Internet Addressing and the Address Registry System

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Overview

- An Introduction to Addressing
- An Introduction to the Address Registries
- Registry Policies and Procedures
- Summary

Internet Addresses

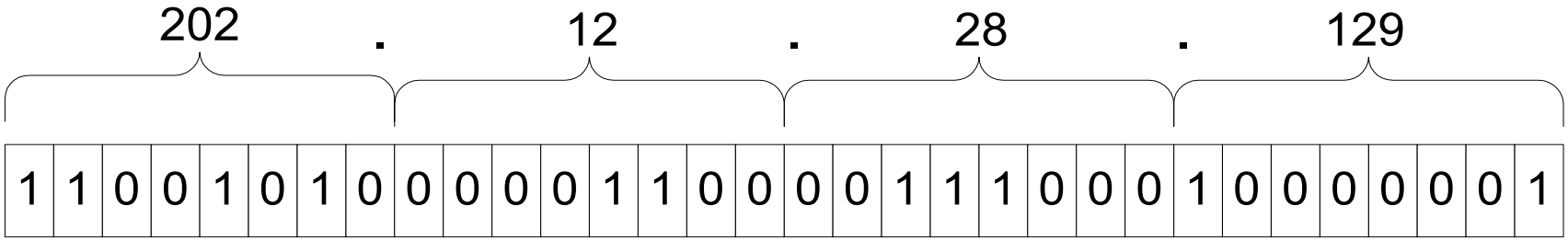
- Any device wishing to use Internet protocols must have at least on Internet address
  - IPv4: 32 bit value
  - IPv6: 128 bit value
- These addresses provide dual functionality
  - Identifying (naming) an end point
  - Describing the path to reach that end point

The Beginning

- Back when the Internet protocols were first being designed, there was a big argument between fixed length and variable length addresses
  - Fixed length will always be limited
    - But if you make it big enough, no one will notice
  - Variable length will always take more cycles to proces
    - But there are tricks you can play to minimize the difference
- The decision was made for fixed, 32 bit addresses
  - Rumor has it, by a flip of a coin...

IP version 4 Addresses

- 32 bit unsigned integers
  - possible values 0 - 4,294,967,295
- Typically written as a “dotted quad of octets”
  - four 8 bit values each having a range of 0-255 separated by “.”
  - For example, 202.12.28.129 can be written as below

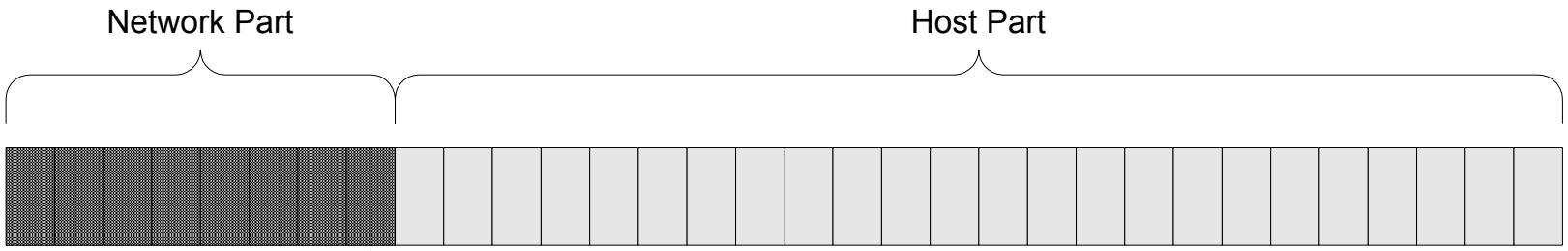


Internet Addresses

- A subset of IPv4 addresses
  - Just one of an infinite number of subsets, albeit an important one
- Guaranteed globally unique by the IANA
  - Generally allocated by delegated authorities such as Internet service providers or regional registries
  - Assumed to be routable
    - Bad assumption
- Partitioned into two parts
  - A host part that identifies a particular machine on a local or wide area network
  - A network part that gives routers information how to get to the local or wide area network via the Internet

