

SHARKFEST '12

Wireshark Developer and User Conference

IPv6 Address Planning

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Agenda

- IPv4 address planning
- IPv6 address planning
- How to get an IPv6 address range (ARIN)

IPv4 Address Planning

- In 1993, IETF introduced classless interdomain routing (CIDR) (RFC 1517). CIDR allowed the following:
 - More efficient use of IPv4 address space
 - **Prefix aggregation**, which reduced the size of routing tables
- The network portion of the address is determined by the network subnet mask, also known as the **network prefix**, or prefix length (/8, /19, and so on).
- We use variable length subnet masks (VLSM) to break out the addresses.

Common Masks

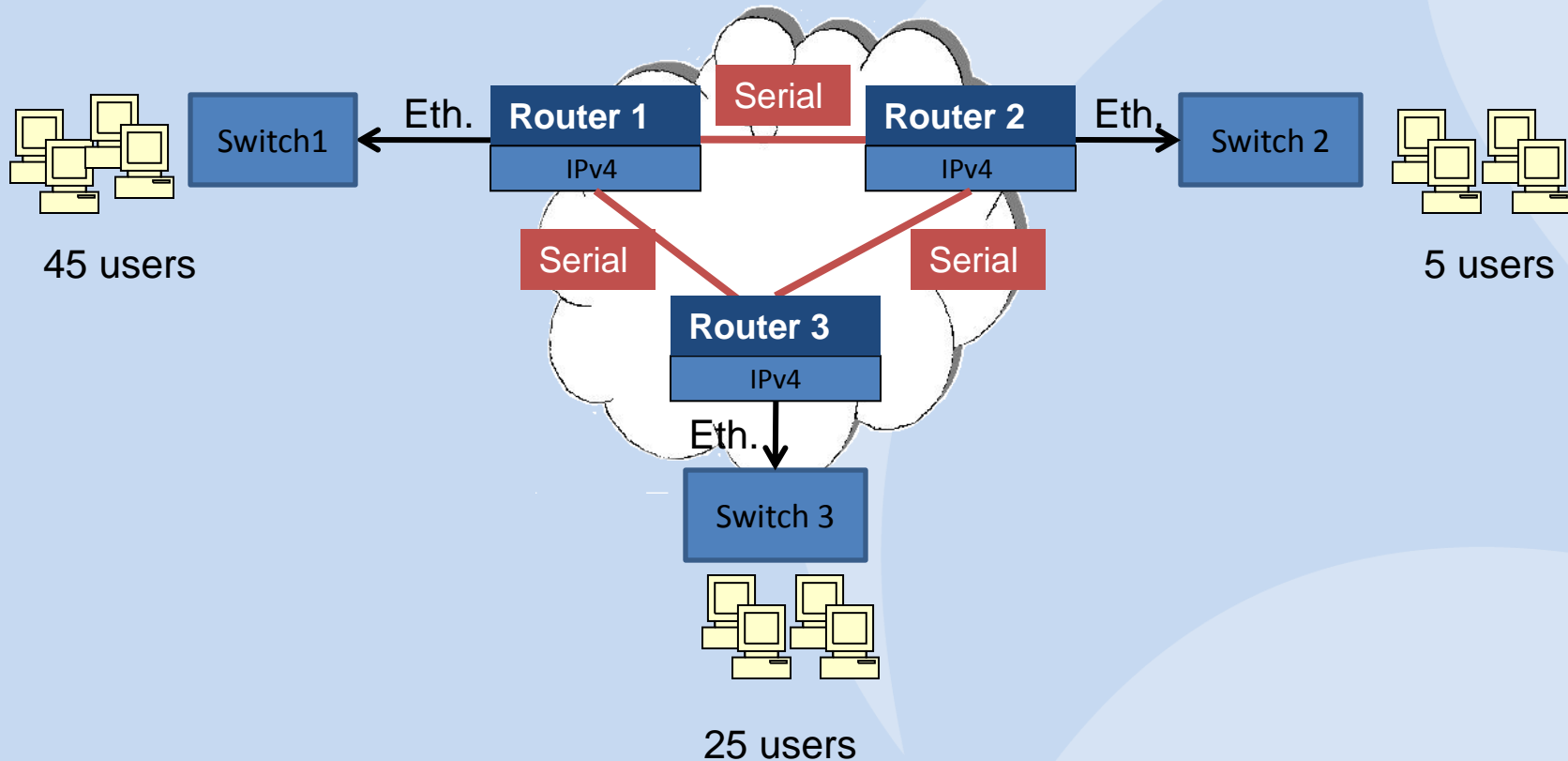
/30 (255.255.255.252) 4 hosts
/24 (255.255.255.0) 256 hosts
/16 (255.255.0.0) 65,536 hosts
/8 (255.0.0.0) 16,777,216 hosts

