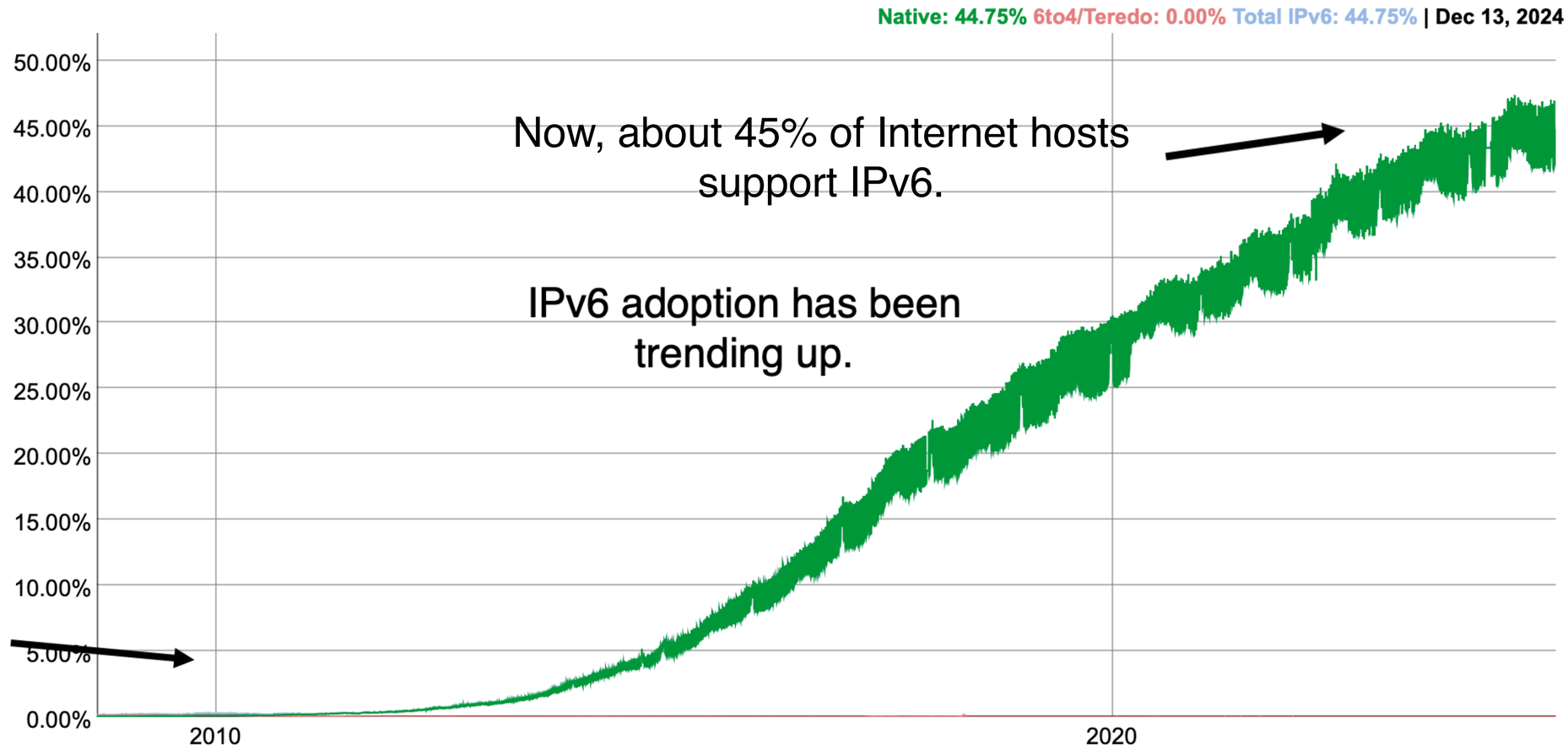
The next generation of IP addressing

- Large address space: 128-bit addresses (16 bytes)
  - Allows up to 3.4 x 10^{38} unique addresses
- Fixed length headers (40 bytes)
  - Improves the speed of packet processing in routers
  - IPv6 options processing happens through a separate mechanism: using the field corresponding to the upper-layer protocol
- New control message protocol: ICMPv6

IPv6 Adoption

When IP became a mainstream network-layer protocol, IPv4 was baked into router hardware.

