IPv6

What is it? Why do we need it?
How do we use it?

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Agenda

- Network Addressing
- IPv4 Addressing
- DNS (Domain Name System)
- RIR (Regional Internet Registry)
- Subnets, CIDR, Routing, NAT
- IPv4 Tech
- IPv4 Depletion
- IPv6 Tech
- Next Steps

What is a Network Address?

- The Internet is basically millions of computers on the Internet communicating and sharing information – connected by routers, switches, etc
- Any computer on a network needs a network address in order to communicate with other computers
- Your house has an address so that utility companies, friends, etc can communicate with you (bills, post cards, etc).

What is an IP Address

- An *Internet Protocol (IP) address* is a unique number that identifies a device on the Internet.
- The popular IP addresses used today is version 4 (IPv4)
- IPv4 addresses are 32 bits in length but for human readable purposes they are divided into 4 groups of 8 bits called octets and converted to decimal form

Example of an IPv4 address

- 11010001010101011000000101100011
- 11010001. 01010101.10000001. 01100011
- 209.85.129.99

Who uses Internet IP addresses?

- Anyone that uses the Internet uses an IP address
- Every device directly connected to the Internet must have a unique IP address. They are used on home computers, web servers, routers, many handheld computers, cell phones, digital cameras, and other devices.

How do I get an Internet IP address?

- You most likely get an IP address from your Internet Service Provider (ISP). As a home Internet user, your ISP "dynamically" gives your computer a unique IP address to use while you're on the Internet.
- Once you've closed your session and no longer need the IP address, the ISP may assign the same IP address to another user on the network.
- In some cases, users with specific needs can get a unique block of IP addresses from an ISP or from a Regional Internet Registry (RIR) like ARIN.

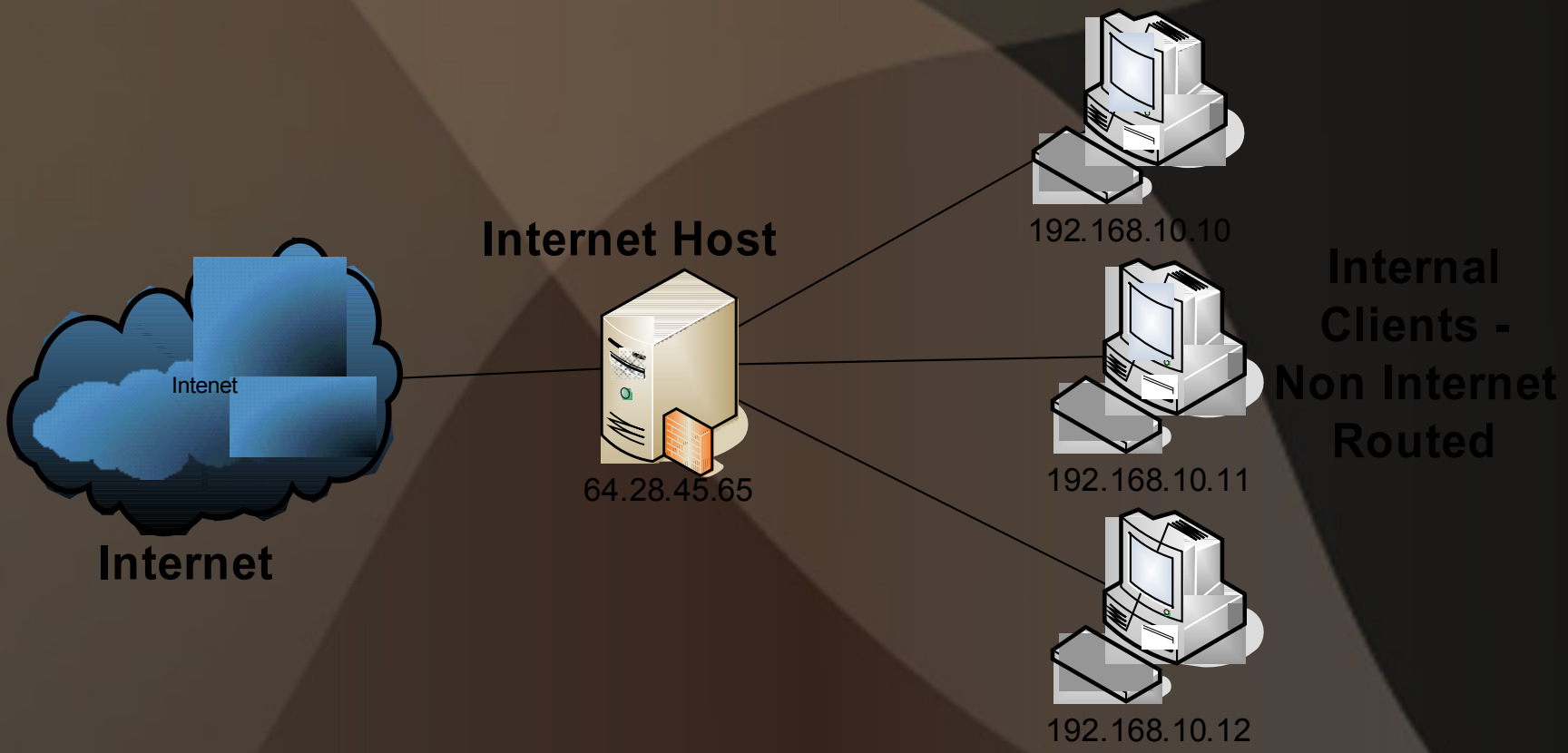
I am not putting my network on the Internet, can I use IP addresses for my network?

- Yes – You can use the same technology that is used for building the Internet to apply to your private network
- Called an Intranet

How can I easily convert my private network to connect to the Internet?