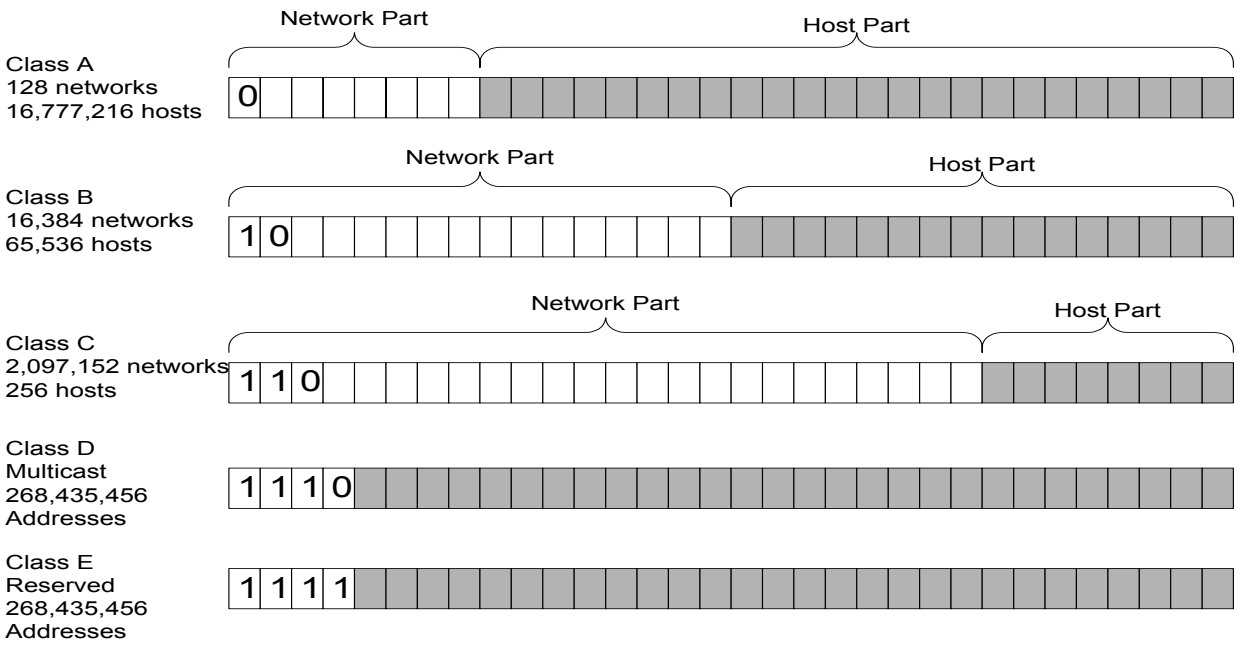
Internet Address Structure

- Originally, the architects of the Internet thought 256 networks would be more than enough
  - Assumed a few very large (16,777,216 hosts) networks
    - They were wrong (in case you were wondering)
- Addresses were partitioned as below
  - 8 bit network part, 24 bit host part



Classfull Addressing

- Original addressing plan too limiting
  - More than 256 networks with many fewer hosts than 224
- Solution was to create address classes

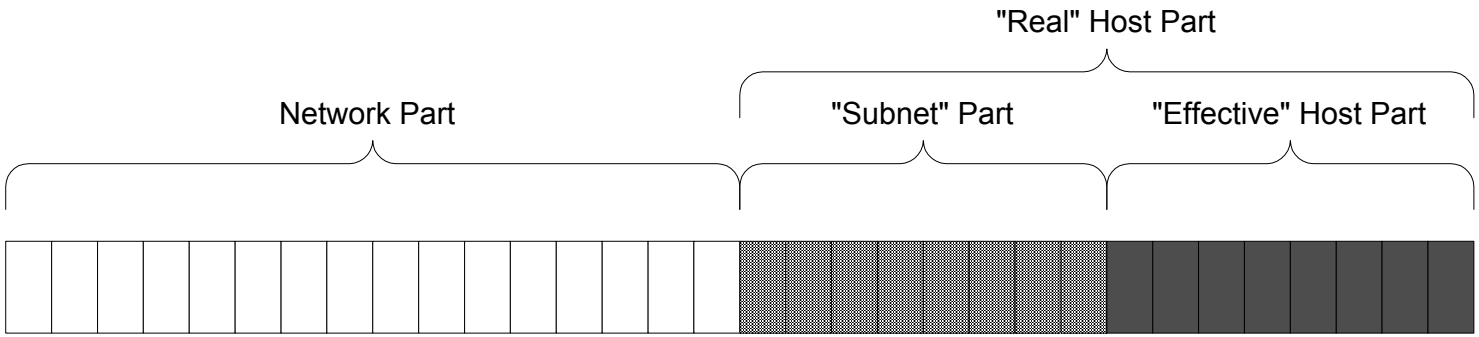


The Problem

- Class A way too big
  - Originally, the TCP/IP architects thought there wouldn be many networks, and each network would have many hosts.
    - They were wrong
- Class B too big
  - Even 65536 host addresses is too many in most case
    - Imagine 65534 hosts all responding to a broadcast
- Class C too small
  - Most sites initially connecting to the Internet were larg Universities, 256 was too small for them

