

Introduction to Networks

See:

- `socket/` example code

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Review last time: sockets

- TCP: connection-oriented, streams
- UDP: connection-less, **unreliable**:
may arrive out of order, duplicated, or not at all
- Client-server model
 - Server: `socket()`, `bind()`, `listen()`, then `accept()`, `send()/recv()`, and finally `shutdown()`, `close()`
 - Client: `socket()`, `connect()`, then `send()/recv()`, and finally `shutdown()`, `close()`

Networking layers

- OSI 7-layer model of networking
- 7: Application (HTTP, SMTP)
- 6: Presentation: data repr., encryption (SSL)
- 5: Session: auth, session checkpointing/restore, stream synchronization (sockets, SSH, RPC)
- 4: Transport: reliability, connection (TCP, UDP)
- 3: Network: routing, addressing (IP)
- 2: Data link: physical address (Ethernet MAC)
- 1: Physical: signals (twisted-pair, fiber, radio)

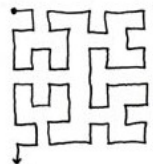
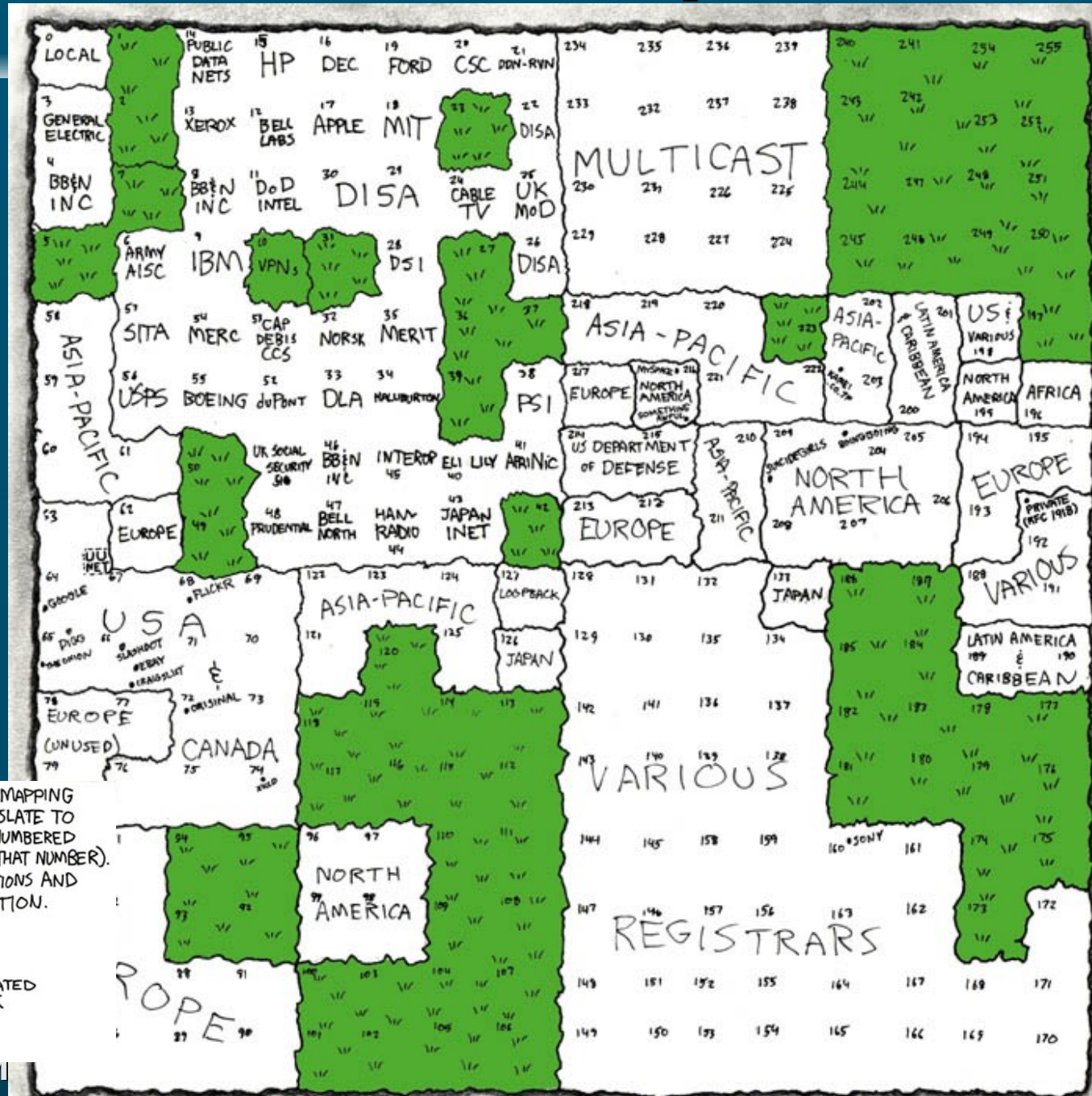
IP addresses