- You can either give each device an Internet IP address (very difficult these days) or you can employ technologies such as proxy or NAT (Network Address Translation)

Simple NAT/Proxy Example



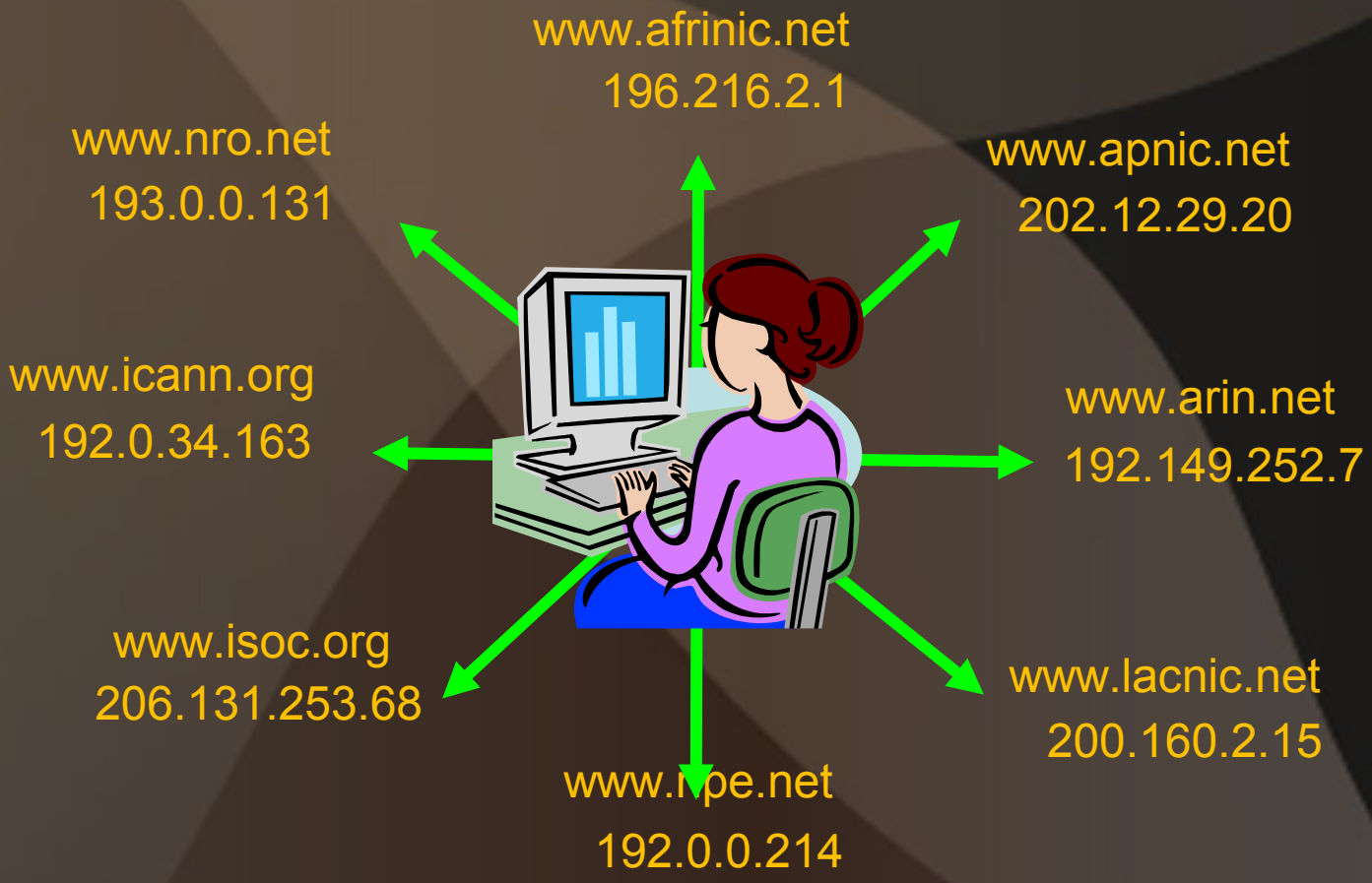
- No one “owns” IP addresses, so they’re not bought, sold, or traded.

Introducing DNS

- We do not need to remember IP addresses to get to web sites

- Eg www.google.tt, we do not normally type http://209.85.129.99 (although we could).

On the Internet, you are nothing but an IP address!



Domain Name System (DNS)

- A domain name is a label that people use to find points on the Internet without having to remember strings of numbers.
- An example of a domain name is www.arin.net
- While an IP address is not property and cannot be bought, sold, or traded, a domain name may be considered intellectual property.

IP Addresses are Not Domain Names

IP Address	Domain Name
Computer-friendly	People-friendly
Identifier	Reference
Unique number identifies computer on the Internet	Host name mapped to an IP address
Used for routing	Not used for routing

Questions so far?

RIR System

- The Regional Internet Registry (RIR) system began in 1992
- They are responsible for allocating IP addresses to customers
- There are five RIRs
- RIRs coordinate closely with the Internet Assigned Numbers Authority (IANA)
- RIRs are nonprofit organizations

The Regions

RIR Structure

Nonprofit	Membership-driven	Community-regulated
Fee for services, not resources	Open	Community-developed policies
100% community-funded	Broad-based	Member-elected executive boards
• Registration services • Organization services • Policy Services	• Public sector • Private sector • Civil society	Open and transparent

Anatomy of an IP address

- Although the IPv4 address is a 32 bit number, there is some structure to it.
- Every IP address can be divided into two parts:
  - A network address (network number/subnet)
  - A node address (within the network)
- The network and node address is determined using a **subnet mask**
- Therefore all nodes within the same subnet will have the same network number
- The network address is used by routers to detemine the destination of IP packets

Subnet Mask Example 1

- IP address: 192.168.100.40
- Subnet mask 255.255.255.0 ≡ /24 (CIDR)
- Means first 24 bits of the address is the network number: 192.168.100.0
- Last 8 bits (last octet) is the node number (40)
- All IP addresses within the subnet will be of the form 192.168.100.x
- 24 bits for the network address means 2^{24} possible networks with each network having approx. 2^{8} nodes

