CS 470
Spring 2018

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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."*

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

- Phil Karlton (Netscape)

Addressing

- Concept of an entity vs. its address
- 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

Naming schemes

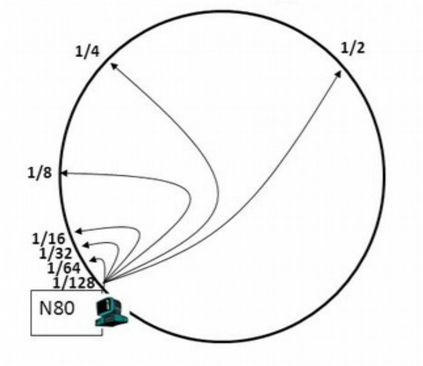
- Flat
- Structured
- Attribute-based

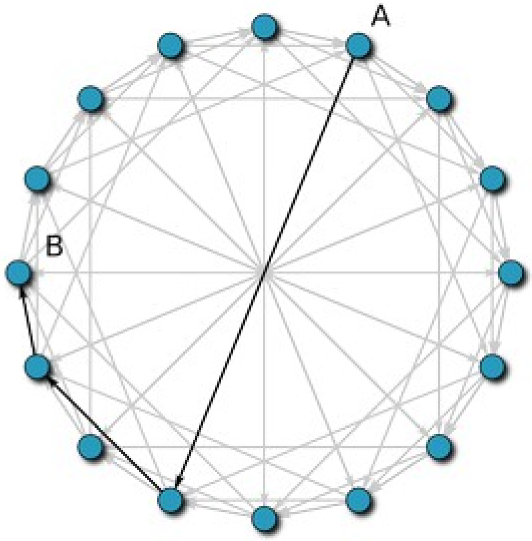
Flat naming

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

Distributed hash tables

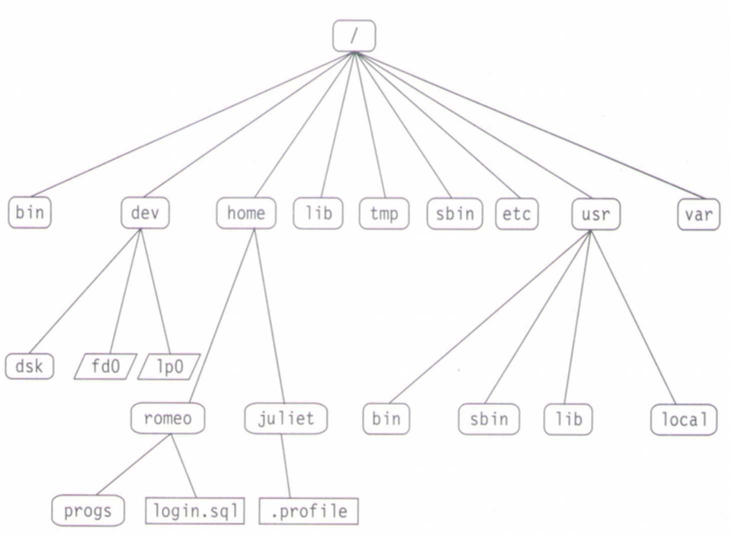
- Chord uses an m-bit identifier space and modulo arithmetic
- Key k is stored at succ(k), the node with the smallest id ≥ k
- Each node maintains a finger table of forward shortcuts
- To look up k, repeatedly follow lookups in finger table
  - Goal: halve distance to destination every hop