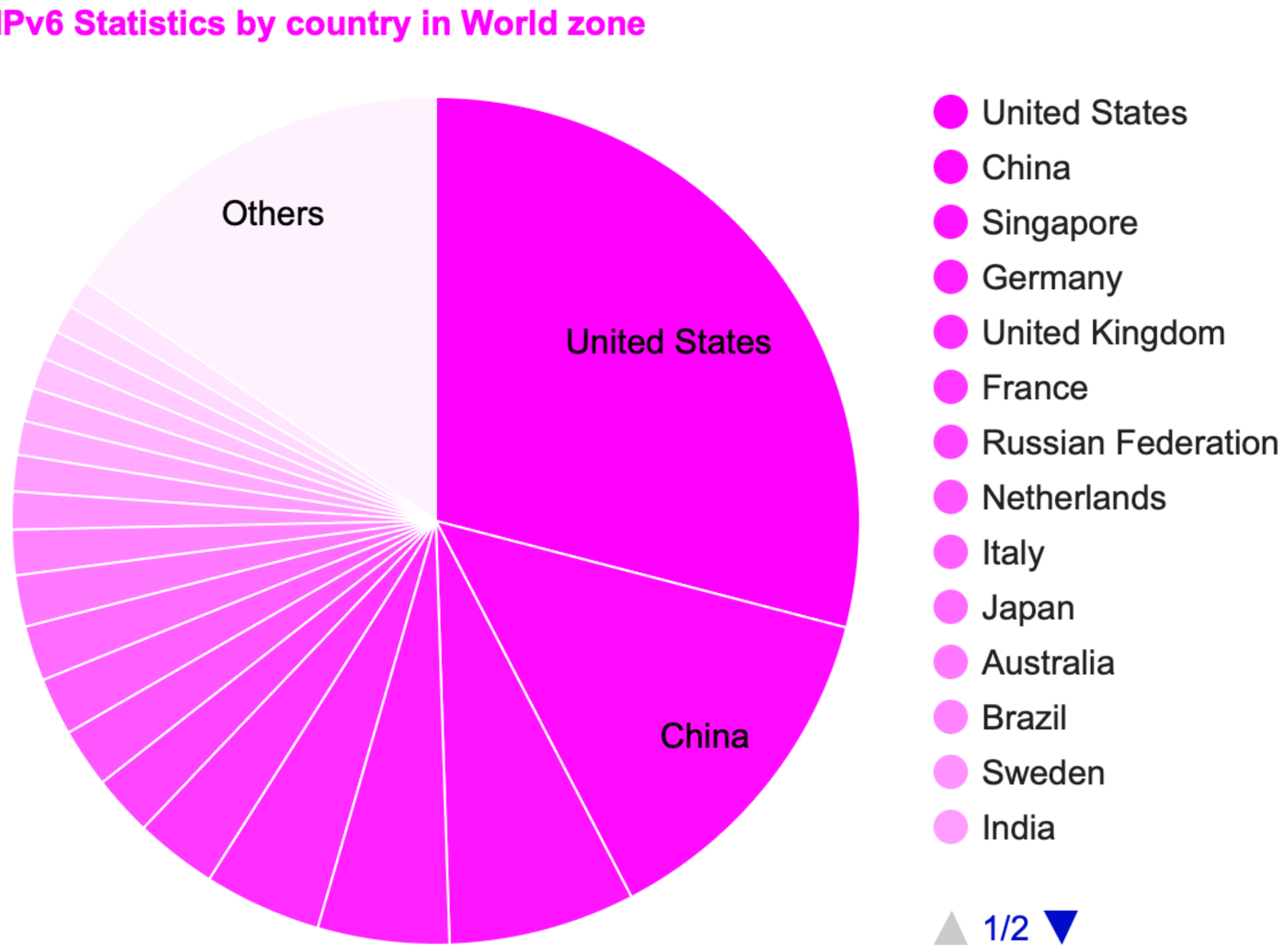
~0% of Internet hosts used IPv6 for a long time (about 30 years)



