Naming in Networking

COS 316: Principles of Computer System Design
Lecture 7

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## Network Naming

<table>
<thead>
<tr>
<th>Type of Name</th>
<th>Example</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hostname</td>
<td><a href="http://www.cs.princeton.edu">www.cs.princeton.edu</a></td>
</tr>
<tr>
<td>Internet Protocol (IP) Address</td>
<td>128.112.136.61</td>
</tr>
<tr>
<td>Media Access Control (MAC) Address</td>
<td>00:15:C5:49:04:A9</td>
</tr>
</tbody>
</table>
Internet Protocol Stack

Application
- Application Messages
  - Hostname, URL

Transport
- Reliable streams
- Datagrams
  - <More on this later>

Network
- Best-effort global packet delivery
  - IP address

Link
- Best-effort local packet delivery
  - MAC address

Physical
- Bit delivery
Internet Protocol Stack

- **Application**: Application Messages
  - Hostname, URL

- **Transport**
  - Reliable streams
  - Datagrams
  - <More on this later>

- **Network**
  - Best-effort *global* packet delivery
  - IP address

- **Link**
  - Best-effort *local* packet delivery
  - MAC address

- **Physical**
  - Bit delivery
Internet Protocol Stack

HTTP message
TCP segment

Hostname, URL
IP address
MAC address

<More later>
Internet Protocol Stack

HTTP message
TCP segment

Hostname, URL
IP address
MAC address

<More later>
MAC Layer Names for Local Packet Delivery

• What are we naming?

Values:

• Network interfaces
  • Ethernet interface
  • WiFi interface
  • ...

Names:

Allocation:

Lookup:
MAC Layer Names for Local Packet Delivery

• Who will use the names?
  Values: Network Interfaces
  • Network adaptors
    • This packet is for you.
    • Is this packet for me?

• Goals for name?
  • Fast and easy for adaptors to check

Names:
Allocation:
Lookup:
MAC Layer Names for Local Packet Delivery

• **Who will use the names?**

• **Network adaptors**
  • This packet is for you.
  • Is this packet for me?

• **Goals for name?**
  • Fast and easy for adaptors to check
  • Globally unique

• **MAC addresses are 48-bit addresses**
  • 00:15:C5:49:04:A9

Values: Network Interfaces

Names:

Allocation:

Lookup:
MAC Layer Names for Local Packet Delivery

• *Globally unique names?*

• Ask central authority for every name? ✗

• Random allocation? ✗

• Two-level allocation? ✓
  • Central authority allocates blocks to vendors
  • Vendors assigns address for its blocks
  • 00:15:C5:49:04:A9
    Dell

Values: Network Interfaces

Names: 48-bit address

Allocation:

Lookup:
MAC Layer Names for Local Packet Delivery

• *Globally unique names?*  

• Ask central authority for every name? **X**

• Random allocation? **X**

• Two-level allocation? **✓**
  • Central authority allocates blocks to vendors
  • Vendors assigns address for its blocks
  • 00:15:C5:49:04:A9
  
  **Dell**

Values: Network Interfaces

Names: 48-bit address

Allocation:

Lookup:
MAC Layer Names for Local Packet Delivery

• Lookup
  • Flood packet to all hosts in the network
  • (Optionally) learn what direction to go

Values: Network Interfaces

Names: 48-bit address

Allocation: Vendor from their assigned blocks

Lookup: Local flooding
Network Layer Names for Global Packet Delivery

• What are we naming?

Values:

• Hosts
  • My laptop
  • Zoom server
  • Your laptop
  • ...

Names:

Allocation:

Lookup:
Network Layer Names for Global Packet Delivery

- **Who will use the names?**
  - Values: Hosts

- **Routers**
  - Where is this packet headed?
  - Names:
  - Allocation:
  - Lookup:
Network Layer Names for Global Packet Delivery

• **Who will use the names?**
  - Values: Hosts

• **Routers**
  - Where is this packet headed?

