POGIL-CSP: Internet III: What is an Address?

(15 min) A. Identification	start time:

1. In the US, every citizen has a unique **Social Security Number (SSN)**. Historically, the first 3 digits are the **area number**, for the local Social Security Office, the next 2 digits are the **group number**, and the last 4 digits are the **Serial Numbe**r. Consider this sample SSN: 987-65-4321 (reserved for advertising). What is the:

a.	area number?	
b.	group number?	
c.	serial number?	

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Similarly, on the Internet, every device (including laptops, phones, routers, etc) has a unique **Media Access Control (MAC) address**. Each MAC address is **48 bits**, so there are 2^{48} = 281,474,976,710,656 (≈ 280 x 10^{12}) possible addresses, usually written as 6 pairs of **hexadecimal digits** (0-9,A-F):

00:21:5C:98:FD:19

The first 3 pairs are the **Organizationally Unique Identifier (OUI)**, assigned to a device manfacturer, which then assigns MAC addresses to individual devices.

00:00:00 Xerox Corporation	00:21:1B Cisco Systems, Inc.
00:00:0C Cisco Systems, Inc.	00:21:5C Intel Corporate
00:00:6D Cray Communications, Ltd.	00:21:70 Dell Inc.

2. For MAC address 00:21:5C:98:FD:19, what is the OUI and the organization?

3. If you have Internet access, choose several devices from different manufacturers, try to find their MAC addresses, and look up their OUIs online.
(You could use http://www.macvendors.com or http://www.macaddresslookup.org).
What do you find? Describe any surprises.

4. Does a person's SSN or a device's MAC address tell us where they are right now or how to reach them? Explain.

5. Different techniques are used to represent **locations**. For example, many countries assign unique labels to locations with **postal codes** (e.g. the US ZIP code, for Zone Improvement Plan). How might postal codes improve mail delivery?

6. Why are **longer** postal codes (e.g. 9 digits rather than 5 digit) better?

(15 min) B. Location	start time:

On the Internet, most devices have a MAC address (assigned by the manufacturer), and an **Internet Protocol (IP) address** (assigned by location).
In IP version 4 (IPv4, introduced in 1980), each address is 32 bits, so there are 2^{32} = 4,294,967,296 (≈ $4x10^9$) possible IPv4 addresses. An IP address is written as a **dotted quad** - 4 numbers (each from 1-255) separated by dots. For example:

192.168.1.1

Usually an **Internet service provider** (ISP) receives a range of IP addresses which start with a common bit sequence, and then assigns values or subranges to its clients. For example, the 255 addresses starting with 192.168.1 are for private networks.

1. If you have Internet access, choose several devices from different manufacturers, and try to find their IP addresses. What do you find? Are they on the same networks? Describe any surprises.

2. In 2014 there were 7,000,000,000 ($7x10^9$) people in the world (although not all have Internet devices). What do you think people mean by **IPv4 address exhaustion**?

3. **Internet Protocol version 6 (IPv6)** will replace IPv4. Each IPv6 address is 128 bits, so there are 2^{128} = 340,282,366,920,938,463,463,374,607,431,768,211,456 ($\approx 3x10^{38}$) possible values. Will this prevent address exhaustion?

4. The number of different Internet devices continues to grow.
Individually, choose a device that costs $100-$1000 and list 3 benefits of connecting it to the Internet. (For example: TV, printer, refrigerator, washer/dryer)
As a team, share your most interesting or unusual ideas.

5. As costs decrease, the number will increase further.
Individually, choose a device that costs $1-$10 and list 3 benefits of connecting it to the Internet. (For example: light switch, coffee mug, sandals)
As a team, share your most interesting or unusual ideas.
(If you have any brilliant ideas, file patents and start a business.)

6. Some people predict that by 2020 there will be $50x10^9$ Internet devices.
What do you think people mean by the **Internet of Things**?