11111111.00000000.00000000.00000000	/8 (255.0.0.0)	16,777,216 hosts
11111111.10000000.00000000.00000000	/9 (255.128.0.0)	8,388,608 hosts
11111111.11000000.00000000.00000000	/10 (255.192.0.0)	4,194,304 hosts
11111111.11100000.00000000.00000000	/11 (255.224.0.0)	2,097,152 hosts
11111111.11110000.00000000.00000000	/12 (255.240.0.0)	1,048,576 hosts
11111111.11111000.00000000.00000000	/13 (255.248.0.0)	524,288 hosts
11111111.11111100.00000000.00000000	/14 (255.252.0.0)	262,144 hosts
11111111.11111110.00000000.00000000	/15 (255.254.0.0)	131,072 hosts
11111111.11111111.00000000.00000000	/16 (255.255.0.0)	65,536 hosts
11111111.11111111.10000000.00000000	/17 (255.255.128.0)	32,768 hosts
11111111.11111111.11000000.00000000	/18 (255.255.192.0)	16,384 hosts
11111111.11111111.11100000.00000000	/19 (255.255.224.0)	8,192 hosts
11111111.11111111.11110000.00000000	/20 (255.255.240.0)	4,096 hosts
11111111.11111111.11111000.00000000	/21 (255.255.248.0)	2,048 hosts
11111111.11111111.11111100.00000000	/22 (255.255.252.0)	1,024 hosts
11111111.11111111.11111110.00000000	/23 (255.255.254.0)	512 hosts
11111111.11111111.11111111.00000000	/24 (255.255.255.0)	256 hosts
11111111.11111111.11111111.10000000	/25 (255.255.255.128)	128 hosts
11111111.11111111.11111111.11000000	/26 (255.255.255.192)	64 hosts
11111111.11111111.11111111.11100000	/27 (255.255.255.224)	32 hosts
11111111.11111111.11111111.11110000	/28 (255.255.255.240)	16 hosts
11111111.11111111.11111111.11111000	/29 (255.255.255.248)	8 hosts
11111111.11111111.11111111.11111100	/30 (255.255.255.252)	4 hosts
11111111.11111111.11111111.11111110	/31 (255.255.255.254)	2 hosts
11111111.11111111.11111111.11111111	/32 (255.255.255.255)	"Host Route"