CIDR (Classless Inter-Domain Routing)

- Subnet mask 255.255.224.0
- Means first 19 bits of the address is the network number
- CIDR Convention: /19
- E.g. /8 means the network number is the first 8 bits => 16.7 million hosts in the network
- /8 ≡ 255.0.0.0

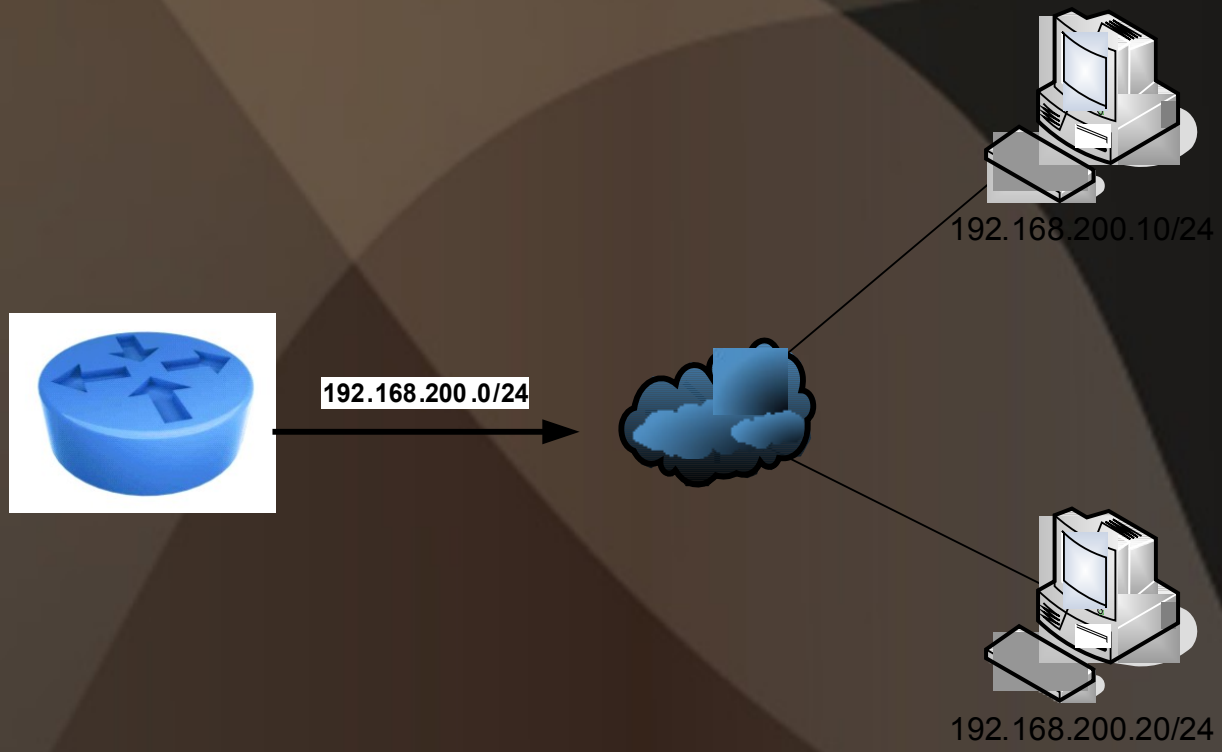
Subnet Mask Example 2

- 10.216.55.107
- Subnet mask 255.0.0.0 ≡ /8
- Means first 8 bits of the address is the network number: 10.0.0.0
- Last 24 bits is the node number 216.55.107
- All IP addresses within the subnet will be of the form 10.x.x.x
- 8 bits for the network address means 2^8 possible networks with each network having approx. 2^{24} nodes
- /8's are the largest networks that RIRs give out

Uses of Network Numbers

- The network number is comparable to the town or country of your address
- Used by routers to route packets more efficiently
- More efficient to route since the router keeps tracks of blocks or network addresses instead of individual addresses
- Therefore easier for a router to route 10.0.0.0/8 instead of the equivalent 16.7 million individual entries!
- Note that a subnet can be broken up into smaller subnets if needed.