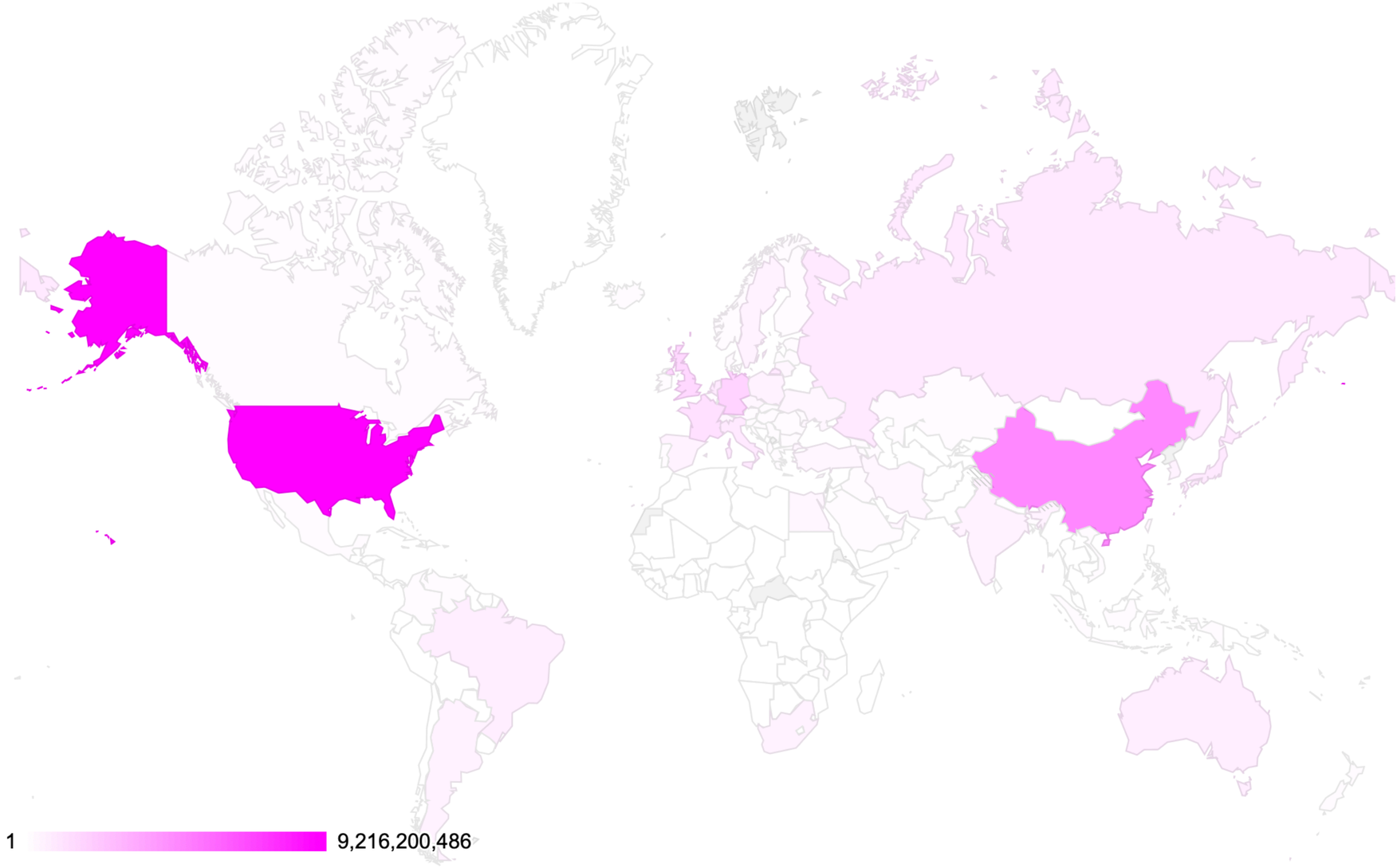
IPv6 Deployment

- China showcased CNGI's IPv6 infrastructure during the 2008 Summer Olympics, being the first time a major world event has had a presence on the IPv6 Internet.

