Automatic Naming
CS 118
Computer Network Fundamentals
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BOOTP
ARP
DHCP

IPv4
IPv6

page 67 - naming pros and cons

Outline

- What is automatic naming?
- Why automatic?
- Designed-in
- Asking someone else
- Figuring it out for yourself
- Issues

What is automatic naming?

- Assigning a name to a network entity without human intervention
- Usually very dynamically
- Usually at the moment when it is first needed
- Often using different names for the same thing at different times

Why automatic?

- “Because it must be!”
- Ease of configuration
- Adapting to changes

Because it must be!

- Without a name, what can you do?
  - Anonymous reporting (N:1)
  - Broadcast announcements (1:N)

Not all that useful, but…
we can use these to get a name!

Ease of configuration

- Convenience matters
  - Plug-and-play, Zero-touch, etc.

- Complexity is painful
  - How many devices do you own?
  - Are they all configured the same way?
  - What if you had to configure them explicitly?

Adapting to changes

moving around changes network names, because the network location has changed

- Mobility

- Renaming

Mobility

change of physical location

- Change of physical location:
  - Changes network location
    - Topological or geographic names change
    - E.g., USC IP on campus, TimeWarner at home
  - Changes network
    - Name space changes
    - E.g., phone number on 4G,. IP address on WiFi

Renaming

area code split

change by network operator

renaming - change from wifi to VPN

- Change by the network operator
  - E.g., area code “split”
- Change by the user
  - E.g., off-campus WiFi then VPN to campus

translation - renaming --> moving from one place to another

How can you get a name?

What are the options?

Alternatives

- Design-in (preconfigure)
- Pick at random
- Ask someone else

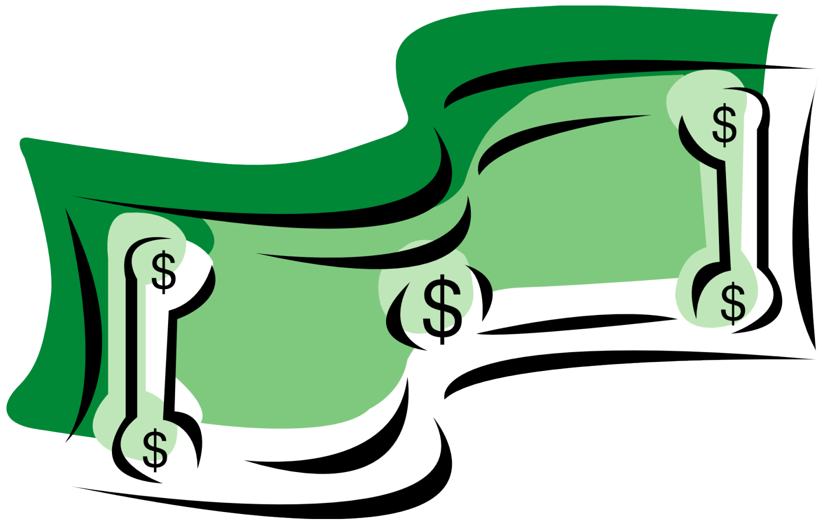
Designed-in sub-options

- The $1 solution
- Dude, where’s my card?
- Getting the boot

The $1 solution

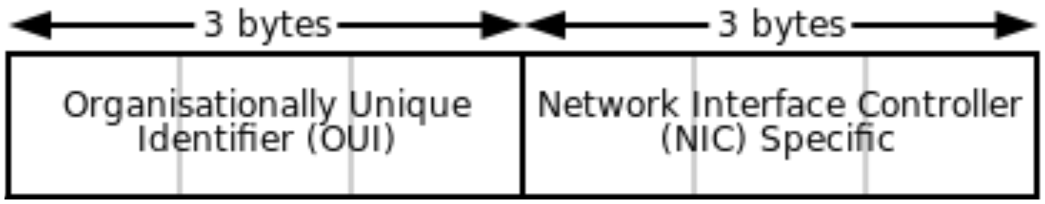
everything is a globally unique name

- Maximum cost of globally unique names
  - Use a USD $1 serial number as your name
  - Put the $1 in the device (or whatever)



Ethernet

- Two part solution:
  - IEEE assigns OUI
    - Organizationally-Unique Identifier
    - \$2,575 per block of 16M addresses (2^{24})
    - \$0.0001535 per address (6,515 per \$1)
  - OUI assignee manages the block


3 bytes
3 bytes
Organisationally Unique Identifier (OUI)
Network Interface Controller (NIC) Specific