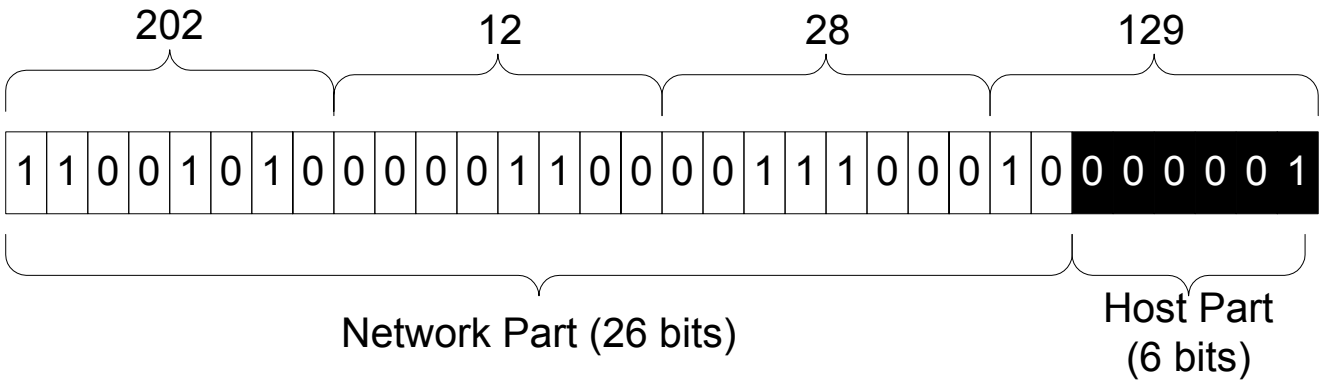
Subnetting

- Classfull addressing was a better fit than origina
  - but class A and B networks impossible to manage
- Solution was to partition large networks internall into sub-networks (subnets)
  - Typically “class C” (8 bit host part) sized subnets although variable length subnets used too



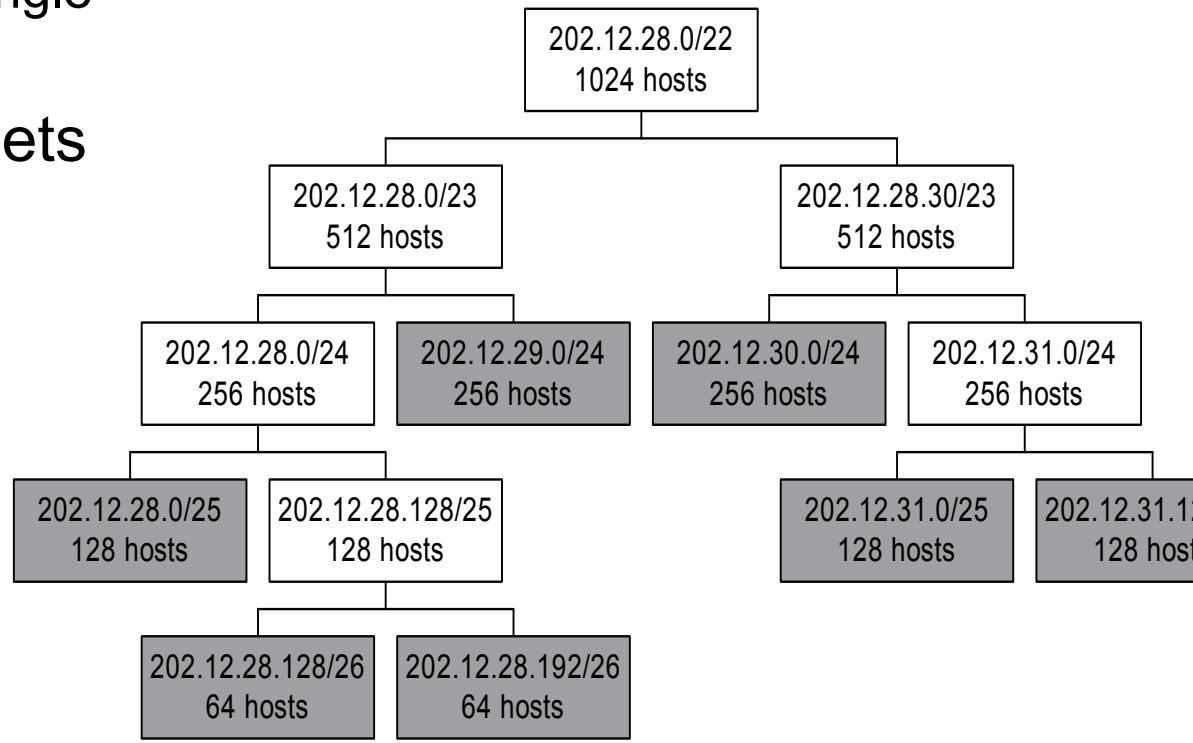
Classless Addressing

- Forget what I just told you
  - Classfull addressing is officially “Bad”™
    - 3 sizes just don’t fit all -- very wasteful
- Better solution is to use variable length partitioning between the host and network parts
  - Actual partitioning for a site provided by routing protocol
  - notation is dotted quad followed by a “/” and the network part length, e.g., 202.12.28.129/26 → First host on 64 host network starting at 202.12.28.128
- No need for subnets



Example of Classless Addressing

- Prefix 202.12.28.0/22
  - 1024 host addresses
  - announced as a single network
- Consists of 7 subnets
  - 202.12.28.0/25
  - 202.12.28.128/26
  - 202.12.28.192/26
  - 202.12.29.0/24
  - 202.12.30.0/24
  - 202.12.31.0/25
  - 202.12.31.128/25



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The Address Registries

- In order to assure global uniqueness for address, a “registry” of allocated addresses is used
- Over time, the role of the registries has changed
  - From a simple accounting role to one with significant policy making capabilities.