IPv6 Address Allocation



IPv6 Address Allocation



You have my name. Can you lookup my address?

DNS (Domin Name System)

DNS (Domin Name System)

- Problem statement:
  - Average brain can easily remember 7 digits for a few names
  - On average, IP addresses have 12 digits
  - We need an easier way to remember IP addresses

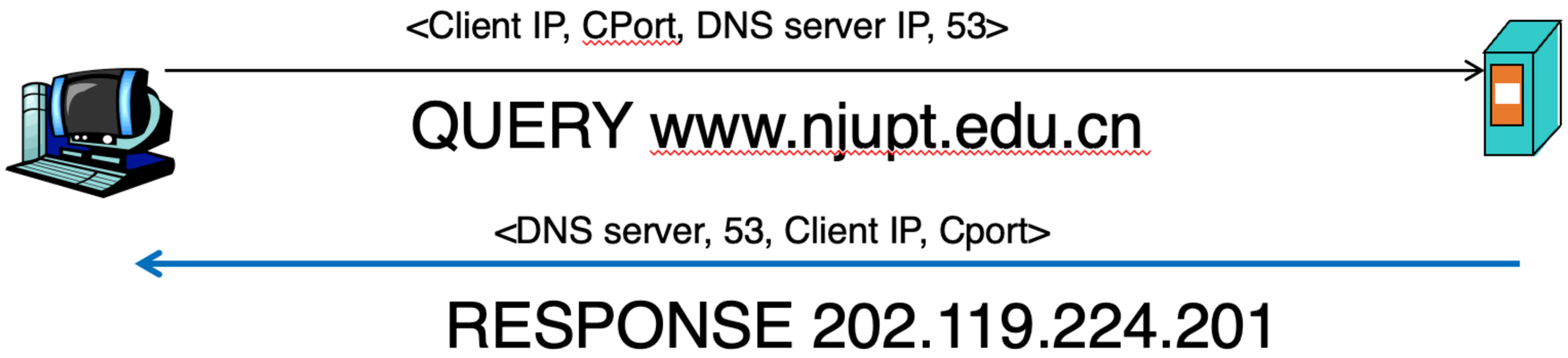
- Solution:
  - Use alphanumeric names to refer to hosts. Called host names or domain names
    - Example: cs.rutgers.edu
  - We need a directory (address book): add a service to map between alphanumeric host names and binary IP addresses
  - We call this process Address Resolution

Types of Directories

- Directories map a *name* to an *address*
- Simplistic designs
  - Central directory
  - Ask everyone (e.g., flooding)
  - Tell everyone (e.g., push to a file like /etc/hosts)
- Scalable distributed designs
  - Hierarchical namespace (e.g., Domain Name System (DNS))
  - Flat name space (e.g., Distributed Hash Table)