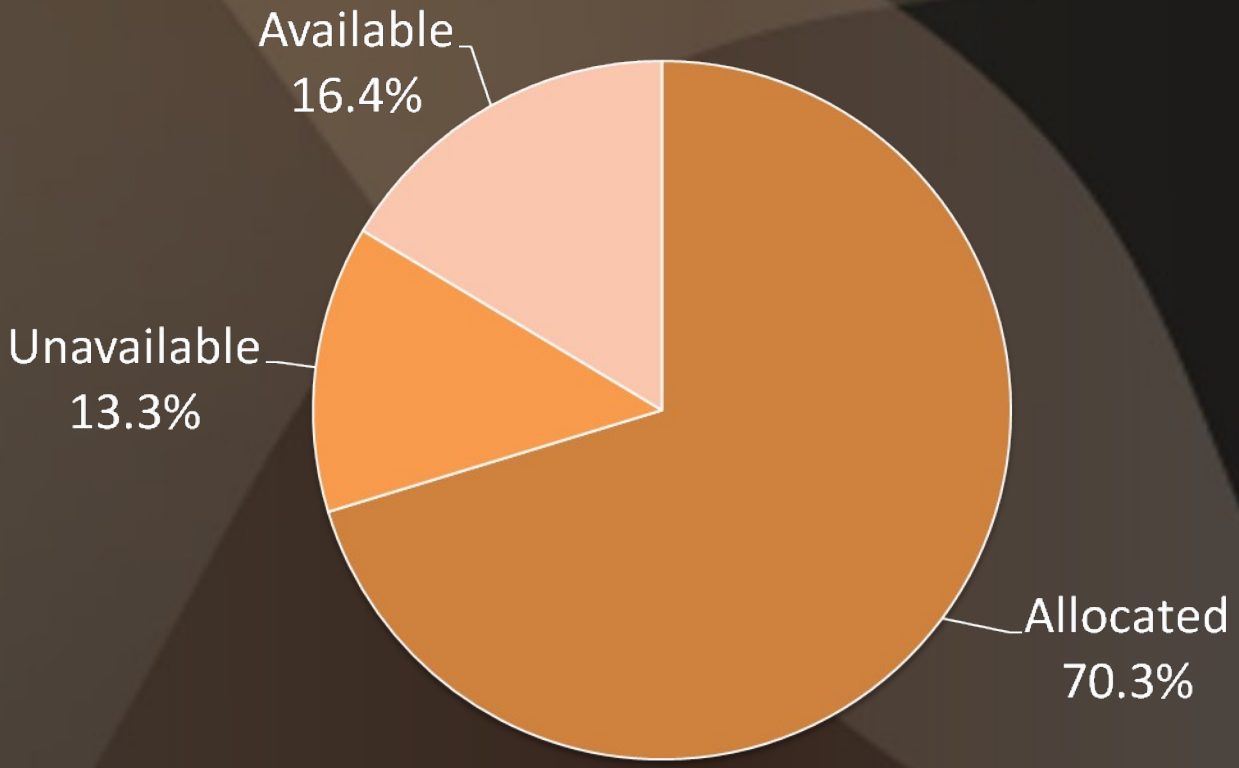
Simple Route Summarization Example

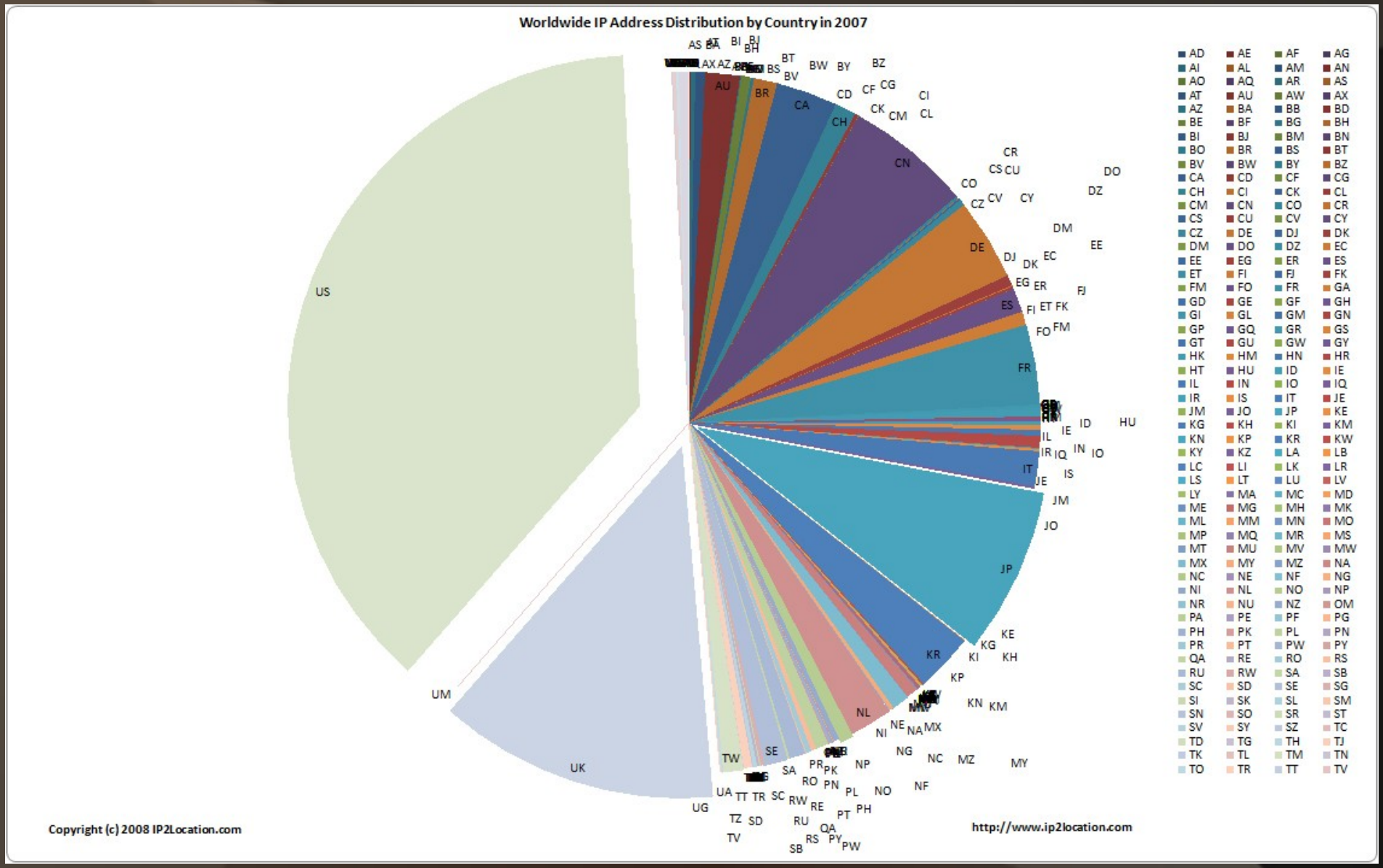


IPv4 Depletion

- Since IPv4 is a 32 bit number
- => there are $2^{32} \approx$ 4.2 Billion IPv4 addresses
- Removing special IP addresses e.g. loopback, non-routed (private), reserved, multicast, etc means there are significantly less than theoretical maximum
- There are 256 x /8 addresses available in the world but some are reserved
- 7 billion people ?!?! - Note that **China** and **India** are barely online !