History

- Back when IP addresses first started being allocated, Jon Postel at USC ISI kept a record of which site had which (class A sized) network block
- This function was formalized into the “Internet Assigned Numbers Authority” in the early 80’s

The Internet Assigned Numbers Authority

- The IANA was (is) the parent of all regional registries and top level domain name administrators
  - In some context at least, the IANA can be said to "own" all administrative resources on the Internet
  - Hands out all globally unique numbers (IP addresses, protocol numbers, port numbers, object Ids, etc.)
- The IANA is now a "function" of ICANN
  - Still at USC ISI
- Administration of the address registry has been sub-delegated to the "Registries"

Registry History

- First NIC at Stanford Research Institute (SRI-NIC)
  - Located in California (near Stanford University)
  - Funded by DOD DARPA
- SRI replaced by GSI in Washington DC area
  - Lowest bidder
    - Unpleasant transition
  - DOD DCA provided funding
- NSF issued InterNIC 5 year Cooperative Agreement
  - Cooperative agreement issued in 1992
  - AT&T, General Atomics, and Network Solutions, Inc. each awarded part of InterNIC

InterNIC History

- InterNIC consisted of 3 parts
  - Registration Services operated by NSI
  - Database and Directory Services operated by AT&T
  - Information services operated by General Atomics
- Registration Services provided
  - Domain name registration
  - Address allocation and registration

Meanwhile, In Europe…

- Two organizations, EARN and RARE were investigating internetworking
  - Albeit with the OSI protocol suite
- Around 1989, folks wanting to get work done formed “RIPE”
  - A working group of RARE looking into internetworking with the TCP/IP protocol suite
- An informal group, funded by the EU (via RARE)
  - Established the RIPE Network Coordination Centre around 1990