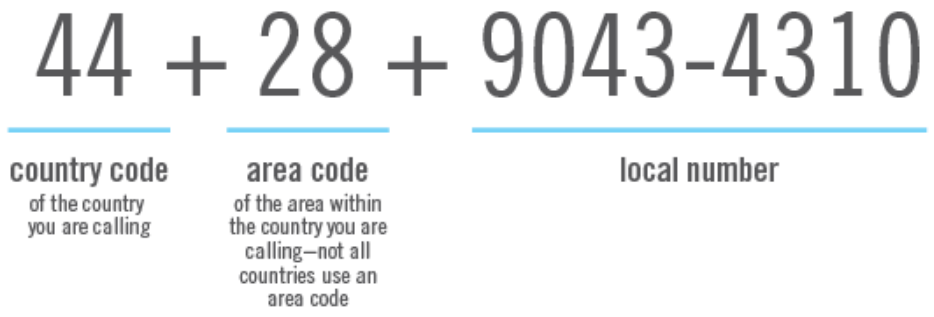
Ethernet addresses

ethernet address is important to know

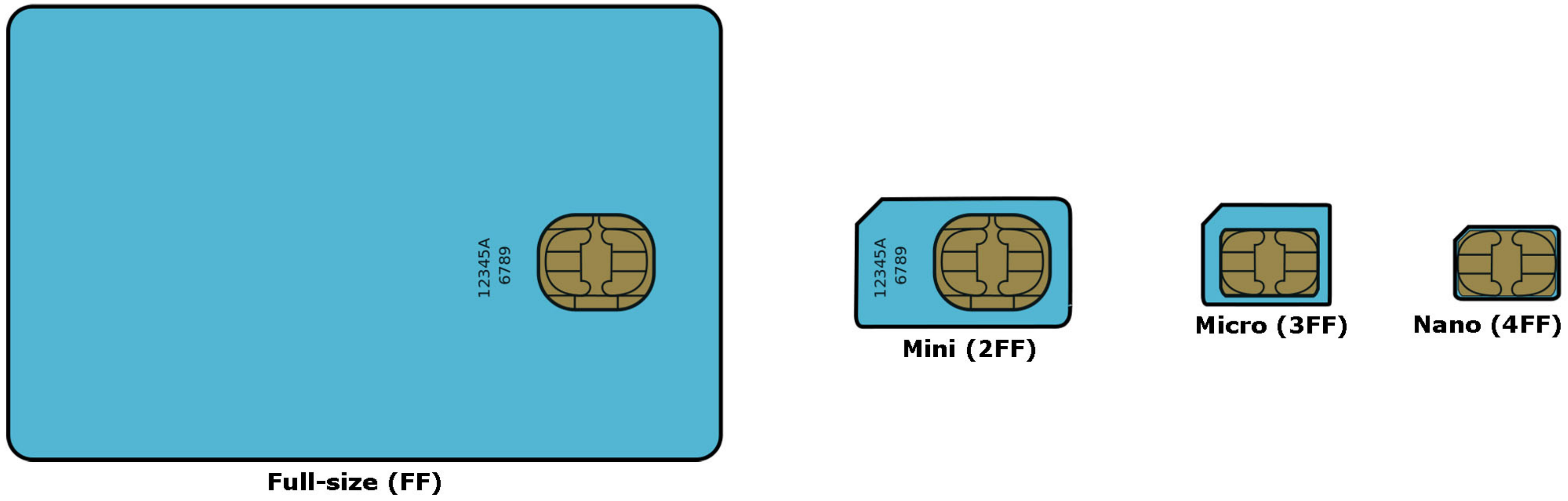
- All Ethernet devices have:
  - Fixed
    - Wired-in or write-only by manufacturer
    - Unique Burned-in (BIA) / hardware (EHA) address
    - Broadcast (all 1's)
  - Writeable
    - To change your BIA (to replace systems)
    - To add multicast addresses

POTS, non-SIM cellphones

- Assigned by a hierarchy of authorities
  - ITU country codes, country area codes, …
  - POTS – paired to the "tail circuit" (house wire)
  - Non-SIM cell – paired to 7-byte MEID (Mobile Equipment ID; 32-bit ESNs ran out in 2008)


44 + 28 + 9043-4310
country code
of the country you are calling
area code
of the area within the country you are calling—not all countries use an area code
local number

Dude, where's my card?