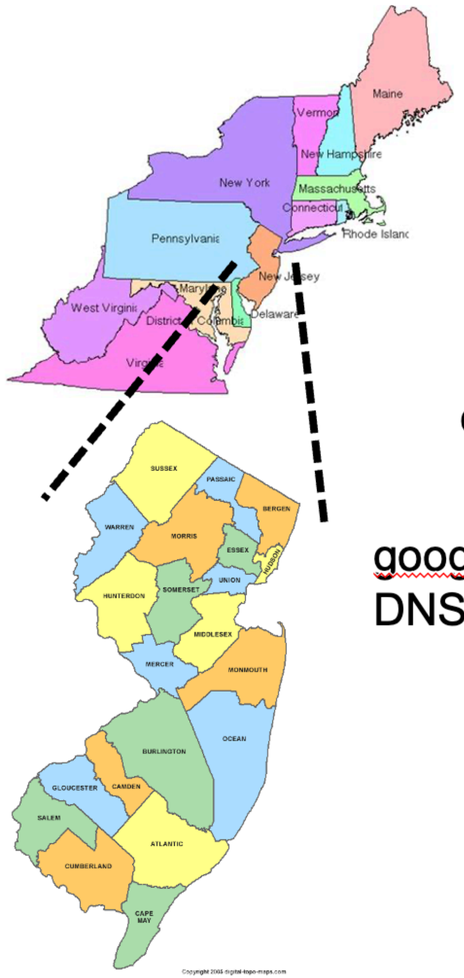
Simple DNS

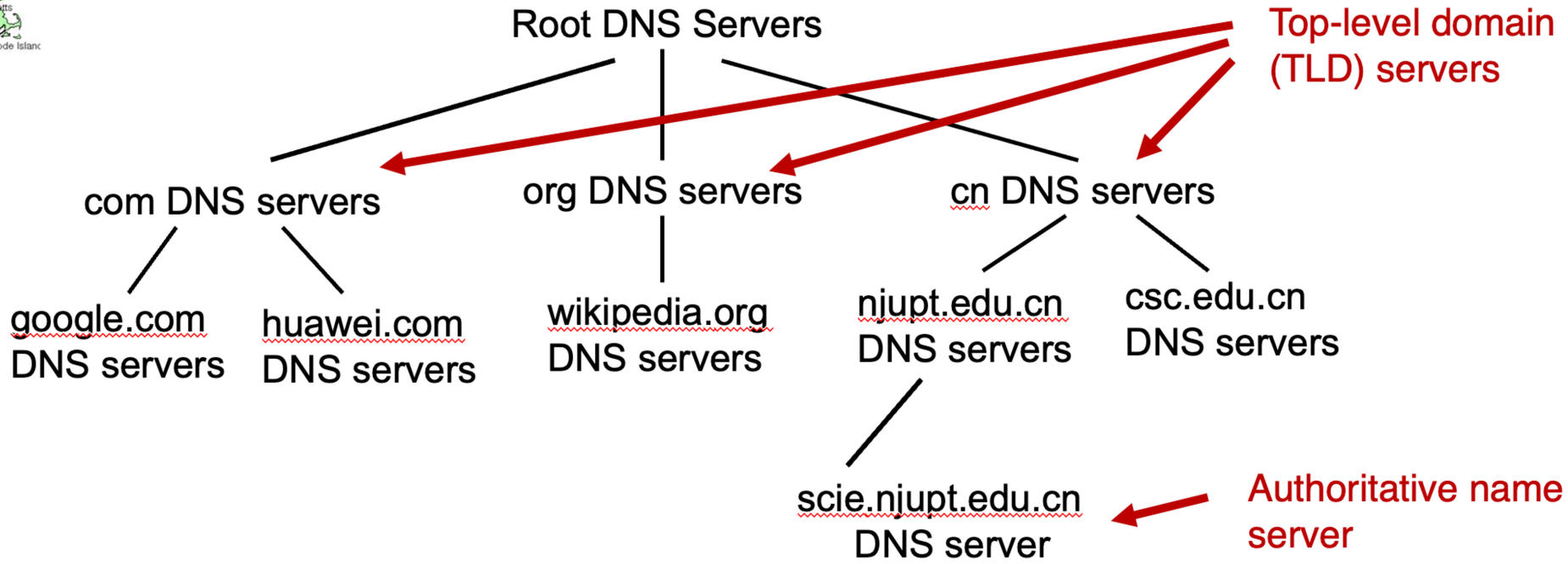
DOMAIN NAME	IP ADDRESS
spotify.com	98.138.253.109
www.njupt.edu.cn	128.6.4.2
www.google.com	74.125.225.243
www.princeton.edu	128.112.132.86



- Key idea: Implement a server that looks up a table.
- Will this scale?
  - Every new host needs to be entered in this table
  - Performance: can the server serve billions of Internet users
  - Failure: what if the server or the database crashes?
  - How to secure this server?

Distributed and Hierarchical Database





RFC 1034: Distribution through hierarchy enables scaling

DNS Protocol

How does DNS protocol works?