IPv4 – Internet Address Space Utilization




Worldwide IP Address Distribution by Country in 2007
US
UM
UK
AU
BR
CA
CH
CN
DE
ES
FR
IT
JP
KR
NL
TW
SE
SA
UA
UG
AD AE AF AG
AI AL AM AN
AO AQ AR AS
AT AU AW AX
AZ BA BB BD
BE BF BG BH
BI BJ BM BN
BO BR BS BT
BV BW BY BZ
CA CD CF CG
CH CI CK CL
CM CN CO CR
CS CU CV CY
CZ DE DJ DK
DM DO DZ EC
EE EG ER ES
ET FI FJ FK
FM FO FR GA
GD GE GF GH
GI GL GM GN
GP GQ GR GS
GT GU GW GY
HK HM HN HR
HT HU ID IE
IL IN IO IQ
IR IS IT JE
JM JO JP KE
KG KH KI KM
KN KP KR KW
KY KZ LA LB
LC LI LK LR
LS LT LU LV
LY MA MC MD
ME MG MH MK
ML MM MN MO
MP MQ MR MS
MT MU MV MW
MX MY MZ NA
NC NE NF NG
NI NL NO NP
NR NU NZ OM
PA PE PF PG
PH PK PL PN
PR PT PW PY
QA RE RO RS
RU RW SA SB
SC SD SE SG
SI SK SL SM
SN SO SR ST
SV SY SZ TC
TD TG TH TJ
TK TL TM TN
TO TR TT TV
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http://www.ip2location.com

Summarization of Statistics

RIRs are consistently allocating over 10 /8s per year

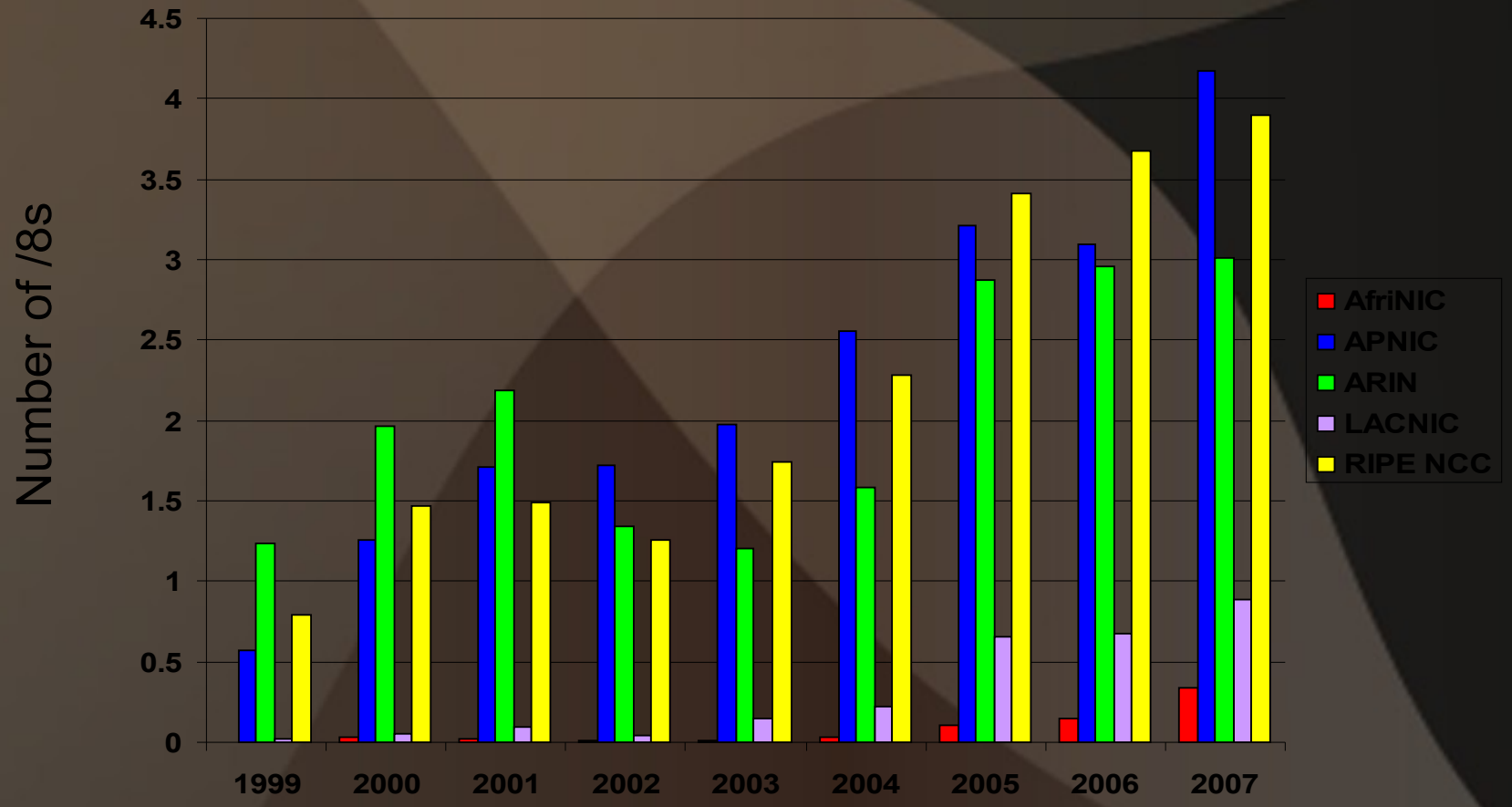
The RIRs collectively allocated over 12 /8s for the first time in 2007

Number of /8s remaining in IANA's unallocated pool:

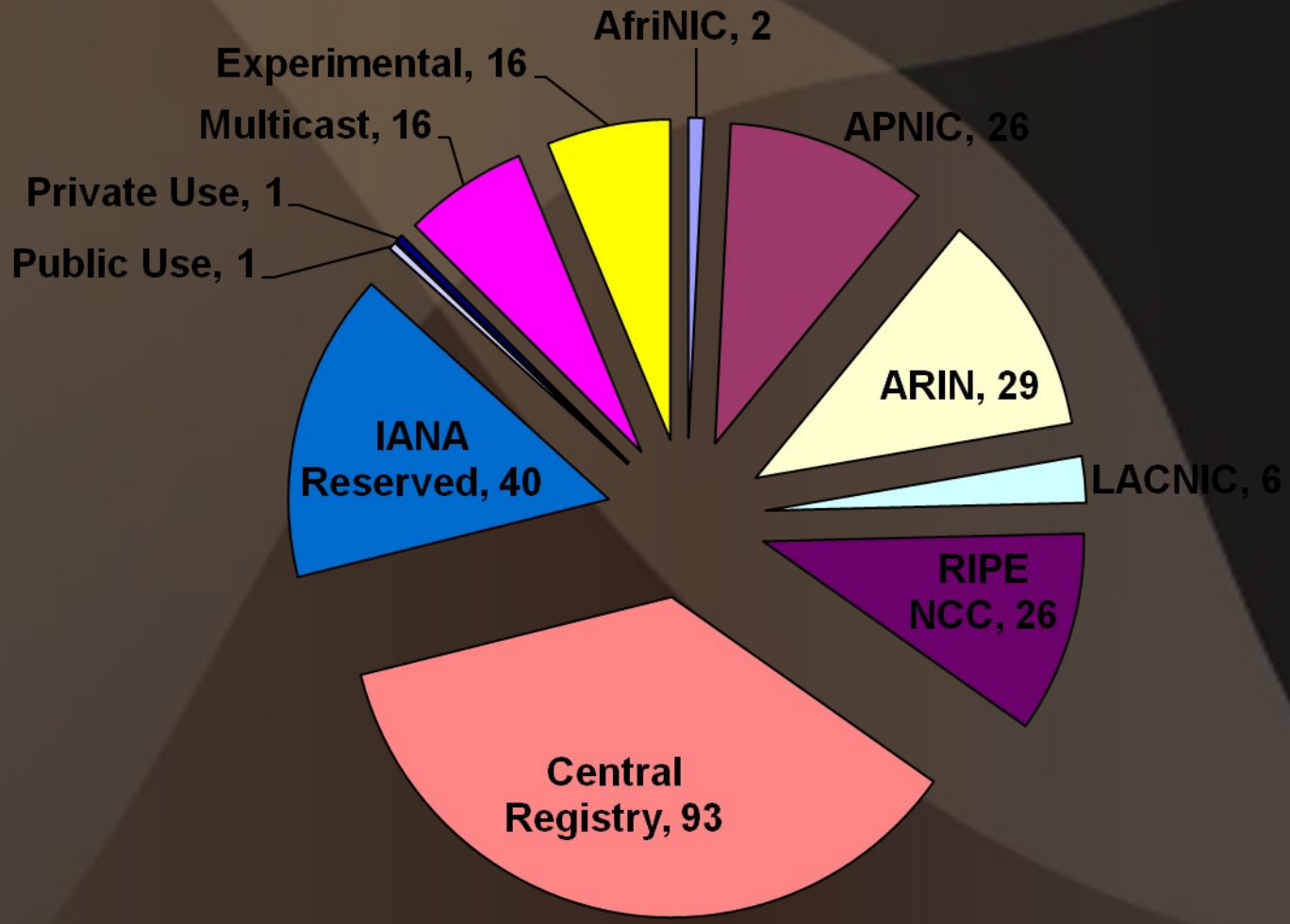
/8 = 16,777,216 IP addresses

IPv4 Allocations
RIRs to LIRs/ISPs

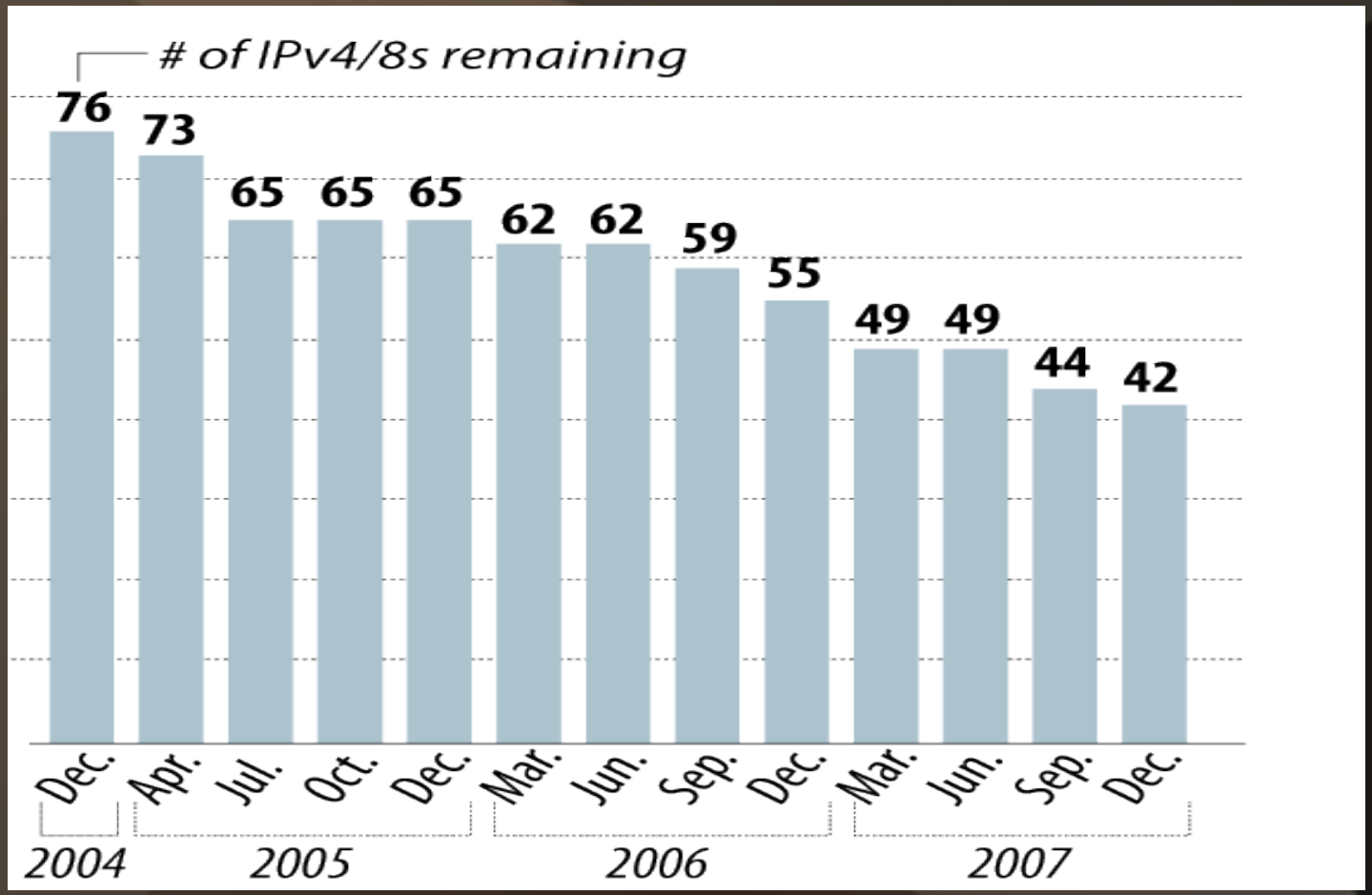
Yearly Comparison



Status of 256 /8s IPv4 Address Space



IPv4 - Address Space Trend



/8 = 16,777,216 IP addresses.

Projections

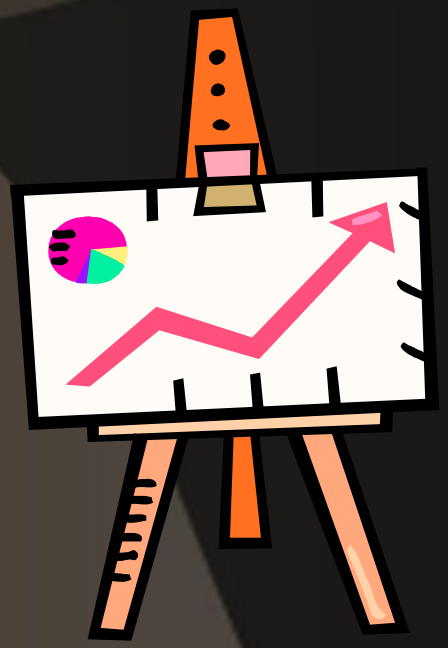
- ARIN makes no predictions
  - But we watch others' predictions closely
- What we know
  - RIRs allocated 13 /8s last year
  - There are 42 /8s left as of December 31
  - Allocation requests may increase as demand continues

Situation

- Current Source of Contiguous Address Space is IPv4
- This Supply is Diminishing

The Simple Solution

- Get New Source of Contiguous Address Space
- This Supply is IPv6



What Could Happen?

- IPv4 Demand Continues
- Frantic IPv6 Deployment
- NAT Use Increases

Why Are NATs Not Adequate?

- they won't work for large numbers of "servers", i.e., devices that are "called" by others (e.g., IP phones)
- they break most current IP multicast and IP mobility protocols
- they break many existing applications
- they limit the market for new applications and services
- they compromise the performance, robustness, security, and manageability of the Internet

The Bottom Line

- We’re running out of IPv4 address space.

Questions?

IPv6

- Whilst IPv4 is a 32 bit address, IPv6 is a 128 bit address
