

CS 470 Spring 2025

Mike Lam, Professor



Naming

Content taken from the following:

"Distributed Systems: Principles and Paradigms" by Andrew S. Tanenbaum and Maarten Van Steen (Chapter 4)

Various online sources (including openclipart.org)

Naming

- "What's in a **name**?"
 - *"That which we call a .com by any other TLD would load just as quickly."*

"There are only two hard things in Computer Science: cache invalidation and naming things."

- Phil Karlton (Netscape)



Trivia

- What is *Netscape*?
 - A. A web browser
 - B. A web directory
 - C. An internet service provider
 - D. A brand name
 - E. All of the above
 - F. None of the above

Addressing

- Concept of an **entity** and its **name** vs. its **address**
- Some names are true **identifiers**
 - Each identifier refers to at most one entity
 - Each entity is referred to by at most one identifier
 - Identifiers are never re-used at another time
- Name-to-address **binding**
 - **Name space**: domain of all possible names
 - **Static** vs. **dynamic**
 - **Central** vs. **decentralized**
 - **Name server**: central host responsible for maintaining bindings

Addressing

- Which of the following is the most **decentralized** name binding?
 - A. Mailing addresses
 - B. Discord server nicknames
 - C. Subreddits
 - D. Human nicknames
 - E. Xbox gamertags

Naming schemes

eb40af8e
c6c1904c
0eceda3e
28dec8ba
4b6683e7
88c9618b
3566223f
38b22b10

Flat

/

bin/
bash
etc/
passwd
usr/
bin/
nano
vim
lib/

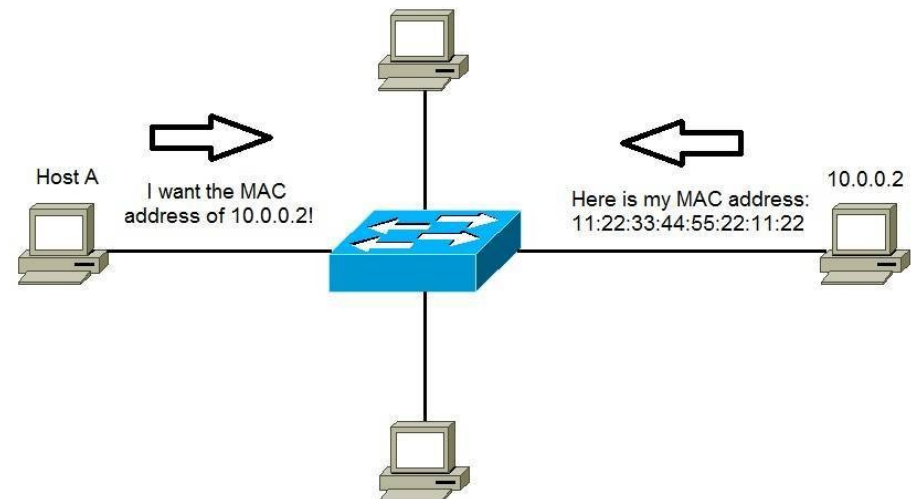
Structured

(444, Molloy)
(445, Sprague)
(456, Weikle)
(458, Heydari)
(470, Lam)
(482, Wang)

Attribute-based

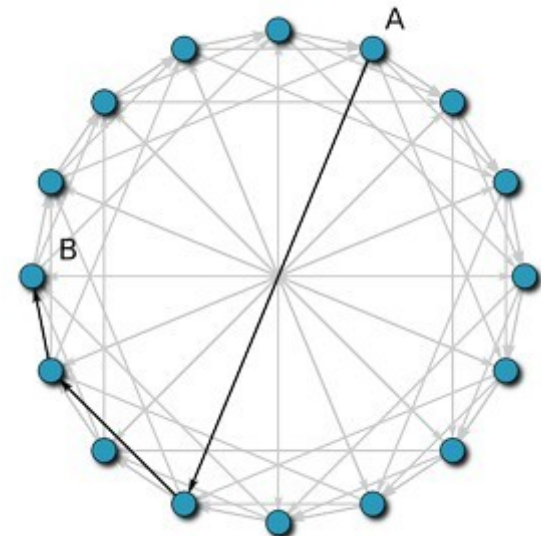
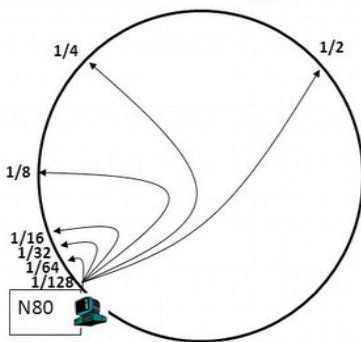
Flat naming

- Identifiers contain no location information
- Various lookup approaches
 - Broadcast / multicast
 - Forwarding pointers
 - Proximity routing
- Examples: **ARP**, **Chord**