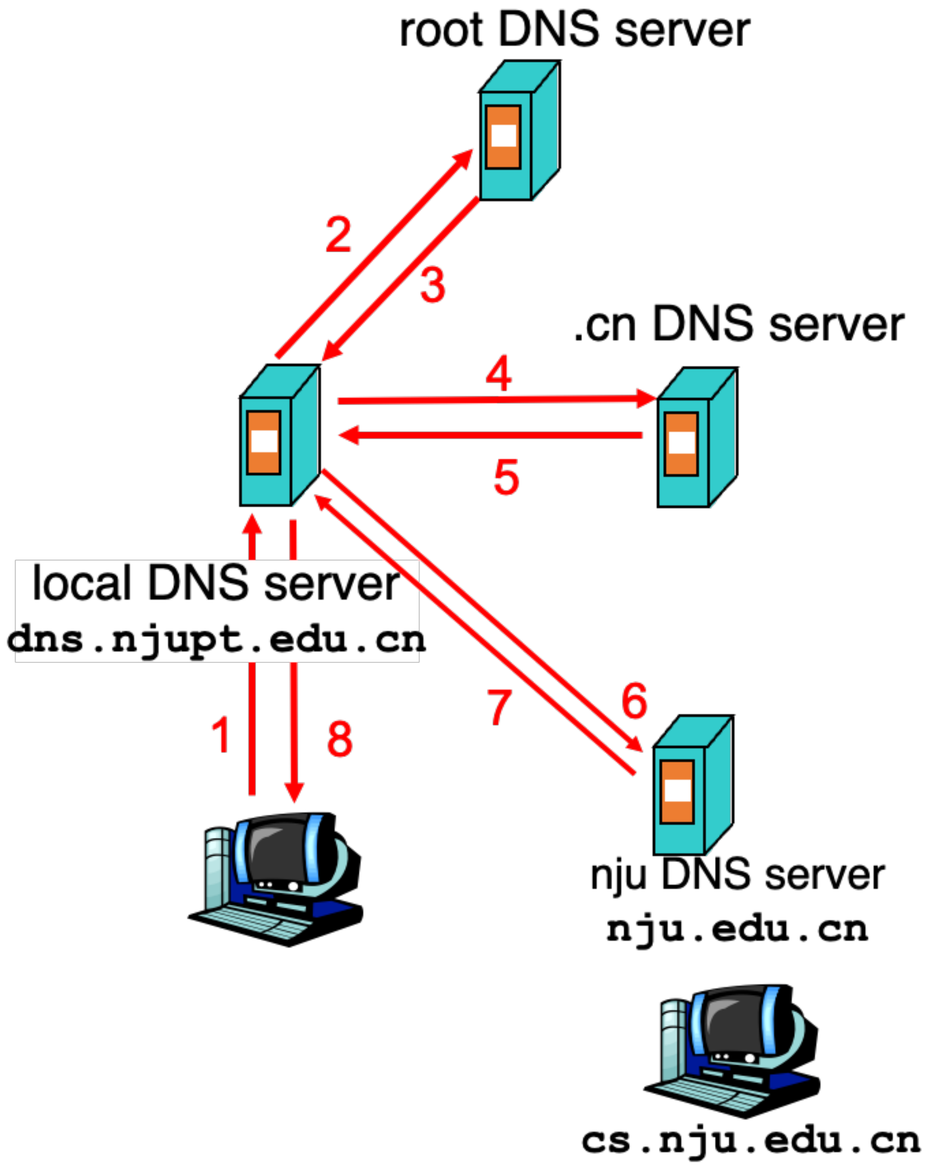
- When client wants to know an IP address for a host name
  - Client sends a DNS query to the “local” name server in its network
  - If name server contains the mapping, it returns the IP address to the client
  - Otherwise, the name server forwards the request to the root name server
  - The request works its way down the tree toward the host until it reaches a name server with the correct mapping

DNS Protocol

How does DNS protocol works?

- Host at scie.njupt.edu.cn wants IP address for cs.nju.edu.cn

- Local DNS server
- Root DNS server
- TLD (Top-Level Domain) DNS server
- Authoritative DNS server



DNS Root Server

A potential risk

- There are 13 DNS root servers, and 10 of them are deployed in U.S.
- Most of the DNS management companies are located in U.S.
- TLD .iq was removed by U.S. after the Iraq war in 2003.
  - Iraq was disappeared in the next two years in the Internet
- 82 Iran’s websites (.com) were banned by U.S in 2010.