- Every public Internet host has an **IP address**:
 - **Four bytes**: e.g., **64.114.134.52**
- IP addresses are partitioned into **networks** (blocks of addresses), according to **netmask**:
 - e.g., **64.114.134.52 / 255.255.255.0** (or / **24**)
means **range**: **64.114.134.0** – **64.114.134.255**
- Large chunks of the **IP address space** have been given out to countries, organizations, companies, etc.



xkcd visualization of IP space

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



= UNALLOCATED BLOCK

THIS CHART SHOWS THE IP ADDRESS SPACE ON A PLANE USING A FRACTAL MAPPING WHICH PRESERVES GROUPING-- ANY CONSECUTIVE STRING OF IPs WILL TRANSLATE TO A SINGLE COMPACT, CONTIGUOUS REGION ON THE MAP. EACH OF THE 256 NUMBERED BLOCKS REPRESENTS ONE /8 SUBNET (CONTAINING ALL IPs THAT START WITH THAT NUMBER). THE UPPER LEFT SECTION SHOWS THE BLOCKS SOLD DIRECTLY TO CORPORATIONS AND GOVERNMENTS IN THE 1990'S BEFORE THE RIR'S TOOK OVER ALLOCATION.

- 0 1 14 15 16 19 →
- 3 2 13 12 17 18
- 4 7 8 11
- 5 6 9 10

Running out of IP space: NAT

- Very **few** public IP addresses left! **Solutions?**
- **NAT** (Network Address Translation)
 - **LAN** goes through **router** to get to Internet
 - Router gets **one** public IP address
 - ◆ 64.114.134.52 is TWU's
 - LAN gets **private** IP addresses:
 - ◆ 192.168.* /16, 172.16.* /12, 10.* /8
 - Connections mapped to **ports** on the router
 - How to run public **services** on a LAN host?

Running out of IP space: IPv6

- Another solution: IPv6
- 128-bit addresses instead of 32-bit
 - Each known star in the sky could get 4.5×10^{15} addresses!
- 64 bits to identify the subnet
 - Hierarchy simplifies routing
 - Easier to do multicast, etc.
- 64 bits to identify host uniquely
 - Every network card has a unique 64-bit MAC (media access control) address

From names to numbers: DNS

- Want to say “**twu.ca**” instead of **64.114.134.52**
- Top-level domains: **.com**, **.org**, **.ca**, etc.
- **DNS** (Domain Name System):
 - Query **local server** for host's IP address
 - ◆ May return **several** IP addresses!
 - ◆ Also info on **mail** server, owner, etc.
 - **Authoritative** for its own domain
 - If it doesn't know, it asks **other** servers
 - ◆ Which may tell it **which** server to ask
 - **Root servers**: **[a-m].root-servers.net**