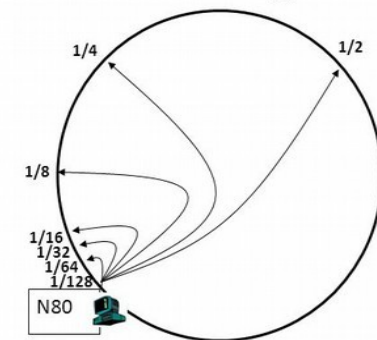
Distributed hash tables

- **Chord** uses an m-bit identifier space and modulo arithmetic
 - Key k is stored at the node with the smallest $\text{id} \geq k$
- Each node maintains a **finger table** of forward shortcuts
- To look up k, repeatedly follow lookups in finger table
 - Goal: halve distance to destination every hop



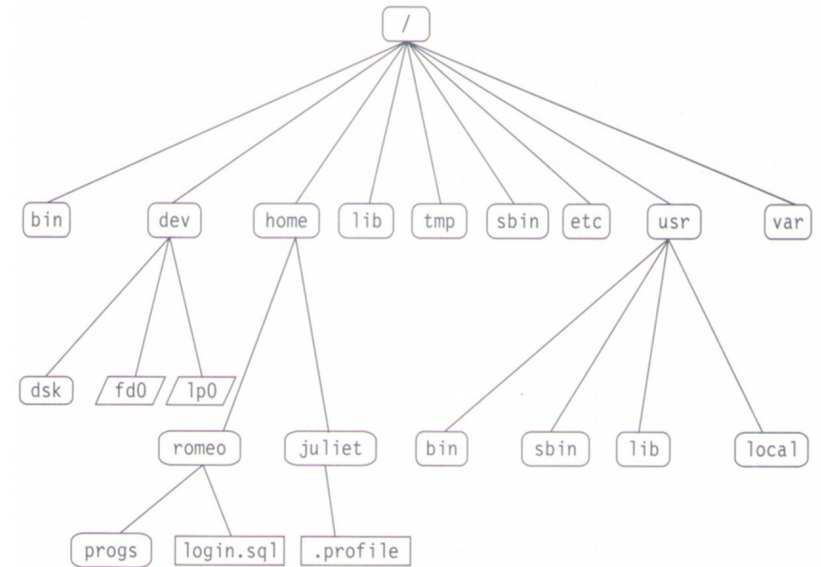
Addressing

- Which of the following is the maximum size of the finger table for a 256-node Chord network?
 - A. 0
 - B. 1
 - C. 8
 - D. 32
 - E. 128

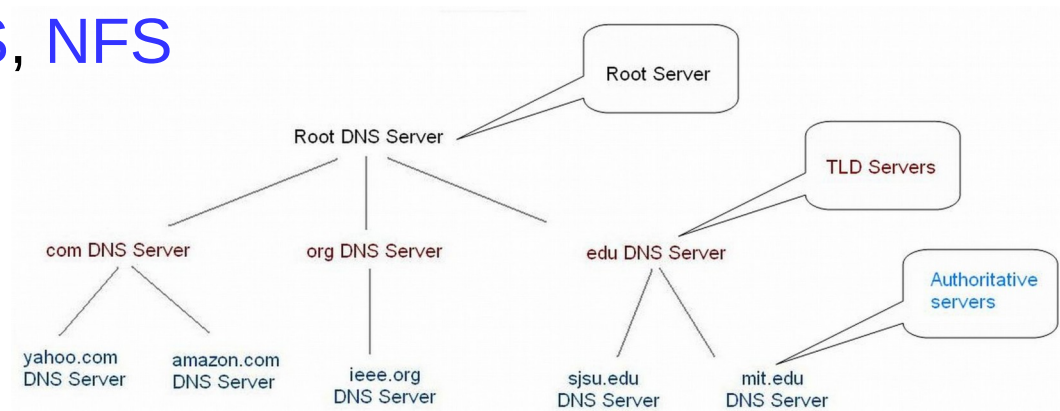


Structured naming

- **Root** vs. **interior** vs. **leaf** nodes
- **Absolute** vs. **relative** names
 - **Global** vs. **local** names
- **Iterative** vs. **recursive** resolution
- Linking and aliasing
 - **Hard** vs. **soft** (symbolic) links
- **Mounting** and **mount points**
- Examples: file systems, **DNS**, **NFS**



Filesystem	Size	Used	Avail	Use%	Mounted on
/dev/mapper/rhel_login01-root	50G	23G	28G	46%	/
/dev/sda6	497M	206M	292M	42%	/boot
nfs.cluster.cs.jmu.edu:/nfs/home	100G	4.6G	96G	5%	/nfs/home
nfs.cluster.cs.jmu.edu:/nfs/scratch	2.0T	862G	1.2T	43%	/scratch



Naming

- Which of the following is an example of a **structured** (as opposed to **flat**) name binding?
 - A. Mailing addresses
 - B. Discord server nicknames
 - C. Subreddits
 - D. Human nicknames
 - E. Xbox gamertags