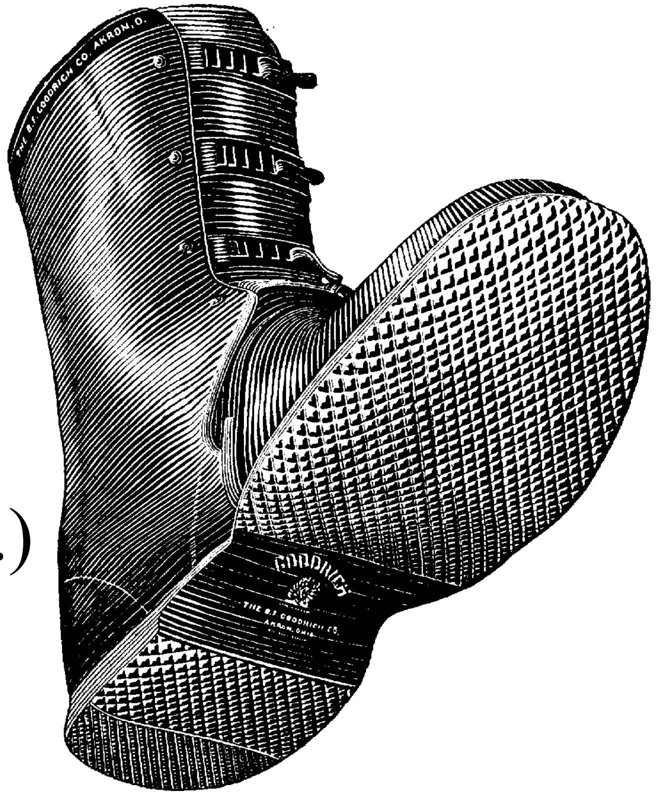


SIM-based cellphones

- GSM phones have two names
  - The phone (IMEI)
    (International Mobile Equipment ID 14 digits, 6.228 bytes)
  - The SIM card (Subscriber Identity Module)
    - Includes a 20 digit ICCID (IC circuit ID)
- Telco links ICCID to your phone number
  - Also checks your IMEI isn't blacklisted (stolen)

Getting the boot

- Power-on configuration
  - Files on disk, USB, floppy
  - Flash memory
  - *PROM (EEPROM)
  - Ask the user (let's hope not . . .)



Figuring it out for yourself

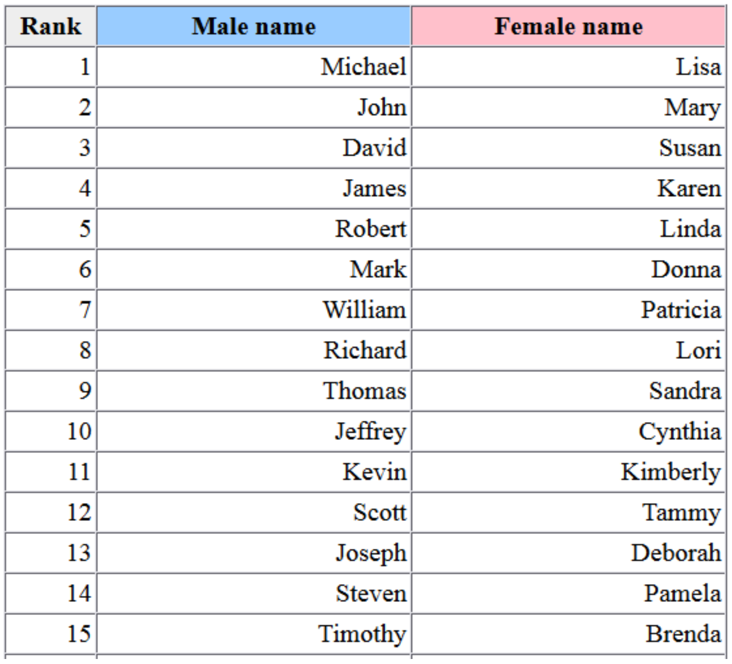
- Pick me a winner!
- Parental support

Rolling the dice…

- If the number space is large enough
  - Why not just pick one?
  - What could go wrong?

People names

- Hierarchical in spirit
  - Given name(s) are "random"
  - But are they?
  - What if your last name is common?



Rank	Male name	Female name
1	Michael	Lisa
2	John	Mary
3	David	Susan
4	James	Karen
5	Robert	Linda
6	Mark	Donna
7	William	Patricia
8	Richard	Lori
9	Thomas	Sandra
10	Jeffrey	Cynthia
11	Kevin	Kimberly
12	Scott	Tammy
13	Joseph	Deborah
14	Steven	Pamela
15	Timothy	Brenda

IPv4 link local

- 169.254.x.x
  - EXCEPT first 256, last 256 (RFC 3927)
  - Based on MS Automatic Private IP Addressing (APIPA)
  - Pick randomly, do a test to confirm
  - Works only on the local link
    - Where the test works (ARP)
    - NEVER relayed
    - E.g., on your Ethernet

Pseudo-what?

- Random
  - Having no predictability
  - A sequence with maximum disorder
- Is a single number ever random?
  - No such thing!
  - Random applies to a *sequence*

Random number generation

- Cannot be generated by a TM in finite time
  - A TM would read only a finite tape
  - TM + finite tape = predictable output

So what do we do?