IPv4 Allocation

IP Space available: 195.25.7.0 /24

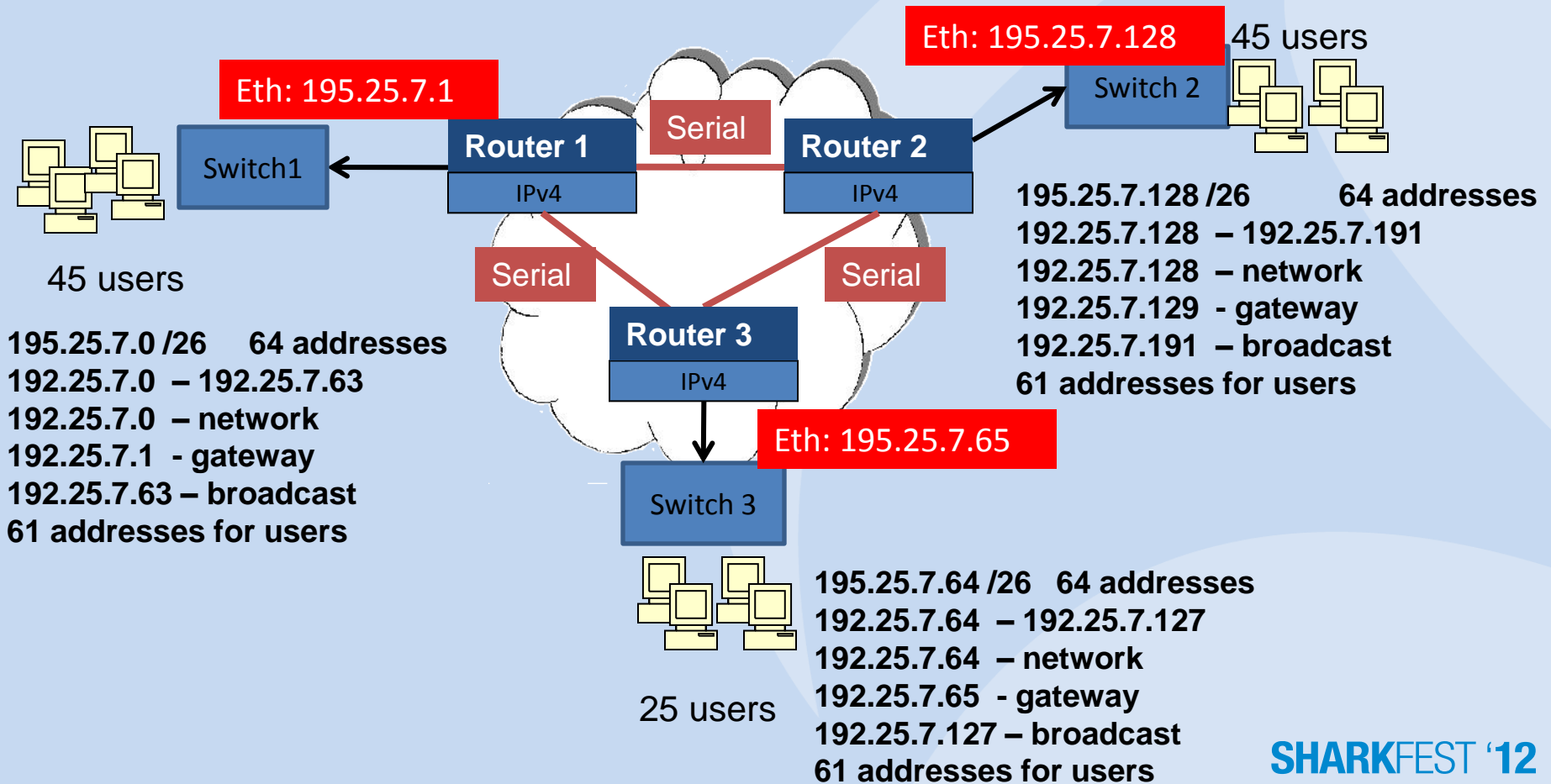
11111111.11111111.11111111.00000000 /24 (255.255.255.0) 256 addresses



Let's Assign Some Addresses

IP Space available: 195.25.7.0 /24

11111111.11111111.11111111.00000000 /24 (255.255.255.0) 256 addresses



Let's Do the Serial Links

IP Space available: 195.25.7.0 /24

11111111.11111111.11111111.00000000 /24 (255.255.255.0) 256 addresses

Eth: 195.25.7.1



Switch1

45 users

Router 1

IPv4

S1 - 192.25.7.193

Serial - Net0

S0 - 192.25.7.194

Router 3

IPv4

Eth: 195.25.7.65

Switch 3



25 users

Serial - Net 4

Router 2

IPv4

Serial - Net 8

Eth: 195.25.7.128

Switch 2



45 users

Net0

195.25.7.192 /30

4 addresses

192.25.7.192 - 192.25.7.195

192.25.7.192 - network

192.25.7.193 - Router1 (S1)

192.25.7.194 - Router3 (S0)

192.25.7.195 - broadcast

Simple IPv6 Allocation Scheme

- Let's assume you are given: 2001:4801:1BFD:: /48
- You are a nationwide company with 50 regions, 500 offices in each region, and 100 departments in each office.
- So, start with your initial allocation as shown below.

/48

```
11111111111111111111.11111111111111111111.  
11111111111111111111. xxxxxxxxxxxxxxxxxxxx.  
xxxxxxxxxxxxxxxxxxxx. xxxxxxxxxxxxxxxxxxxx.  
xxxxxxxxxxxxxxxxxxxx. xxxxxxxxxxxxxxxxxxxx
```

2001:4801:1BFD

Define Regions

- Step 1: Let's make all the regions /56. You have then 255 possible regions. Only have 50, but there is room for growth.
- The range is: 2001:4801:1BFD:00xx:: - 2001:4801:1BFD:FFxx::

/56

```
11111111111111111111 . 11111111111111111111 .  
11111111111111111111 . 11111111111111111111 .  
XXXXXXXXXXXXXXXXXXXX . XXXXXXXXXXXXXXXXXXXX .  
XXXXXXXXXXXXXXXXXXXX . XXXXXXXXXXXXXXXXXXXX
```

- For example:
 - Alabama: 2001:4801:1BFD:00xx::
 - Alaska: 2001:4801:1BFD:01xx::
 - Arizona: 2001:4801:1BFD:02xx::
 - California: 2001:4801:1BFD:03xx::