IPv4

- IPv4: 32 bits - four octets w/ CIDR notation (/8, /16, etc.)
 - Classful addressing: Class A, Class B, Class C
 - IETF and IANA allocate addresses (32 bits - 4 billion total addresses)
 - Published in 1981; now nearly exhausted
- Notable networks
 - Private (10.0.0.0/8)
 - Loopback (127.0.0.0/8)
 - JMU (134.126.0.0/16)
 - Private (192.168.0.0/16)

An IPv4 address (dotted-decimal notation)

172 . 16 . 254 . 1
↓ ↓ ↓ ↓
10101100.00010000.11111110.00000001
└───┬───┬───┬───┘
One byte=Eight bits
└──────────────────┘
Thirty-two bits (4 x 8), or 4 bytes

from <https://en.wikipedia.org/wiki/IPv4>



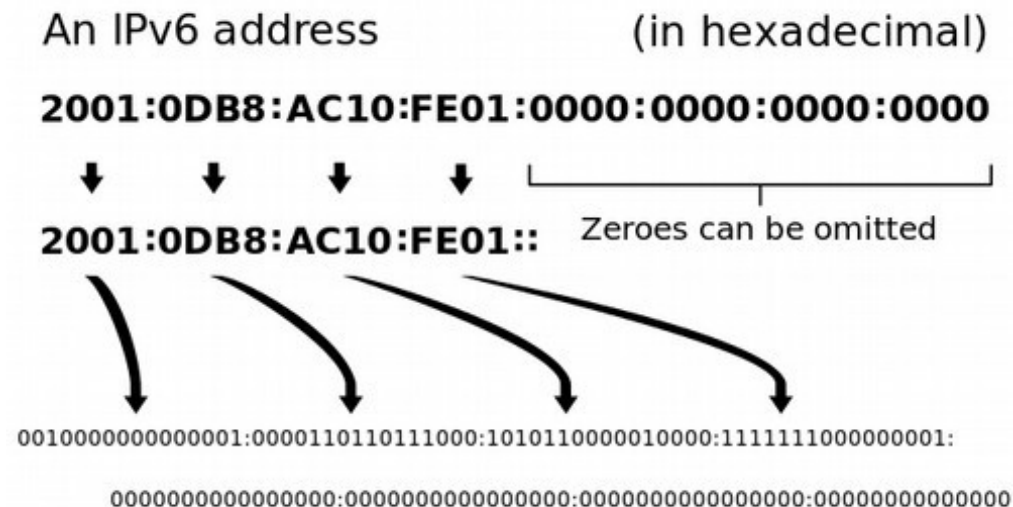
<https://xkcd.com/195/>

IPv4

- What is the total number of addresses in IPv4?
 - A. 2^8
 - B. 2^{16}
 - C. 2^{32}
 - D. 2^{64}
 - E. 2^{128}

IPv6

- **IPv6** published in 1998
 - 128 bits - 3.4×10^{38} total addresses
 - Eight groups of 16 bits (4 hex chars)
 - 64-bit routing prefix, 64-bit host/interface identifier



IPv6

- What is the total number of addresses in IPv6?
 - A. 2^8
 - B. 2^{16}
 - C. 2^{32}
 - D. 2^{64}
 - E. 2^{128}

IPv4 vs. IPv6

- The IPv6 name space is far larger than you think!
 - In fact, there is NO WAY to draw the two address spaces to scale. If IPv4 were a 1.6-inch square, IPv6 would be a square the size of the solar system!
 - $2^{128} \approx 10^{38} \gg$ the number of drops of water in all the world's oceans (10^{25}) or the number of stars in the observable universe (10^{23})
 - “If we had been assigning IPv6 addresses at a rate of 1 billion per second since the earth was formed, we would have by now used up less than one trillionth of the address space.”
 - “We could assign an IPv6 address to every atom on the surface of the earth – and have enough addresses left over for another hundred earths.”

Sources:

- <http://waitbutwhy.com/2014/11/10000000-grahams-number.html>
- http://www.tcpipguide.com/free/t_IPv6AddressSizeandAddressSpace-2.htm
- <http://www.brucebnews.com/2010/10/ipv6-and-really-large-numbers/>

Why haven't we transitioned?

- Advantages
 - Solves IP naming problem pseudo-permanently
 - Deals with explosion of **Internet of Things** (IoT) devices requiring an address
 - Increasing cost to acquire IPv4 addresses
- Obstacles
 - **Network Address Translation** (NAT) allows multiple hosts to use a single public IP address
 - IPv4 blocks have become more “fluid”
 - Lack of expertise managing multi-protocol networks

Attribute-based naming

- Human-friendly resource identifiers
- Storage of (key, value) pairs
- Often implemented with distributed hash tables
 - Centralized vs. decentralized lookups
 - You will implement this in P3!
- Semantic overlay networks
 - Nodes maintain explicit links to "semantically proximate" nodes
 - Most useful in distributed peer-to-peer networks
 - Exploit small-world effect

Attribute-based naming

- Which of the following is the best example of a **semantic overlay** network?
 - A. Mailing addresses
 - B. Discord server nicknames
 - C. Subreddits
 - D. Human nicknames
 - E. Xbox gamertags