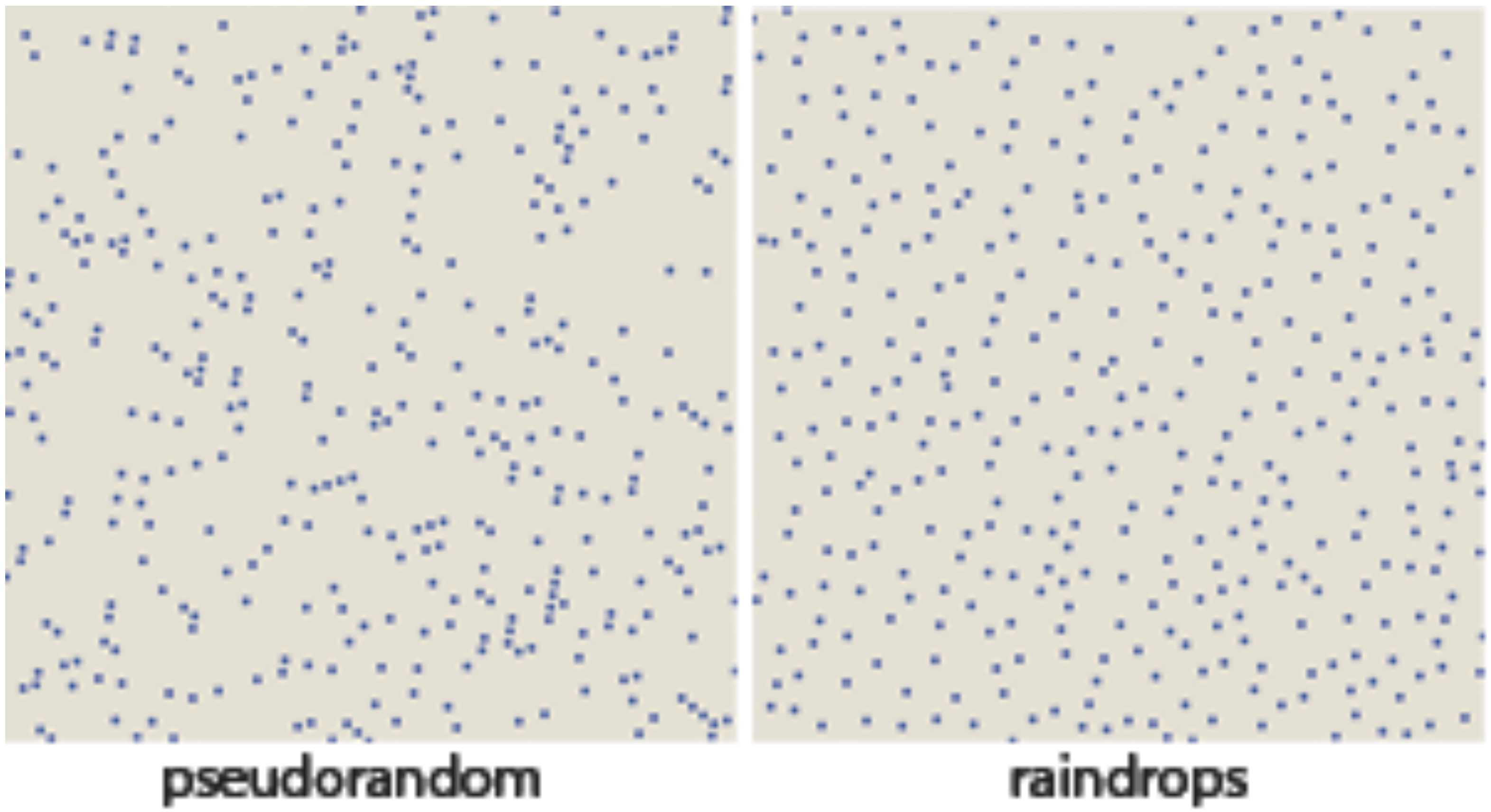
True random

- Need an external source of infinite entropy
  - A random physical event
  - E.g., radioactive decay, thermal noise, Brownian motion

Pseudorandom

- Deterministic, but appearing random
  - Unix rand()
  - Sometimes includes arbitrary "seed" (input)
    - Ethernet BIA
    - Disk access times
    - Keystroke delays
    - Mouse movements
  - Repeatable
    - Useful to replay simulations

“Spot” the difference



random (not evenly distributed)