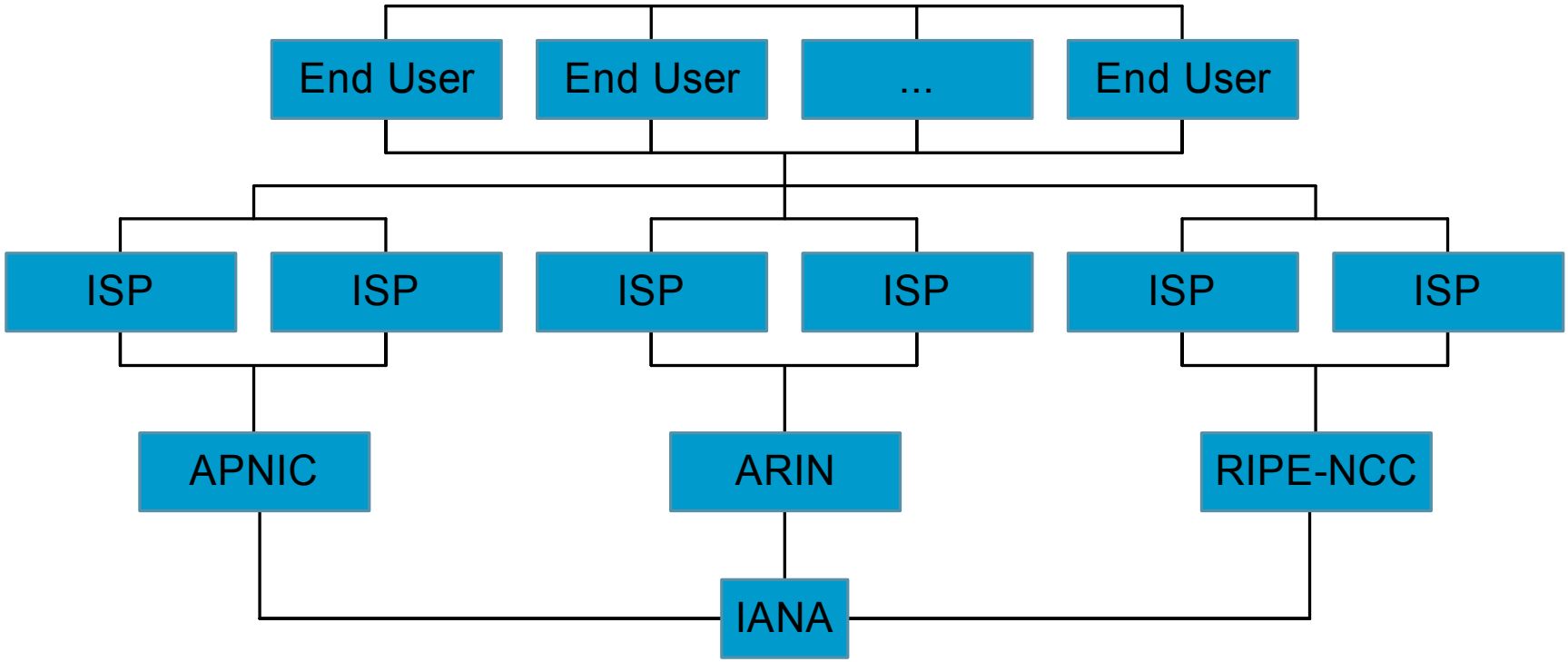
RFC 1366

- In 1990, RIPE-NCC requested a large block of address space so it could manage allocations for Europe
  - Politically correct rationale: to distribute the address management load
  - The IANA allocated 193/8 and 194/8 to RIPE-NCC
- RFC 1366 was written to formalize the sub-delegation of address allocation authority to “regional registries”
  - Originally, the regional registries were to be agents of InterNIC
    - Not politically viable
  - The regional registries consider themselves peers

Before ICANN

- The regional registries operated under the authority of the IANA
- Allocation policies defined by the operations groups and the IAB/IETF
  - IEPG
  - NANOG/APOPS/EOF
  - IETF CIDRD and ALE Working Groups
- The regional registries self-organized themselves in a bottom-up fashion
  - Authority derived from their memberships

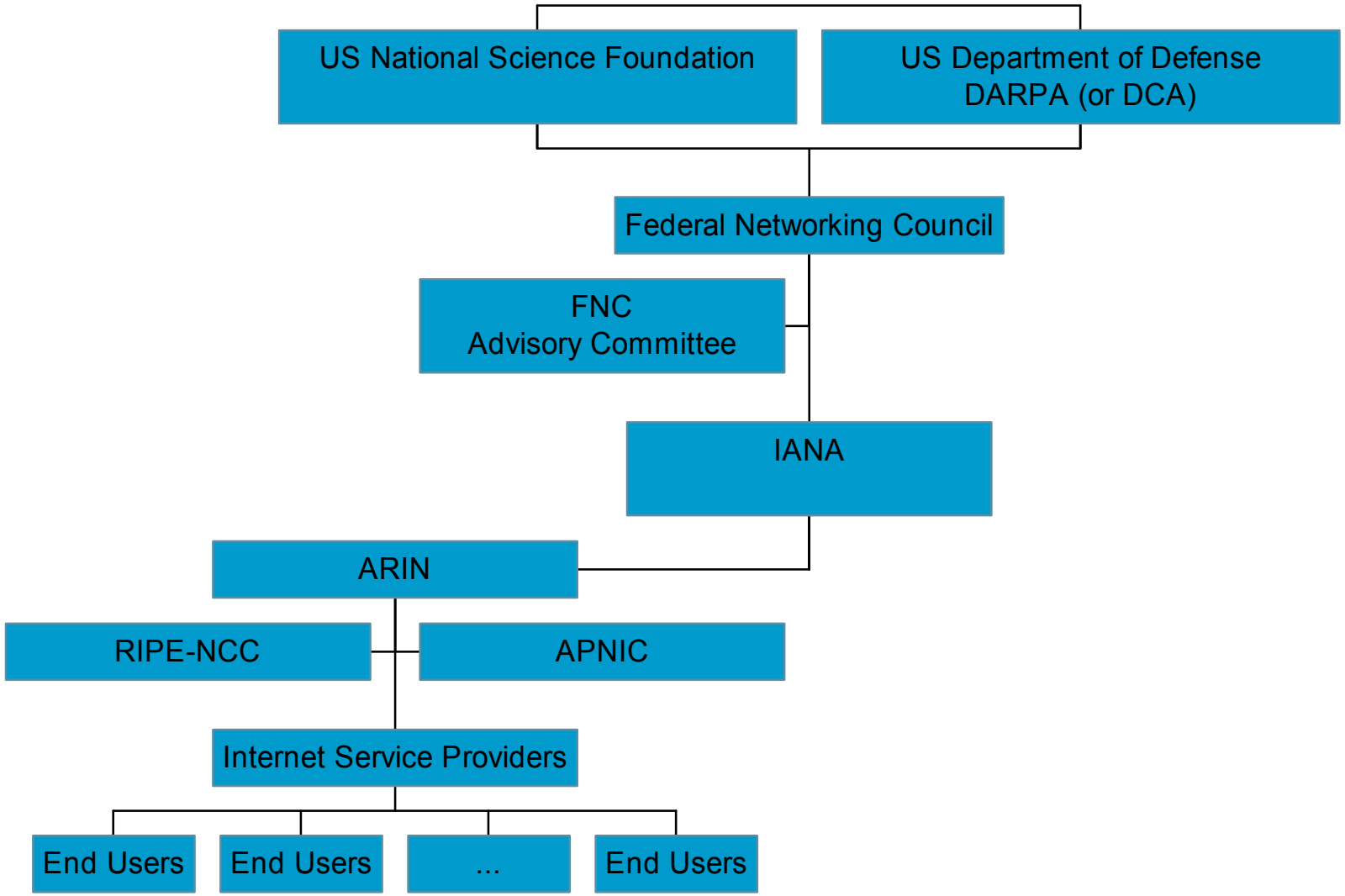
Internet Hierarchy (Bottom Up View)