Define Offices

- Step 2: Let's make all the offices /64. You have then 65535 possible offices per region. Currently, there are only 500 per region, but there is room for growth.
- The range is: 2001:4801:1BFD:0000:: - 2001:4801:1BFD:FFFF::

/64

```
11111111111111111111 . 11111111111111111111 .  
11111111111111111111 . 11111111111111111111 .  
XXXXXXXXXXXXXXXXXXXXX . XXXXXXXXXXXXXXXXXXXXX .  
XXXXXXXXXXXXXXXXXXXXX . XXXXXXXXXXXXXXXXXXXXX
```

```
0000:0000:0000:0000::  
FFFF:FFFF:FFFF:FFFF::
```

- For example, in California:
 - Oakland: 2001:4801:1BFD:0301::
 - Carmel Valley: 2001:4801:1BFD:0302::
 - Moraga: 2001:4801:1BFD:0303::
 - San Diego: 2001:4801:1BFD:0304::

Define Employees

- Step 3: Each office has a lot of flexibility. They may want to give each department a /72. You have then 65535 possible departments per office.
- The range is: 2001:4801:1BFD:0000:00xx:: - 2001:4801:1BFD:FFFF:FFxx::

/72

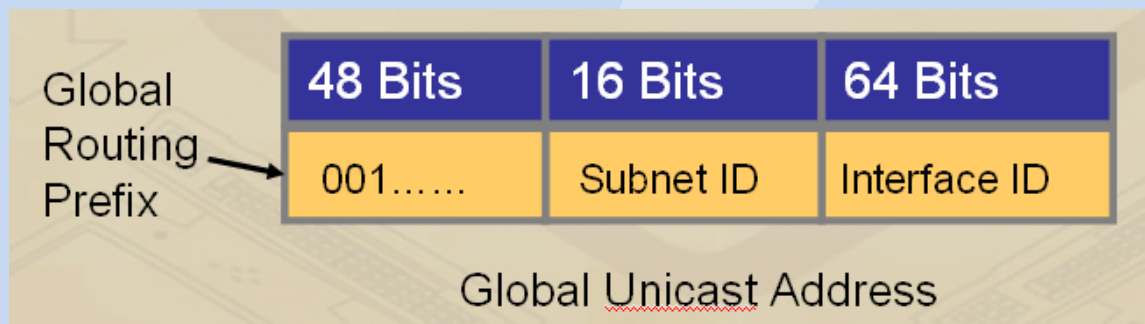
```
11111111111111111111.11111111111111111111.  
11111111111111111111.11111111111111111111.  
1111111111xxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxx.  
xxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxx
```

```
0000:0000:0000:0000:00xx::  
FFFF:FFFF:FFFF:FFFF:FFxx::
```

- For example, the Carmel Valley office:
 - Payroll: 2001:4801:1BFD:0302:00xx:
 - Engineering: 2001:4801:1BFD:0302:01xx:
 - Shipping: 2001:4801:1BFD:0302:02xx:
 - Sales: 2001:4801:1BFD:0302:03xx:

But wait! 64-bit Interface ID

- This is the format of a Global Unicast Address!
- We have to try to save 64 bits for the Interface ID.