Eyeballs aren’t always useful

2089986280348253421

1706798214808651328

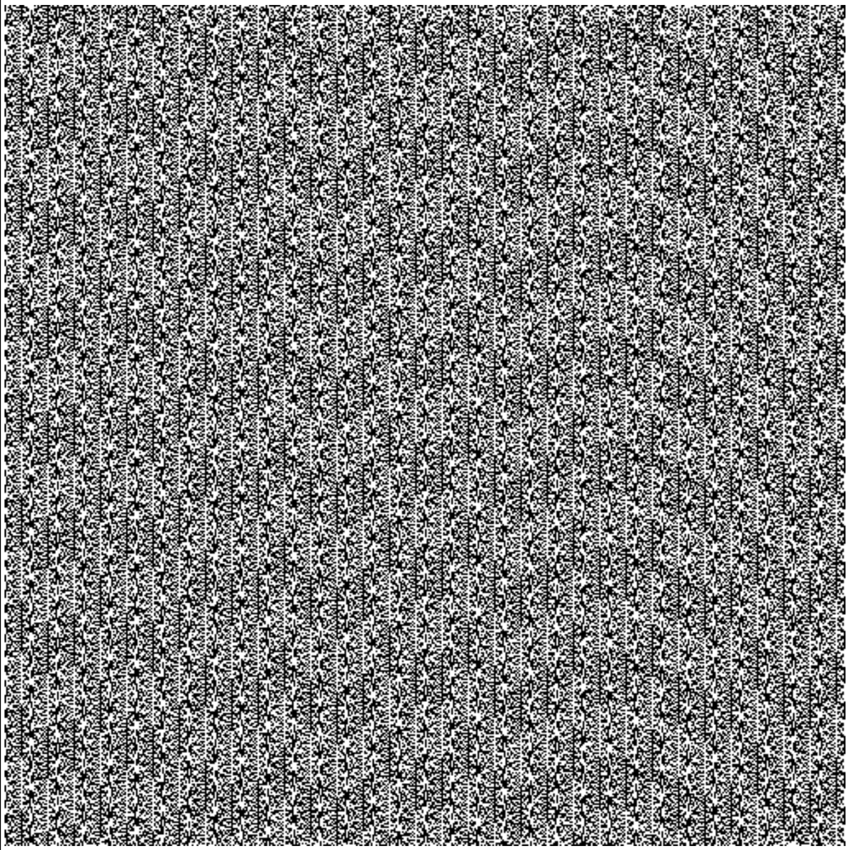
2306647093844609550

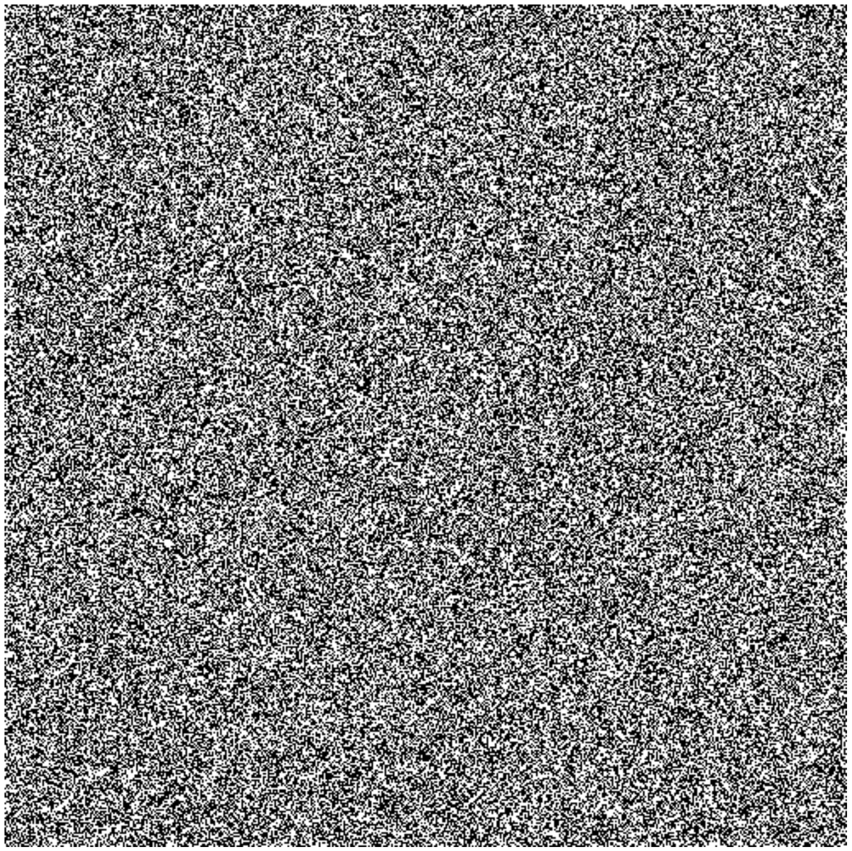
5822317253594081284

8111745028410270193

8521105559644622948

Compute the difference





more random here

IPv6 link local

- FE80::/10
  - Assign based on MAC address
    or
    Pick randomly (RFC 4193)

    can't change the MAC address of a device
  - Do a test to confirm
  - Works only on the local link
    - Where the test works (ND)
    - NEVER relayed

iOS Ethernet anonymity

- When configured
  - Every time device wakes from “sleep” (almost never, FWIW)
  - Pick a new random MAC
  - Hope it doesn’t collide (!)
    - There is no test!
  - Avoids “fingerprinting” SSID requests
    - Some stores monitor these