The US View

- When the Internet commercialized, the US Gov't began to take notice
  - Prior to NSF permitting NSI to charge for domain names, US Gov't involvement was characterized as "benign neglect"
- A top-down model was asserted

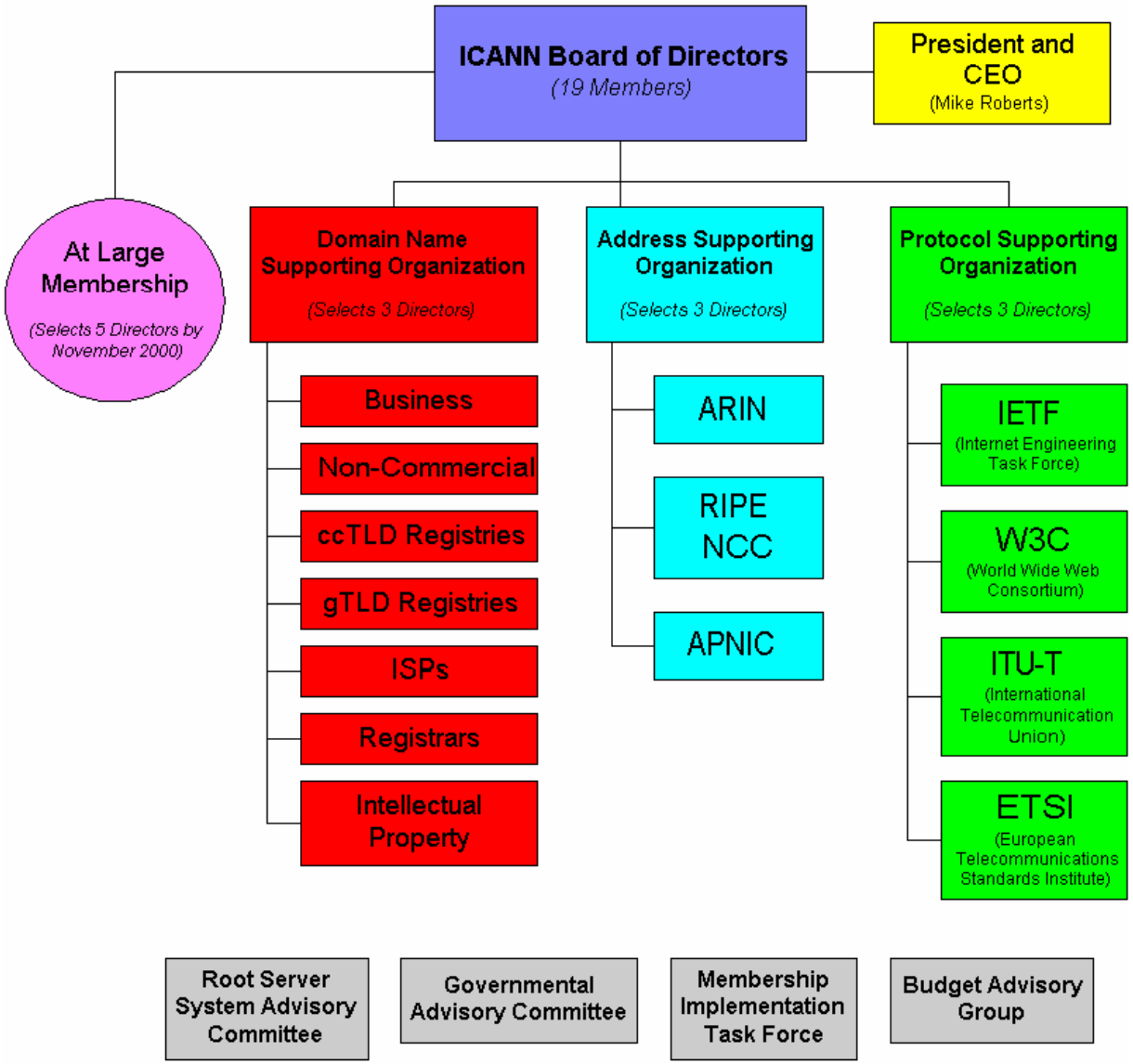
Internet Hierarchy (US View)