Let's Make Some Rules

1. Use /49 - /63 for addressing structure.

ARIN - Aggregation

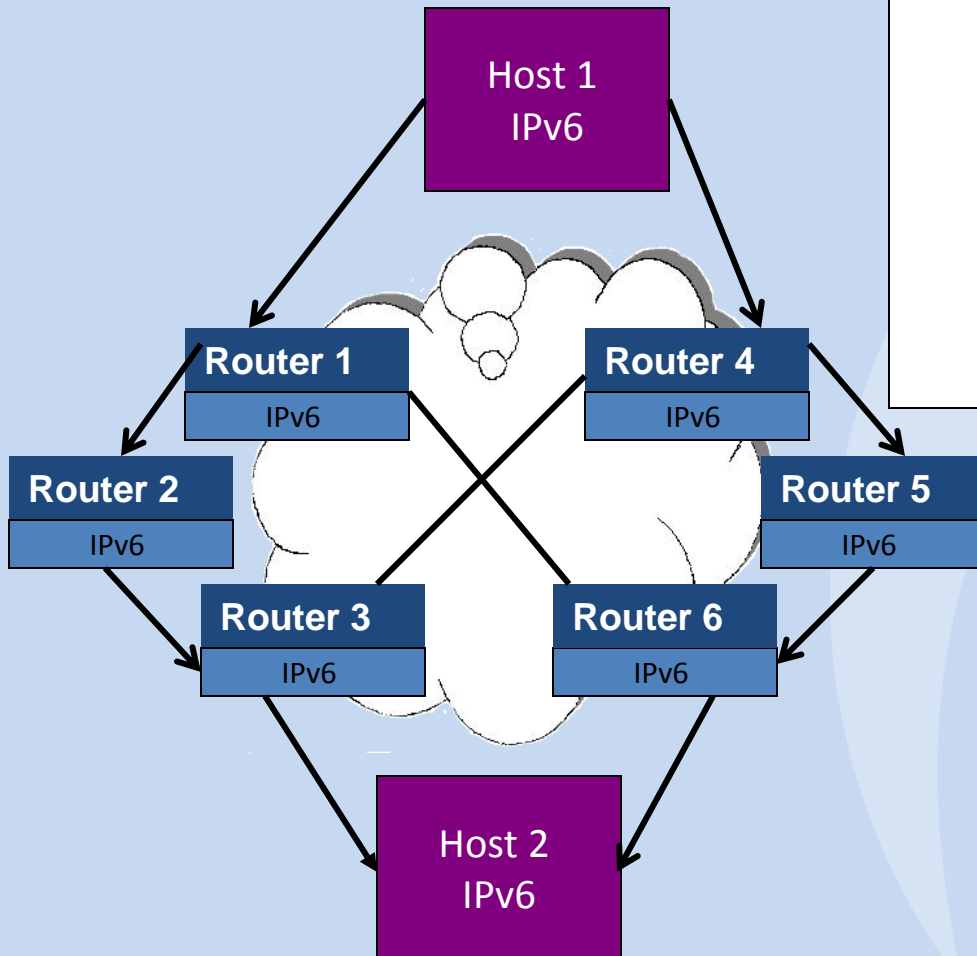
From: Goals of IPv6 address space management

Aggregation

- Wherever possible, address space should be distributed in a hierarchical manner, according to the topology of network infrastructure. This is necessary to permit the aggregation of routing information by ISPs, and to limit the expansion of Internet routing tables.
- This goal is particularly important in IPv6 addressing, where the size of the total address pool creates significant implications for both internal and external routing.
- IPv6 address policies should seek to avoid fragmentation of address ranges.

- Another rule(?) from ARIN?
- Aggregate – don't fragment.
- Why?

What Can We Aggregate?

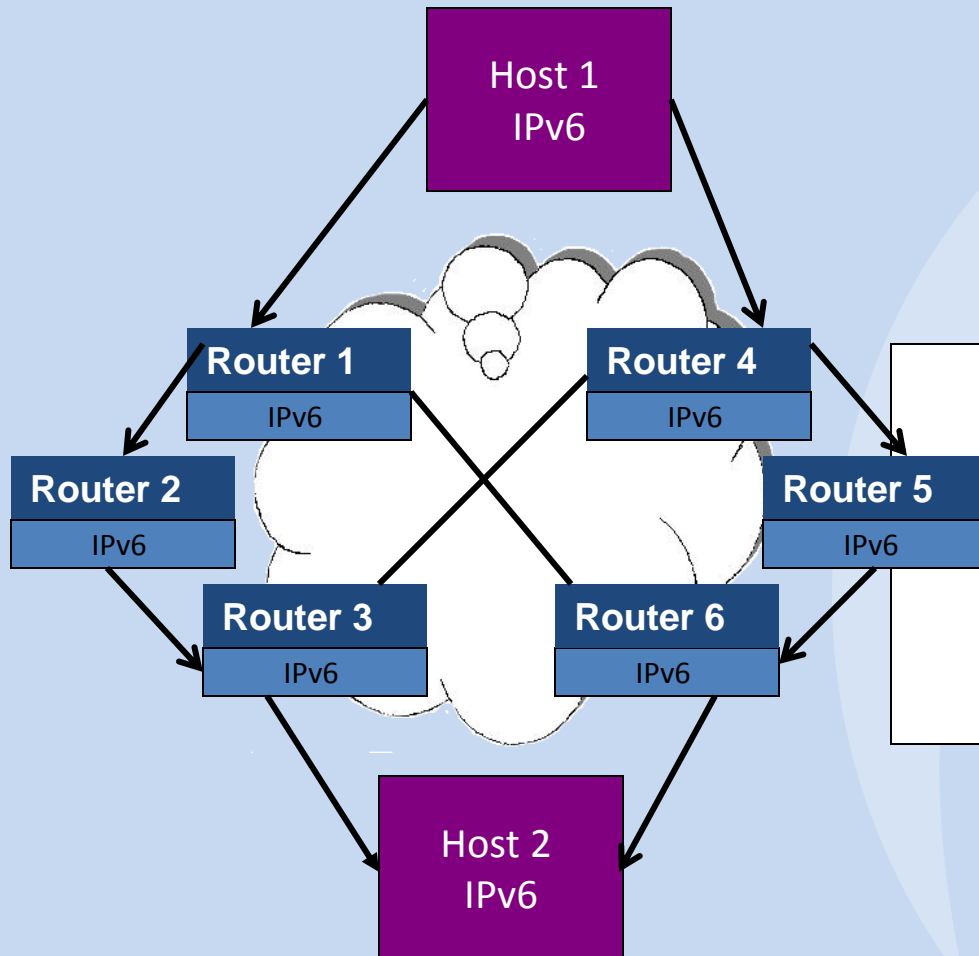


```
Router 1: 2001:4801:1BFD:0301::  
Router 2: 2001:4801:1BFD:0302::  
Router 3: 2001:4801:1BFD:0303::  
Router 4: 2001:4801:1BFD:0401::  
Router 5: 2001:4801:1BFD:0402::  
Router 6: 2001:4801:1BFD:0403::
```