Asking DAD for help

- Duplicate Address Detection
  - Any general mechanism
  - "DAD" is specific to IPv6

- Works where?
  - IPv4: yes
  - IPv6: yes
  - Ethernet: NO

IPv4 duplicate detection

- Use ARP

  see if something is occupied

  - Send an ARP probe for yourself
    - Source IP = none
    - Destination IP = broadcast
    - Owner MAC = yours (*presumed unique*)
    - Query for = the tested address

  could have overwrite existing stuff

  if you are testing address, don't send a query from that address

  - Do NOT send a query *from* the tested address
    - It will overwrite the cache of others!
    - Possibly even the existing owner!

Crossing the streams?

- ARP vs. IP
  - Different layers
  - IP nodes sit on ***both***
    - Nodes on shared links
- Are these gateways?
  - Not quite
  - We never translate, only encapsulate (stack)

ARP - protocol that used for checking if address is available
IP - internet protocol

Implications for IPv4

because it broadcasts --> send to everyone

- IPv4 addressing
  - Ask one network layer for help with another
  - Exchange ARP so IP can autonumber
  - Exchange ARP so IP can discover
  - IP on shared links doesn't exist alone!
- What about non-shared links?
  - Addresses are assigned statically

IPv6 DAD

IPv6 can't broadcast (send to everyone)

- Use IPv6 Neighbor Solicitation
  - Same basic principle as IPv4
  - Ask to see if anyone has the desired address
  - If nobody asks, we get it

IPv6 Neighbor Solicitation

another way of ARP probing - broadcast
IPv6 can only do broadcast --> neighbor solicitation

- IP-level replacement for ARP
  - But IPv6 has no broadcast
  - Use multicast instead

find the MAC of the party that would likely contain it

it knows who you are targeting, so it is like 'targeted ARP'

- How?
  - Could multicast to "all nodes" (like ARP does)
  - Instead multicast to MAC based on IPv6 addr
  - Only the node we want joins that group
  - NOBODY ELSE IS BOTHERED!

only send to MAC based on IPv6 addr

More parental support – IPv6

- Global IPv6 address
  - Listen for a Router Advertisement (or ask routers via Router Solicitation)
- Create an address you know is unique
  - Combine RA information with Ethernet MAC
- Do a test to confirm

router and ethernet >> unique

  - The test is only on the local link
    - Avoids MAC collisions
  - But the address is good globally
    - RA part is assumed unique

IPv6 example

- Listen for router advertisements
  - Collect them as they come in
- For each RA received on an interface
  - Combine the router prefix with the MAC BIA
  - Also join an IPv6 multicast based on the BIA

Asking someone else

- A horse with no name
- Name servers for self-namers

A horse with no name

- Asking a question without an ID
  broadcasting >> sending to everyone
- Getting an answer without an ID?

Asking a question…

- How do you start?
  - If you don't know who to ask, broadcast the question
  - If you do know who to ask, send directly

- What's your address?
  - At the layer you need to know, NONE (typically "0")

What layer do you ask?

- IPv4
  - Another layer (generally)
- IPv6
  - Your layer (always)

IPv4

IPv4 go to different layer
network layer no name
go to ethernet layer to get your name
and do it there

- Mixing the layers
  - On a *different* layer that already has an address
    - E.g., broadcast Ethernet ARP with your MAC address
    - E.g., ATMARP request to LANE server on known circuit
- Same layer

another option - go to DHCP server

  - IP (with UDP inside) to DHCP server
    - On the same layer to a server
    - Using source address 0

IPv6

- IP directly
  - Neighbor Discovery neighbor solicitation
  - Source address = 0

Getting an answer…

- Broadcast
  - When you didn't know who was asking
- Unicast
  - When you do send to one person
    (e.g., when the request is over a different layer)

What can someone else tell you?

What are the options now?

What can someone else tell you?