This domain name has been seized by ICE - Homeland Security Investigations, pursuant to a seizure warrant issued by a United States District Court under the authority of 18 U.S.C. §§ 981 and 2323.

DNS Root Server

A potential risk

- China also suffered an issue:
  - All people in China lost Internet connection in 2014.
  - Because the DNS root server was attacked
    - That DNS root server was working well for other countries, but only had trouble for China.

The Solution

IPv6 DNS root server

- There 25 IPv6 DNS root servers in the world.
- They are deployed in China, U.S., India, France, Germany, Russia, Italy, Spina, Austral, Swiss, Netherland, Chile, South Africa, Australia.

The Stuxnet Virus: A Cyberweapon

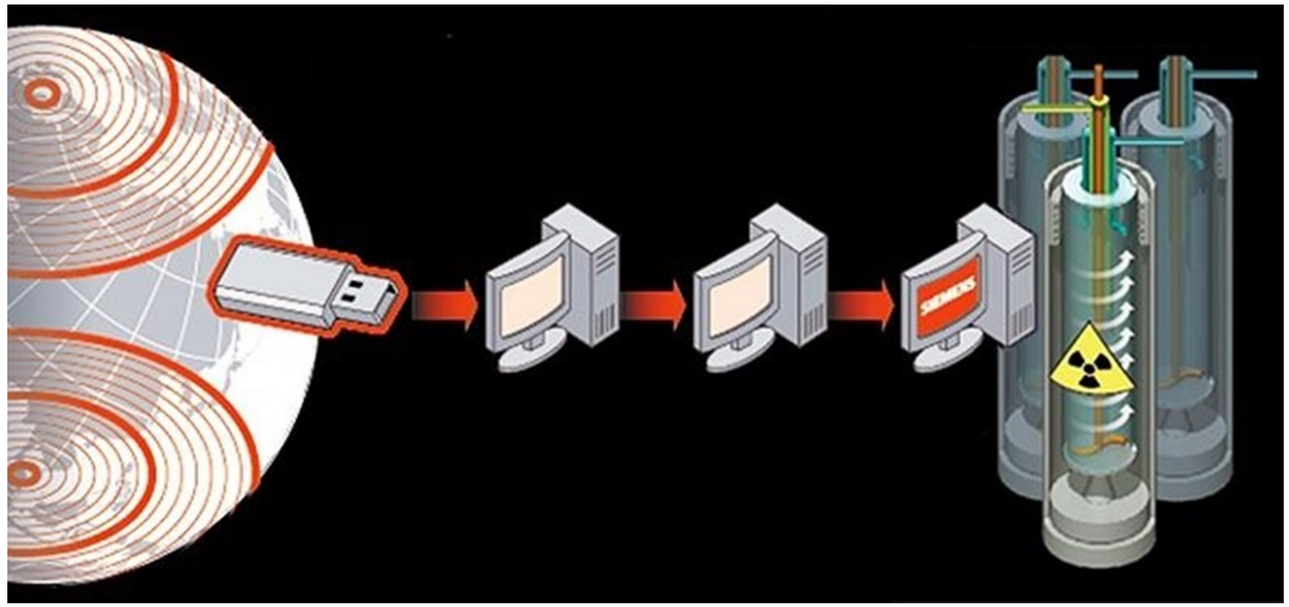
Stuxnet: A Cyberattack that Changed the World

- Stuxnet is a computer worm discovered in 2010 that targeted SCADA systems controlling industrial machinery.
- It was specifically designed to target the nuclear enrichment facilities in Iran, damaging centrifuges.
- Stuxnet is believed to be a state-sponsored cyberattack, making it one of the first known examples of cyberwarfare.

The Stuxnet Virus: A Cyberweapon

Stuxnet: A Cyberattack that Changed the World

- Infection: The worm spread via infected USB drives and targeted systems using Windows operating systems.
- Target: Specifically targeted Siemens PLCs (Programmable Logic Controllers) used in nuclear enrichment facilities.
- Payload: The worm caused the centrifuges to spin at irregular speeds, physically damaging them, while reporting normal operation data to monitoring systems.
- Stealth: The worm was designed to remain undetected by traditional security measures, using advanced techniques to hide its presence.



Thank You