Let's Add To Our Rules

1. Use /49 - /63 for addressing structure.
2. Aggregate – don't fragment

More Address Assignment Policy Ideas



- Using existing systems
 - translate the existing subnet number into IPv6 subnet id
 - translate the VLAN id into IPv6 subnet id

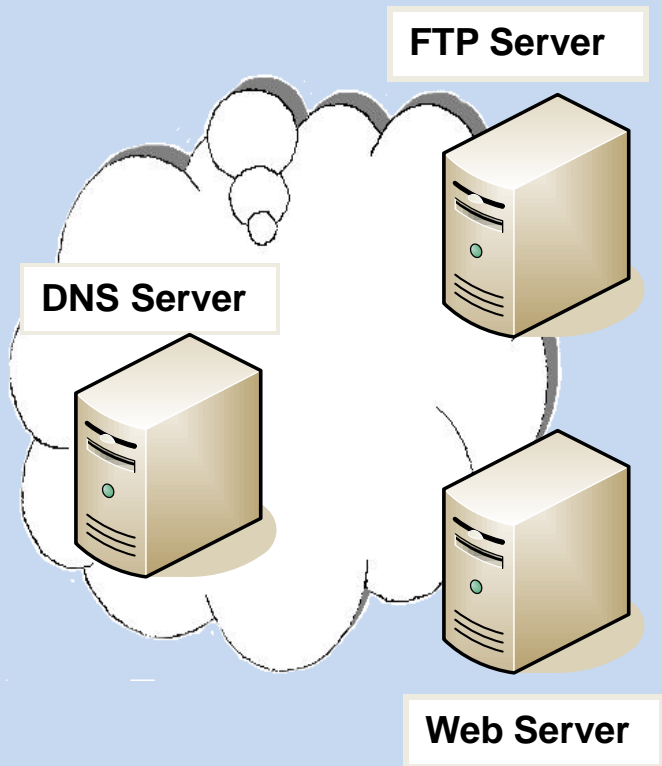
```
Router 1: 2001:4801:1BFD:0096::
Router 2: 2001:4801:1BFD:0097::
Router 3: 2001:4801:1BFD:0100::
Router 4: 2001:4801:1BFD:0101::
Router 5: 2001:4801:1BFD:0102::
Router 6: 2001:4801:1BFD:0103::
```

- What are the implications for route aggregation?
- Any benefits?

Other Ways to Assign

- Geographical Boundaries - by assigning a common prefix to all subnets within a geographical area
- Organizational Boundaries - by assigning a common prefix to an entire organization or group within a corporate infrastructure
- Service Type - by reserving certain prefixes for predefined services such as: VoIP, Content Distribution, wireless services, Internet Access, Security areas etc. This type of addressing may create dependencies on IP addresses that can make renumbering harder if the nodes or interfaces supporting those services on the network are sparse within the topology.

Security Considerations



```
FTP Server 1:2001:4801:1bfd:03df::
FTP Server 2:2001:4801:1bfd:04df::
DNS Server 1:2001:4801:1bfd:03aa::
DNS Server 2:2001:4801:1bfd:04aa::
Web Server 1:2001:4801:1bfd:0322::
Web Server 2:2001:4801:1bfd:0422::
```

- Aggregation for routing (If you allocate at random (or without thought), then you will get many routing table entries)
- But...if you allocate in a pattern, then a hacker can easily deduce your topology.
- DHCPv6 servers can serve to provide addresses for FTP, other servers. These addresses can be privacy addresses.