- Just the facts
  - An address based on a table
- The facts and stuff
  - An address based on a table
  - A file that could have anything
- A loan
  - More specific information
  - Organized by type
  - Loaned out, then recovered for reuse

Reverse ARP

also over ethernet like ARP

- ARP
  - Broadcasts request providing IP address
  - *Owner* replies with corresponding Ethernet MAC
- RARP

  opposite of ARP
  - Broadcasts request providing Ethernet MAC
  - *Server* replies with corresponding IP address

RARP limitations

- Only provides an IP address
  - Systems often need more, e.g., default router, DNS server (to avoid bugging the roots), etc.
- Requires preconfigured server
  - Each expected request must match an entry
- Runs on its own protocol
  - Like ARP, this isn't over IP; it's over Ethernet

BOOTP

runs UDP over IP

- Bootstrap Protocol
  - Still needs a static, preconfigured table
- Replacement for RARP
  - Runs over UDP over IP
    (rather than Ethernet directly)
  - Also provides a file to retrieve
    - That file can be a script, a program, or a table

DHCP

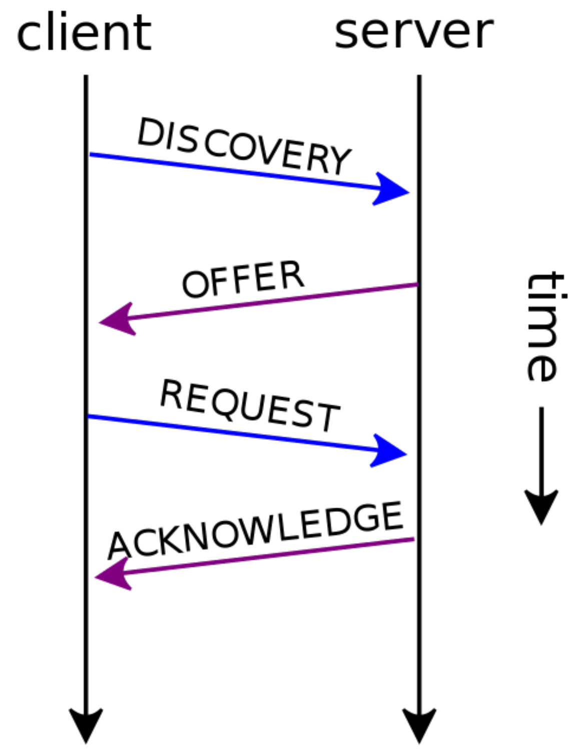
replace BOOTP

- Dynamic Host Configuration Protocol
- Replacement for BOOTP
  - Runs over UDP over IP
  - Explicit way to manage specific configuration parameters
  - Managed via *leases*
    - Assignment has an expiration; can be renewed, released
    - Allows easy reassignment

DHCP loans you a name

Steps in DHCP

- ARP-like two-phase address assignment
  - Client broadcasts (IPv4) or multicasts (IPv6) a UDP DISCOVER request
  - DHCP servers *all* broadcast/multicast a UDP lease OFFER
  - Client picks one offer and *unicasts* a REQUEST
  - DHCP server *unicasts* a UDP ACK



Why two phases?

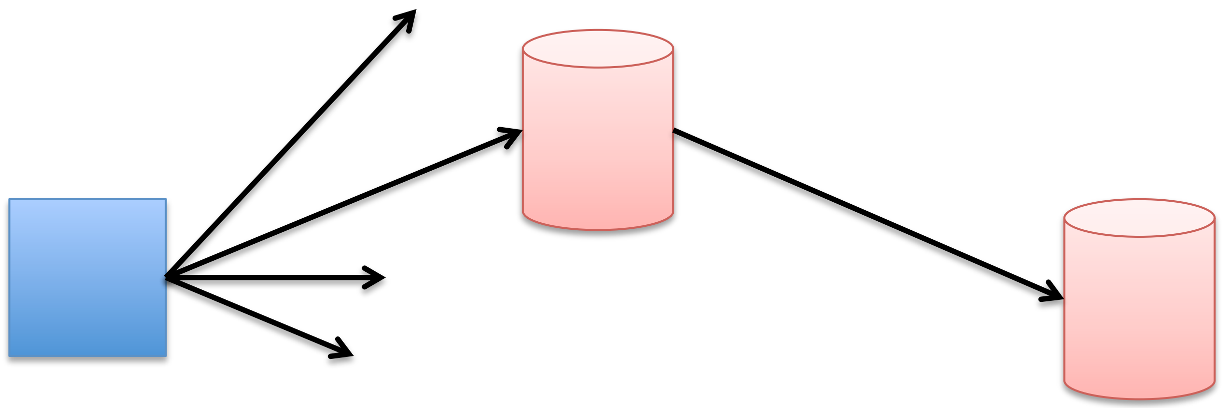
- Multiple servers can make an offer
  - Client picks only one
  - Second phase confirms selection
  - Offers are released after a time if not selected