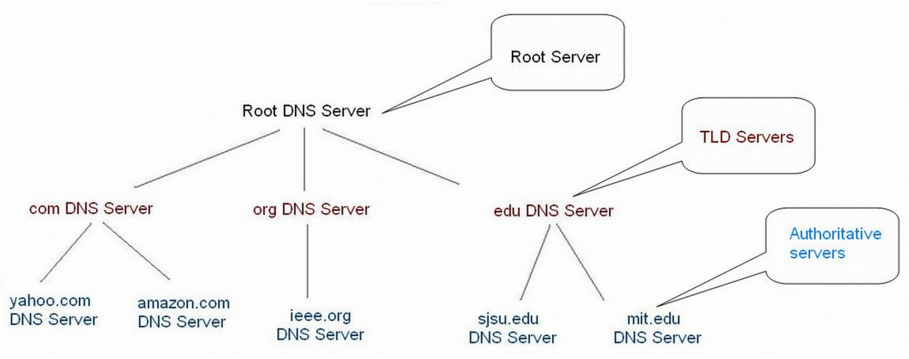


Structured naming

- Root 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

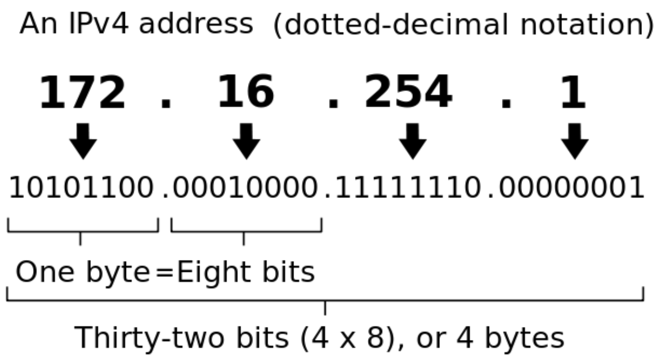


```
Filesystem                            Size  Used Avail Use% Mounted on
/dev/mapper/rhel_login01-root          50G   23G   28G  46% /
/dev/sda6                             497M  206M  292M  42% /boot
nfs.cluster.cs.jmu.edu:/nfs/home      100G  4.6G   96G   5% /nfs/home
nfs.cluster.cs.jmu.edu:/nfs/scratch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



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

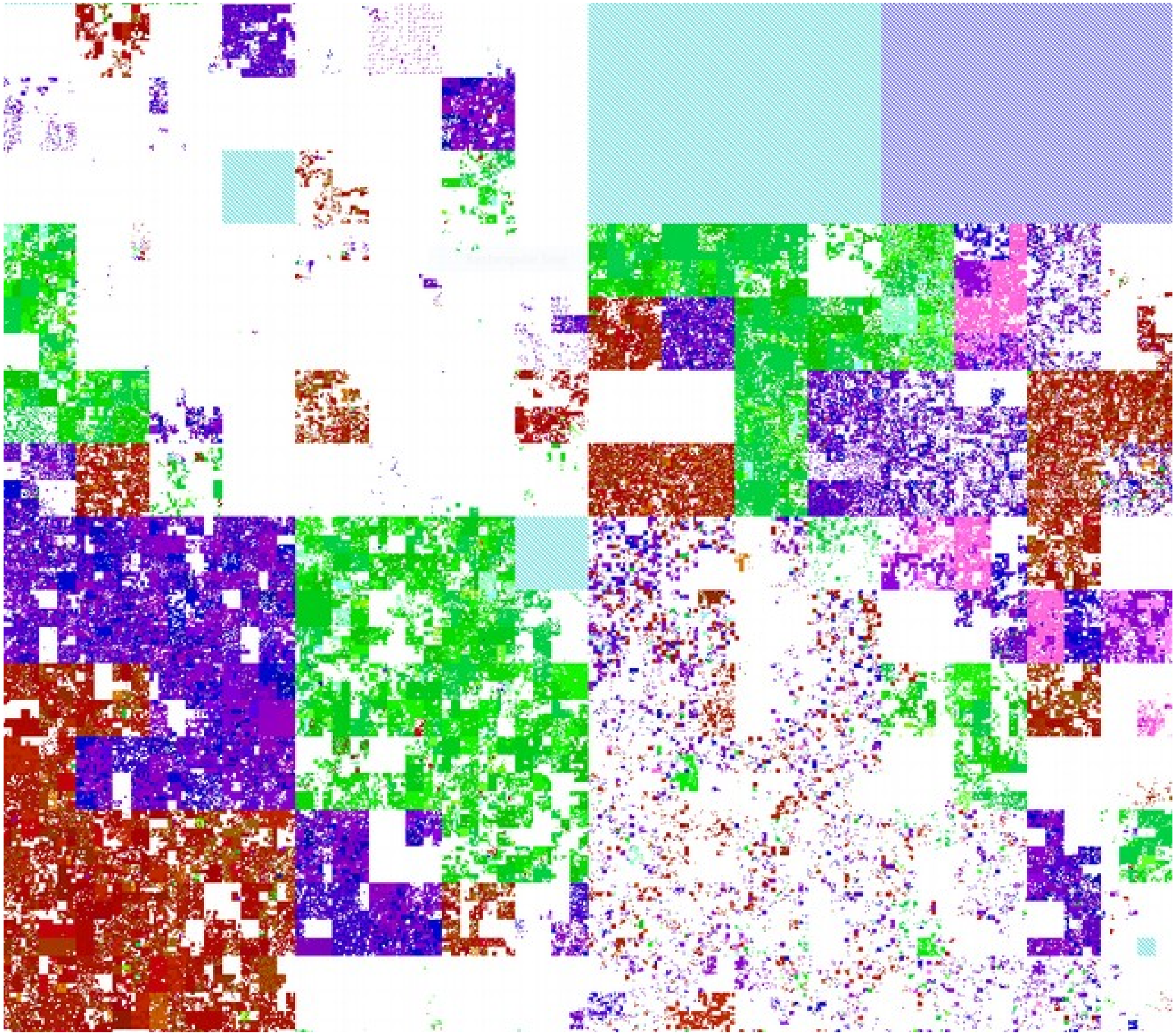
Thirty-two bits (4 x 8), or 4 bytes

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

LOCAL
GENERAL ELECTRIC
BBN INC
PUBLIC DATA NETS
HP
DEC
FORD
CSC
XEROX
BELL LABS
APPLE
MIT
BBN INC
DoD INTEL
DISA
CABLE TV
UK MoD
DISA
MULTICAST
ARMY AISC
IBM
DSI
DISA
SITA
MERC
NORSK
MERIT
USPS
BOEING
DLA
PSI
ASIA-PACIFIC
ASIA-PACIFIC
US DEPARTMENT of DEFENSE