Another Rule?

1. Use /49 - /63 for addressing structure.
2. Aggregate – don't fragment.
3. Remember security!

Slightly Smarter Allocation Scheme

- Let's revisit our simple addressing scheme.
- Assume you are given: 2001:4801:1BFD:: /48
- You are a nationwide company with 50 regions, 500 offices in each region, and 100 departments in each office.
- So, start with your initial allocation as shown below.

/48

```
11111111111111111111.11111111111111111111.  
11111111111111111111. xxxxxxxxxxxxxxxxxxxxxx.  
xxxxxxxxxxxxxxxxxxxxxxxx. xxxxxxxxxxxxxxxxxxxxxx.  
xxxxxxxxxxxxxxxxxxxxxxxx. xxxxxxxxxxxxxxxxxxxxxx
```

2001:4801:1BFD

Define Regions by Geography

- Step 1: We have 50 regions, but we may have 10 'super' regions divided according to geography. We can make these a /56. You have then 255 possible 'super' regions.
- The range is: 2001:4801:1BFD:00xx:: - 2001:4801:1BFD:FFxx::

/56

```
11111111111111111111 . 11111111111111111111 .  
11111111111111111111 . 11111111111111111111 .  
XXXXXXXXXXXXXXXXXXXX . XXXXXXXXXXXXXXXXXXXX .  
XXXXXXXXXXXXXXXXXXXX . XXXXXXXXXXXXXXXXXXXX
```

- For example:
 - Southeast: 2001:4801:1BFD:00xx::
 - Northeast: 2001:4801:1BFD:01xx::
 - MidWest: 2001:4801:1BFD:02xx::
 - PacificCoast: 2001:4801:1BFD:03xx::

This addressing scheme may serve the goal of route aggregation better than the first scheme.

Can We Learn From the Past?

Prefix aggregation problems / Alain Durand

Alain Durand spoke on routing anomalies that he has observed in the running 6bone.

- Inconsistency in method of aggregation. Too many routes.
- Backdoor routes...leads to looping, requires additional routes to suppress.
- Unaggregated advertisements (might have been one-time blip)
- "Weird" prefixes...typos, incorrect scope. Alain noted that site-local prefix could use a tighter definition. His conclusion...160 routes today, could easily be cut to 95 through better aggregation.

6BONE Address Problems:

- No organized hierarchical addressing structure.
- No correlation between DNS structure and addressing structure.
- No correlation between 6bone topology and addressing structure.

Allocate from the Left or Right?

Last prefix allocated:	<input type="text" value="2001:4801:1BFD:0001::/56"/>
Number of bits (range):	<input type="text" value="16"/>
Bit Allocation Algorithm:	<input type="radio"/> leftmost <input type="radio"/> centermost <input checked="" type="radio"/> rightmost
Number of prefixes to generate:	<input type="text" value="10"/>
Output format	<input checked="" type="radio"/> HTML Table <input type="radio"/> txt
<input type="button" value="Show Prefix Allocations"/> <input type="button" value="Reset"/>	


- The web site : <http://www.ipv6book.ca/allocation.html> provided by Mark Blanchet provides a free web tool which will allow you to create a set of IPv6 addresses.
- Mark Blanchet wrote RFC 3531 which describes allocations from the left rather than the right.
- Let's see how this might work.

Allocating from the Right

Last prefix allocated:	<input type="text" value="2001:4801:1BFD:0001::/56"/>
Number of bits (range):	<input type="text" value="16"/>
Bit Allocation Algorithm:	<input type="radio"/> leftmost <input type="radio"/> centermost <input checked="" type="radio"/> rightmost
Number of prefixes to generate:	<input type="text" value="10"/>
Output format	<input checked="" type="radio"/> HTML Table <input type="radio"/> txt
<input type="button" value="Show Prefix Allocations"/> <input type="button" value="Reset"/>	

1	2001:4801:1bfd:101::/56
2	2001:4801:1bfd:201::/56
3	2001:4801:1bfd:301::/56
4	2001:4801:1bfd:401::/56
5	2001:4801:1bfd:501::/56
6	2001:4801:1bfd:601::/56
7	2001:4801:1bfd:701::/56
8	2001:4801:1bfd:801::/56
9	2001:4801:1bfd:901::/56
10	2001:4801:1bfd:a01::/56

