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. Socrative participant names
  - C. Subreddits
  - D. Human nicknames
  - E. Xbox gamertags
Naming schemes

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

Flat  Structured  Attribute-based

(444, Molloy)
(445, Sprague)
(455, Aboutabl)
(458, Heydari)
(470, Lam)
(482, Wang)
(482, Tjaden)
(488, Johnson)
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 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**

<table>
<thead>
<tr>
<th>Filesystem</th>
<th>Size</th>
<th>Used</th>
<th>Avail</th>
<th>Use%</th>
<th>Mounted on</th>
</tr>
</thead>
<tbody>
<tr>
<td>/dev/mapper/rhel_login01-root</td>
<td>50G</td>
<td>23G</td>
<td>28G</td>
<td>46%</td>
<td>/</td>
</tr>
<tr>
<td>/dev/sda6</td>
<td>497M</td>
<td>206M</td>
<td>292M</td>
<td>42%</td>
<td>/boot</td>
</tr>
<tr>
<td>nfs.cluster.cs.jmu.edu:/nfs/home</td>
<td>100G</td>
<td>4.6G</td>
<td>96G</td>
<td>5%</td>
<td>/nfs/home</td>
</tr>
<tr>
<td>nfs.cluster.cs.jmu.edu:/nfs/scratch</td>
<td>2.0T</td>
<td>862G</td>
<td>1.2T</td>
<td>43%</td>
<td>/scratch</td>
</tr>
</tbody>
</table>
Which of the following is an example of a **structured** (as opposed to **flat**) name binding?

- A. Mailing addresses
- B. Socrative participant names
- 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
IPv4 map

from https://ant.isi.edu/address/browse/index.html
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 - $3.4 \times 10^{38}$ total addresses
  - Eight groups of 16 bits (4 hex chars)
  - 64-bit routing prefix, 64-bit host/interface identifier

An IPv6 address (in hexadecimal)

```
2001:0DB8:AC10:FE01:0000:0000:0000:0000
```

Zeroes can be omitted

```
2001:0DB8:AC10:FE01::
```

from https://en.wikipedia.org/wiki/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!
  – $2^{128} \approx 10^{38}$ ≫ 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/
Why haven’t we transitioned?

• Advantages
  - Solves IP naming problem pseudo-permanently
  - Internet of Things (IoT) threatens to explode the number of 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

Informed by discussion with Mike Ripley, JMU Information Technology
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 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. Socrative participant names
  - C. Subreddits
  - D. Human nicknames
  - E. Xbox gamertags