- What is 2^{128} ?
- 340 billion-billion-billion-billion IP addresses
- Is it enough?

IPv4 and IPv6

Internet Protocol version 4	Internet Protocol version 6
32-bit* number	128-bit* number
Dotted Decimal Notation *199.43.0.202*	Hexadecimal Notation *2001:500:4:1::80*
~4 billion IP addresses	340 billion-billion-billion-billion IP addresses

IPv6 notation

- Written as 8 groups of 4 hexadecimal numbers separated by colons
- One all zero contiguous block can be represented by a double colon ::
- Examples:
  - 2001:0dB8:ac10:fe01:abcd:567a:edca:8543
  - 2001:0db8:0000:0000:0000:ac10:f00d:3212
  - 2001:0db8::ac10:f00d:3212

IPv6 pool size compared to IPV4

"If all of IPv4 could fit in an iPOD, then IPv6 is the size of the entire earth"

Allocation of Internet IPv6

- For an organisarion (non-ISP) applying for a block of IPv6, the standard block is a /48
- /48 means 48 bits for the network address, and 128-48 = 80 bits for the host number
- This means that a standard block of addresses has enough for 2^{80} hosts
- 2^{80} = 1,208,925,819,614,629,174,706,176

- An ISP gets a /32 block
- /32 means 128-32 = 96 bits for the host
- 2^{32} = 79,228,162,514,264,337,593,543,950,336

- ccTLDs (.tt, .us, jm, .etc) – get a /48 block
  - Montserrat is the only ccTLD in the Caribbean that applied for theirs