• **Goals for name?**
  - Fast and easy for routers to process
  - Globally unique
  - Location-based: enable routing packets to destination

• IP addresses are 32 or 128 bit addresses
  - 128.112.7.156
Network Layer Names for Global Packet Delivery

• **Globally unique and location-based names?**
  
  Values: Hosts

• Multi-level allocation? \(\checkmark\)
  
  Names: 32 bit address

  • ICANN assigns large blocks to
  • Regional Internet registries assign sub-blocks to
  • Internet Service Providers assign addresses to
  • Hosts

  Allocation:

  • ISPs serve a group of nearby hosts
  • ISPs can route to hosts in their sub-blocks

  Lookup:
Network Layer Names for Global Packet Delivery

• *How to map 128.112.7.156 to host?*

• Network Routing!
  • Can’t get all the way there right away, so figure out next hop: use routing table
  • Routing protocols map destination to next-hop IP address (fill in routing table)
    • BGP, OSPF, RIP, ...
  • ARP maps next-hop IP address to MAC address

  **Values:** Hosts

  **Names:** 32 bit address

  **Allocation:** Multi-level, location-based

  **Lookup:**
Network Layer Names for Global Packet Delivery

• ARP: Address Resolution Protocol briefly
  • Broadcast Request: Who has 128.112.7.156?
  • Broadcast Response: 00:15:C5:49:04:A9 has 128.112.7.156
  • Hosts cache responses, lookup in local table

Values: Hosts

Names: 32 bit address

Allocation: Multi-level, location-based

Lookup: Routing table for next-hop IP; ARP next-hop IP -> MAC address
Host Names for Applications {Websites}

• *What are we naming?*

Values:

• Hosts
  • CS department webserver
  • COS316 webserver
  • ...

Names:

Allocation:

Lookup:
Host Names for Applications {Websites}

• Who will use the names?  
  Values: Hosts

• People  

• Goals for name?
  • Memorable  
  • Reflect organizational hierarchical  
    • e.g., educational?, princeton?

• Hostnames are variable length, hierarchical strings  
  • www.cs.princeton.edu vs cos316.princeton.edu  

Names:

Allocation:

Lookup:
Host Names for Applications {Websites}

- *Globally unique and organizational-hierarchy-based names?*

- Multi-level allocation? √
  - IANA assigns top-level domains
    - .com, .edu, ...
  - Registries assigns second-level domains
    - princeton.edu
  - Organizations assign subdomains
    - cs.princeton.edu OR cos316.princeton.edu
  - And so on...
    - www.cs.princeton.edu

**Values:** Hosts

**Names:** hierarchical variable-length strings

**Allocation:**

**Lookup:**
Host Names for Applications {Websites}

• *How to map cos316.princeton.edu to host?*

• Map to IP address, give to networking layer
  • Domain Name System (DNS) maps a hostname to an IP address

**Values:** Hosts

**Names:** hierarchical variable-length strings

**Allocation:** Multi-level, organization based

**Lookup:** DNS maps hostname to IP
Host Names for Applications {Websites}

• How to map cos316.princeton.edu to host?
  • Map to IP address, give to networking layer
    • Domain Name System (DNS) maps a hostname to an IP address

Values: Hosts

Names: hierarchical variable-length strings

Allocation: Multi-level, organization based

Lookup: DNS maps hostname to IP
Different Layers, Different Names

- **Host name** (e.g., www.cs.princeton.edu)
  - Mnemonic, variable-length, appreciated by humans
  - Hierarchical, based on organizations

- **IP address** (e.g., 128.112.136.61)
  - Numerical 32-bit address appreciated by routers
  - Hierarchical, based on organizations and location

- **MAC address** (e.g., 00:15:C5:49:04:A9)
  - Numerical 48-bit address appreciated by adapters
  - Hierarchical, based on vendors, unrelated to location
Hierarchical Allocation Processes

- **Host name**: www.cs.princeton.edu
  - **Domain**: registries for each top-level domain (e.g., .edu)
  - **Host name**: local administrator assigns to each host

- **IP addresses**: 128.112.136.61
  - **Prefixes**: ICANN, regional Internet registries, and ISPs
  - **Hosts**: static configuration, or dynamic using DHCP

- **MAC addresses**: 00:15:C5:49:04:A9
  - **Blocks**: assigned to equipment vendors by the IEEE
  - **Adapters**: assigned by the vendor from its block
Different Layers, Different Lookup Protocols

• Host name -> IP address via Domain Name System (DNS)
• Destination IP address to next-hop address via routing table (populated by network routing protocols)
• Next-hop IP address to MAC address via ARP
• MAC address to network interface via local flooding (or learning)
Network Naming Conclusion

• Network names identify remote endpoints

• Different layers, different names
  • Who will use the name?

• Multi-level hierarchical allocation
  • Goals: Unique √, reflect organizations √, location-based?

• Different layers, different lookup protocols
  • We covered ARP, COS 461 covers them all 😊

• More on network layers in a few weeks