EUROPE
NORTH AMERICA
AFRICA
NORTH AMERICA
EUROPE
ASIA-PACIFIC
EUROPE
BBN INC
INTEROP
HAM RADIO
JAPAN INET
LOOPBACK
JAPAN
VARIOUS
USA
ASIA-PACIFIC
JAPAN
LATIN AMERICA & CARIBBEAN
EUROPE (UNUSED)
CANADA
VARIOUS
NORTH AMERICA
REGISTRARS
EUROPE

https://xkcd.com/195/

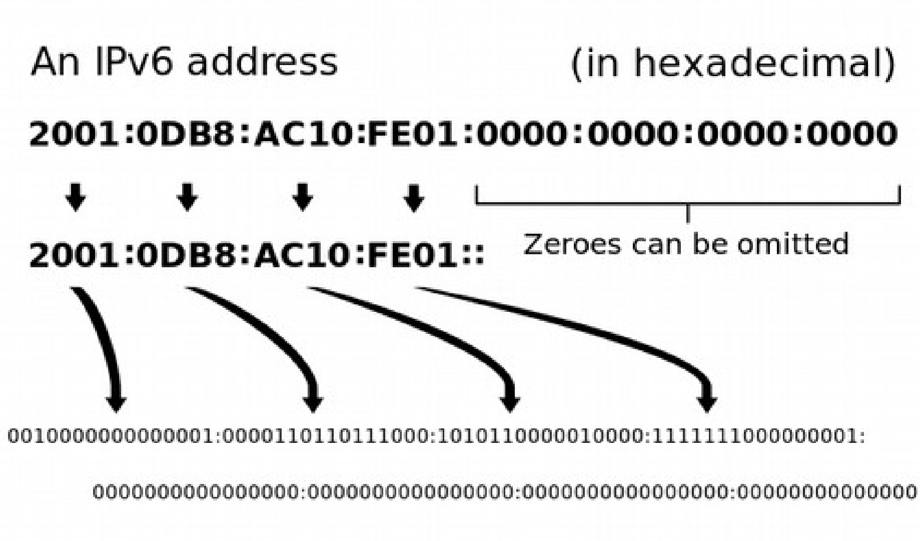
IPv4 map



from `https://ant.isi.edu/address/browse/index.html`

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
  - Slow uptake due to migration complications



from `https://en.wikipedia.org/wiki/IPv6`

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/2014/11/1000000-grahams-number.html`
- `http://www.tcpipguide.com/free/t_IPv6AddressSizeandAddressSpace-2.htm`
- `http://www.brucebnews.com/2010/10/ipv6-and-really-large-numbers/`

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 P4!
- Semantic overlay networks
  - Nodes maintain links to "semantically proximate" nodes
  - Most useful in distributed peer-to-peer networks
  - Exploit small-world effect