(5 min) C. Postal Addresses	start time:

Head Groundskeeper Taj Mahal Agra, Utter Pradesh 282001, India	Manager, Sydney Opera House Bennelong Point, Sydney NSW 2000, Australia
President, International Court of Justice Peace Palace 2517 KJ The Hague, The Netherlands	The President 1600 Pennsylvania Ave, Washington DC, USA 20500

1. Postal codes and IP addresses help computers manage locations and routing, but people generally prefer things that are easier to remember and understand. For example, most countries have similar conventions for postal addresses. List parts **common** to most postal addresses (e.g. postal code).

2. If you send postal mail to a friend in another country, which parts of the address are:

a.	**most useful** to **your** local post office?	
b.	**least useful** to your local post office?	
c.	**most useful** to **your friend's** local post office?	

3. Explain why every post office only needs to understand some parts of every address.

(10 min) D. Domain Names	start time:

www.google.com www.google.co.uk www.google.co.jp	craigslist.org wikipedia.org 360.cn	cs.stanford.edu chemistry.stanford.edu www.ox.ac.uk

The **Domain Name System** (DNS) keeps track of a unique name (and IP address) for Internet devices. Some **domain names** are shown above. Domain names have parts (called **labels**), separated by dots. The **most general** labels (similar to countries) are called **top-level domains** (TLDs). Once there were 7 TLDs; now there are many. Each TLD is subdivided into **second-level domains** (SLDs), and further subdomains. The most specific label (e.g. "www") is often (not always) for a specific computer.

1. List the TLDs used in the table above.

INFORMATION

DNS is like a phone directory - we can look up a domain name to find its IP address, and vice versa. (Actually, DNS keeps track of much, much, more data.)
DNS lookup results can contain several types of records. For example:

- an **address** (A) record lists the IP address for a domain.
- a **mailserver** (MX) record lists a server that can receive mail for a domain.
- a **nameserver** (NS) record lists a server with current information for a domain.

Domain	Type	TTL	Answer
wikipedia.org.	NS	86400	ns0.wikimedia.org.
wikipedia.org.	NS	86400	ns1.wikimedia.org.
wikipedia.org.	NS	86400	ns2.wikimedia.org.
wikipedia.org.	A	3600	208.80.154.224

2. A **DNS lookup** for the domain **wikipedia.org** returns the info above.

a.	How many nameservers have info about wikipedia.org?	
b.	What is the IP address for wikipedia.org?	

```
IP Location:   United States San Francisco
               Wikimedia Foundation Inc.
Whois Server:  whois.arin.net
IP Address:    208.80.154.224
Reverse IP:    14 websites use this address.
Comment:       http://www.wikimediafoundation.org
RegDate:       2007-07-23
Updated:       2014-01-29

OrgName:       Wikimedia Foundation Inc.
OrgId:         WIKIM
Address:       149 New Montgomery Street
Address:       3rd Floor
City:          San Francisco
StateProv:     CA
PostalCode:    94105
Country:       US
```

3. A **reverse DNS lookup** for IP address **208.80.154.224** returns the info above:

a.	How many other websites use the same IP address?	
b.	When was this information last updated?	

4. If you have Internet access, do a **DNS lookup** on a domain name,
and do a **reverse lookup** (sometimes labeled with **pointer** or PTR) on an IP address.
Describe what you find.

(5 min) E. Conclusions	start time:

Like the postal system, DNS is **distributed** and **hierarchical** -
information is spread out, but in ways that it can be found and used effectively.
Every Internet device can contact a local DNS server it can ask for information.
Every DNS server can contact the server for each TLD,
and each TLD server can contact the server for each of its SLDs.

1. Why might Amazon or Google or Wikipedia have many computers use the same domain name? Hint: could one computer handle all of the traffic?

2. Why might a small organization have several names for the same computer? (e.g. www.example.com, mail.example.com, ftp.example.com)
Hint: Suppose the organization expects to grow?

3. Does every Internet device need a DNS name? Why or why not?