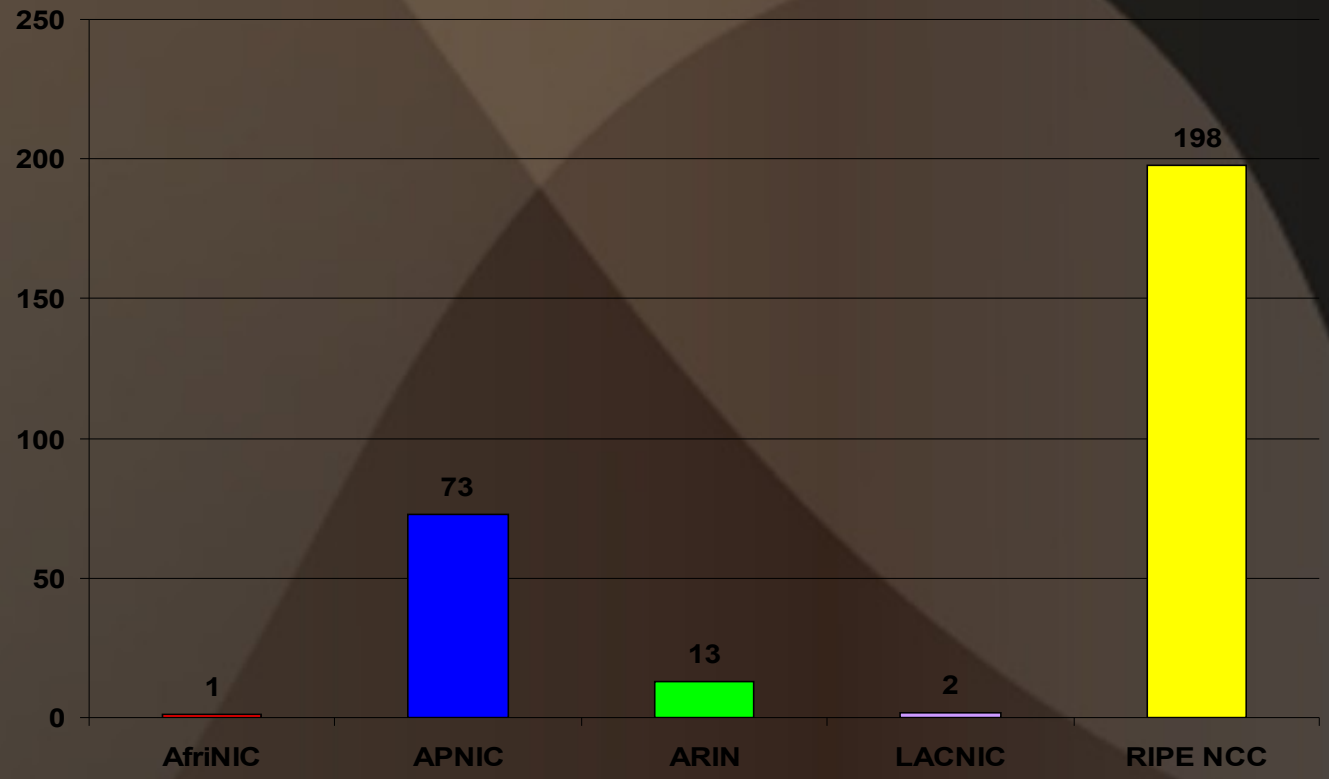
Why so many Addresses?

- Removal of dependency on NAT
  - Every device can easily have an Internet IPv6 address
  - When you connect to TSTT, you should get a block of addresses instead of just one
  - Static addresses for life should be more than possible
- Applications never before imagined
  - Nanobot addressing
  - Can put messages in an IPv6 addresses without adding to the payload
  - Interplanetary routing

- **Some persons have claimed that a /48 for customers is not enough!**

IANA IPv6 Allocations to RIRs

issued as /23s prior to Oct 06



IANA IPv6 Allocations to RIRs

issued Oct 06

RIR	IPv6 Address
AfriNIC	2C00:0000::/12
APNIC	2400:0000::/12
ARIN	2600:0000::/12
LACNIC	2800:0000::/12
RIPE NCC	2A00:0000::/12

Some /23s from the previous slide are incorporated in these /12s

Regionally: Can our organisation apply for a block of IPv6?

- NO – LACNIC is currently giving out to ISPs only
- There is a US$2,500 processing fee once the application is approved
- But ARIN is giving their blocks for FREE!

What can we do?

- Organisations:
  - Lobby to your ISPs for IPv6 addresses – Dynamic addresses should be made extinct
  - Find out if your ISP can route IPv6 addresses
  - When available, apply for your IPv6 block and let your ISP know what you are doing

What can we do?

- Research IPv6 – Begin testing to prepare for IPv6 readiness – software and hardware upgrades:
  - Routers, Switches, Firewalls
  - Hosts (PCs, Servers)
  - Application Software
  - Network Management Software

What can we do?

- Since IPv6 is a totally separate network protocol, you can have it running concurrently on your PC and Server
- IT Staff and CSR Training

Your Next Steps when you get IPv6

- Make mail and web servers reachable via IPv6 in addition to IPv4
- Introduce IPv6 support into your product cycle as soon as possible
- Encourage customers to use IPv6 and test their applications over it as soon as possible.

- Home Users
  - Ask your ISP about IPv6 readiness
  - Find out if your PC, Cable Modem, Wireless Router, Cell Phone, etc is IPv6 ready
  - How easy can it be configured?
    - Grandmother?

Does the previous tips sound familiar?

Y2K?

Y2K? Maybe/Maybe not

- Moving target – estimated to exhaust in 3 years at present rate of consumption
- Maybe just an inconvenience?
  - Machines running IPv4 alone can only connect to IPv4 machines
  - Machines running IPv4 alone can only connect to IPv4 machines
  - Machines with both IPv4 and IPv6 can connect to either
  - DNS is the key (A, AAAA records)

What the Future Holds

- The Internet will have two IP versions at the same time (IPv4 & IPv6) - this is the “dual-stack” approach.
- For a brief while, IPv6 poses no benefit at all and real work to support (as all customers who have IPv6 also have IPv4)
- At some point, there will be IPv6-only Internet users being connected by the ISP community
- Your content clients are not going to accept not being reachable to newer Internet customers, and will find a way to fix this quickly.

Consequences

- Today, there are organizations attempting to reach mail and web servers via IPv6.
- In the near future, there will be organizations that have NO CHOICE but to reach mail and web servers via IPv6.

Consequences

- No Access to Internet Services
  - IPv6-only Networks
  - IPv6-only Users
- Routing Table Fragmentation
  - NAT Use Increase
  - Other Markets Develop

Web Links

- http://www.getipv6.info
- http://www.ttcsweb.org/ipv6
- www.arin.net
- www.lacnic.net
- http://www.nro.net/statistics/index.html

Questions?

Thank You