Enter ICANN

- As a result of the “White Paper” ICANN was given authority over all IP addresses
  - IANA becomes a function of ICANN
- The Address Supporting Organization (ASO) provides advice to ICANN on the management of address resources
- The ASO is comprised of an Address Council
  - Each regional registry provides 3 people to the AC
- Uncomfortable mixture of bottom-up and top-down models

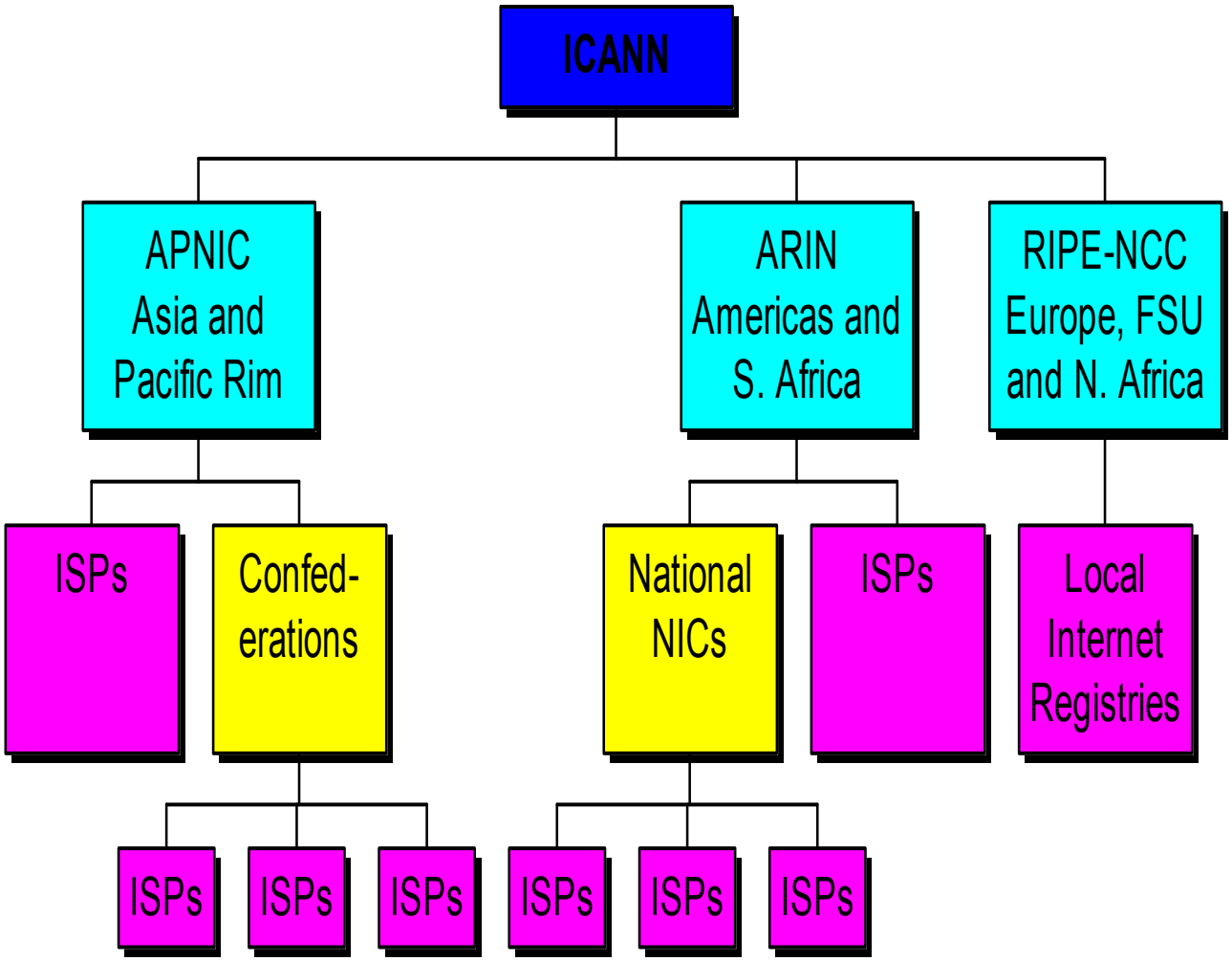
ICANN Organizational Chart



Who Cares?