B/Mcast vs unicast

- Unicast where possible
  - If you know which DHCP server you want
  - If you've already leased some info
    - E.g., and you go back to get more…

DHCP relay

- A little like proxy ARP
  - But in both directions



DHCP relay

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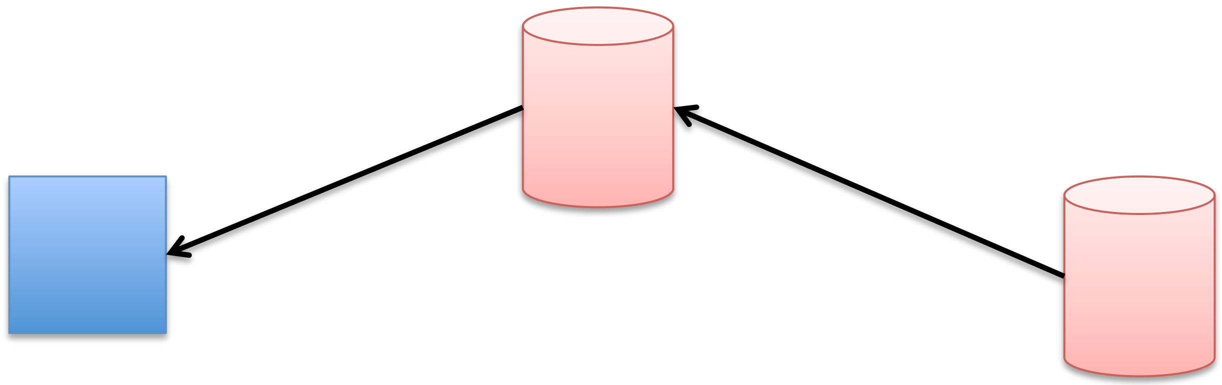

What can DHCP configure?

- DHCP offer
  - Information critical to configuring the channel
  - IP address
    - dynamic from a range or static based on a table
  - Default router
    - And “netmask” (indicates shared link addresses)
  - Lease time
  - DNS server
    - To avoid root overload
- DHCP inform
  - Other additional context
  - Time server
    - Network Time Protocol
  - Web proxy
    - Address, parameters, etc. for shared caching
  - Just about anything else

DHCP events

this is important - what DHCP means

- Request
  - Client searching for initial offers
- Offer
  - Servers making initial offers
- Request
  - Client picking one offer
- ACK
  - Server confirming offer
- Renew
  - Client asking for lease extension
- Release
  - Client asking for lease cancellation

USB

- Master (host), assigns to slaves
  - Assigned each time a device is plugged-in
  - 127 addresses (7 bits, 0=not set yet)

The single master controls “the world”

Name service for self-namers

- Recall: bind
  - Maps a process to a TCP/UDP port
  - How does another party find that port?
    - It knows the number (IANA list, pre-agreement)
    - It knows the name, but not the number
- Register your name
  - Contact the DNS that has your name:IP map
    - Add the portname:portnum entry too

Issues

- Telling everyone else
- Configuring DHCP
- Impact to communication in progress

Telling everyone else…

- How do others know your new name?
  - Esp. if you make one up
- Remember the DNS?
  - Can also map persistent names to changing ones
  - lever.cs.ucla.edu -> IPv4 address that isn't 131.179.192.136
  - IMAP@lever.cs.ucla.edu -> port that isn't 110

Using the net to find names

- Remember the need for glue?
  - DHCP's "glue" to the client:
    - Router address
      - Even better when it's a "default" router
    - Channel subnet mask
      - What's reachable without contacting the router
    - DNS server
      - A way to get names without needing a default router
      - It needs to be reachable either on the shared channel or via the router indicated

Configuring DHCP server

- DHCP makes leases
  - Where does it get its land (resources)?
- Currently:
  - Manual configuration
- Experimentally:
  - Another server (“Dynamic DHCP Configuration”)

Pros and cons

- Design-in (preconfigure)
  - Pro: easiest, known to work
  - Con: won’t deal with mobility, changes
- Pick at random
  - Pro: second easiest, might work
  - Con: might not (verify?), finding others is hard
- Ask someone else
  - Pro: easy for the client, allows coordination
  - Con: right back where you started for the server!

Impact on in-progress comm.

- What happens to connections or relays using addresses that change?
  - Continue using the old name
    - How do you know if this is even possible?
  - Shift to the new name
    - What if there isn’t one?
    - What if there’s more than one?

Summary

- Giving a name to yourself can be easy
  – Verification is needed
  – Using that name beyond the shared link is harder
- Most naming involves
  – Assumed uniqueness
  – Asking someone else
- Getting started is still manual
  – True "zero configuration" is very rare