- The regional registries can still believe they gain their authority from their members
- ICANN is seen as a formalization of the IANA
  - provides legal and political authorization
- The registries continue to operate as they have in the past
  - The ASO may play a role in policy formalization

Registry Hierarchy



Regional Registries

- Registries allocate numbers
  - Internet addresses
    - (plus in-addr.arpa domains)
  - Autonomous System Numbers
- Currently three regional registries exist
  - APNIC, ARIN, RIPE-NCC
    - All are self-funded
  - ICANN may create others as needs arise
    - AfriNIC and LATNIC are fairly well along

Regional Registries (cont'd)

- Regional Registries are NOT regulatory bodies
  - They do not "license" ISPs
    - This is a national governmental issue
  - They are not the authority for who can or cannot connect to the Internet
    - Anyone can who is permitted by law in their country
  - They cannot control any organization
    - So complaining to them is pretty pointless

Regional Registry Funding

- Historically, Internet registries have been funded by the US government
  - Either NSF or DoD
- RFC 1366 specified the creation of regional registries
  - But didn't indicate how they would be funded
- All 3 regional registries have a membership model that provides funding
  - APNIC and RIPE's funding is almost exclusively membership fees
  - Most of ARIN's money comes from allocation fees

APNIC

- Started as an APCCIRN/APEPG Pilot Project in Sept., 1993, received address space from IANA in April, 1994, Incorporated in April 1996
- Membership based organization with tiers (very large, large, medium, small) depending on total amount of APNIC allocated address space used
  - Used to be self-determined
- Has a staff of 15
- Located in Brisbane, Australia
- More info: see http://www.apnic.net

RIPE-NCC

- Created in 1990 as the IP networking special interest group of RARE, a EU funded group working to deploy OSI networks in Europe
  - Incorporated in 1998
- Membership based organization with a tiers (large, medium, small) depending on total amount of address space used (complex formula)
  - Used to be self-determined
- Has a staff of about 50
- Based in Amsterdam, The Netherlands
- More info: see http://www.ripe.net

ARIN

- Incorporated in 1998 with seed funding from NSI (InterNIC), took over address allocation functions performed by InterNIC (NSI Registration Services)
- Flat membership fee
  - Only small part of income
- Allocation fees dependent on amount of address space consumed within the last year
- Has a staff of around 25
- Based in Chantilly, US (near Washington, DC)
- More info: http://www.arin.net

Local Internet Registries

- Regional Registries delegate authority to “Local Internet Registries” to allocate resources
  - Usually Internet Service providers
  - Sometime confederations of service providers
  - Sometimes national level Internet registries
    - APNIC and ARIN only
- Local Internet Registries sub-delegate to customers
- Each Local Internet Registry may have its own rules, but all must follow the rules of their parent registry

Creation of New Regional Registries

- An issue for the ASO
- Regional Registries are expected to be continental in scope
- Potential regional registries must demonstrate consensus in their region that they should be the regional registry for that region
  - A bit vague on how this is done

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Address Delegation Policies

- RFC 2050 provides the guidelines for address delegations.
- Goals of the Registry policies are:
  - Conservation
    - IPv4 is a limited resource
  - Routability
    - Limit the addition of new prefixeis to the routing system
  - Registration
    - Keep track of delegations
- The first two of these often conflict

Allocation Framework

- Addresses are allocated to LIRs for sub-delegation
  - Typically, this is address space delegated to ISPs so they can give their customers address space
  - Occasionally (at APNIC and ARIN), allocations are made to non-ISPs (confederations or national Internet registries)
- Allocations will be made by RIRs if the organization is at an Internet Exchange point or is multi-homed

Guidelines for Allocations

- Don’t break up a block
  - Assignments made from the allocation should be treated as “loans” of address space from an ISP to a customer
    - The customer should return the address space when they change providers
- Address space is allocated on CIDR boundaries
  - Sub-delegations should be aggregated
- LIRs sub-delegate based only on justified requirements
- Sub-delegations must be registered at the RIR
  - Known as “reassignments” or “SWIPs”

Slow-Start

- All RIRs use “slow-start” for allocations
  - Delegate a small block
  - Additional delegations occur when that block is consumed and reassigned
    - Typically doubling the amount of address space each time
- This policy is to improve address space utilization efficiency
  - Doesn’t conform to ISP market projections
    - Often a source of friction

Assignment Framework

- The delegation of address space to an end enterprise for its internal use
  - Address space is not sub-delegate as in the case of allocations
- Occurs from a RIR when
  - The organization is not connecting to an ISP and cannot use private address space
  - The organization is multi-homed
  - The request is very large
- All others should get address space from their ISP

Common Requirements

- Must document 25% immediate utilization, 50% utilization within 1 year
- Provide Network Engineering plans
  - Not business plans
  - Includes network deployment plans
  - Basically document how the address space will be used and when
- Reference previous delegation history (if any)

Specific Registry Quirks

- APNIC
  - May refer organizations to a national Internet registry
  - Confederations
- ARIN
  - Will not allocate address space unless the organization can demonstrate existing /21 utilization
  - May refer to a national Internet registry

Issues

- Divergent policies
  - What you get depends on where you are
- Registries-as-police
  - Registries have very few tools
- Scarcity vs. Routability
  - Which is most important
- IPv6

Summary

- IPv4 addresses are considered a limited resource that must be managed
- The Internet Registry system has evolved over time to provide that management
- Currently, 3 regional registries serve the world's address allocation needs
  - New regional registries are in the process of being formed
- Significant issues continue to face the registry system