Allocating from the Left

Last prefix allocated:	<input type="text" value="2001:4801:1BFD:0001::/56"/>
Number of bits (range):	<input type="text" value="16"/> 
Bit Allocation Algorithm:	<input checked="" type="radio"/> leftmost <input type="radio"/> centermost <input type="radio"/> rightmost
Number of prefixes to generate:	<input type="text" value="10"/>
Output format	<input checked="" type="radio"/> HTML Table <input type="radio"/> txt

Show Prefix Allocations

Reset

1	2001:4801:1b03:1::/56
2	2001:4801:1b83:1::/56
3	2001:4801:1b43:1::/56
4	2001:4801:1bc3:1::/56
5	2001:4801:1b23:1::/56
6	2001:4801:1ba3:1::/56
7	2001:4801:1b63:1::/56
8	2001:4801:1be3:1::/56
9	2001:4801:1b13:1::/56
10	2001:4801:1b93:1::/56

Sparse Allocation

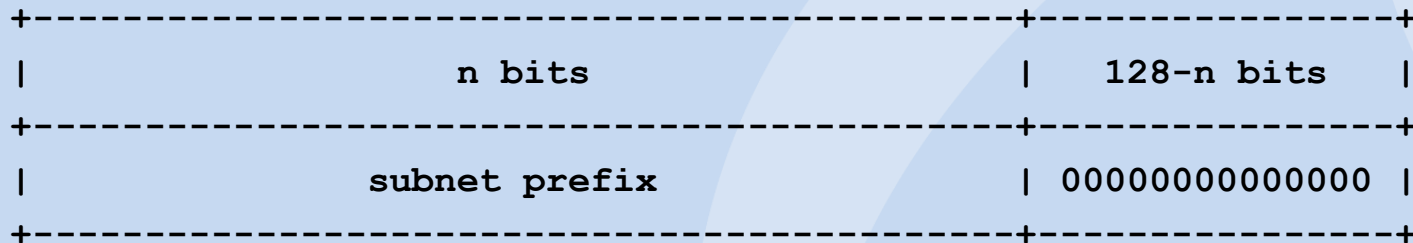
- Sparse allocation for IPv6 addresses is strongly recommended.
- If allocated address blocks are not adjacent to each other then when someone says, "I need more addresses," there is a strong probability that you can grant the request by simply changing the prefix length.
- This keeps your routing table small and tidy.
- You get lots and lots of IPv6 addresses, so if you only break them up into a dozen pools you still have plenty with which to do sparse allocation.

One More Rule

1. Use /49 - /63 for addressing structure.
2. Aggregate – don't fragment.
3. Remember security!
4. Leave some room to grow.

Subnet Router Anycast Address

- RFC4291 provides a definition for the required Subnet Router Anycast Address as follows:



- It is recommended to avoid allocating this IPv6 address to a device which expects to have a normal unicast address.
- This is an address such as:
2001:4801:1BFD:0000:0000:0000:0000:0000 (2001:4801:1BFD::)

Other IPv6 Reserved Ranges

- Then, within each subnet, ranges are reserved for assignment as subnet anycast addresses.
- Another range is reserved for Mobile IPv6.

Interface Identifier Range	Description
0000:0000:0000:0000-0000:0000:0000:0000	Subnet Router Anycast [RFC4291]
fdff:ffff:ffff:ff80-fdff:ffff:ffff:fffd	Reserved Subnet Anycast [RFC2526]
fdff:ffff:ffff:ffff-fdff:ffff:ffff:ffff	Reserved Subnet Anycast [RFC2526]
fdff:ffff:ffff:fffe-fdff:ffff:ffff:fffe	Mobile IPv6 Home Agents Anycast [RFC2526]

Still Another Rule...

1. Use /49 - /63 for addressing structure.
2. Aggregate – don't fragment.
3. Remember security!
4. Leave some room to grow.
5. Watch out for reserved addresses.

IPv6 /126 Prefix

- What do we use for serial links?
- From IPv6 Unicast Address Assignment Considerations (draft-ietf-v6ops-addcon-07.txt) “The 126 bit subnet prefixes are typically used for point-to-point links similar to a the IPv4 address conservative /30 allocation for point-to-point links.
- Let’s review first what a /30 allocation in IPv4 is and then what a /126 might look like.

Serial Links

IP Space available: 195.25.7.0 /24

11111111.11111111.11111111.00000000 /24 (255.255.255.0) 256 addresses

Eth: 195.25.7.1



Switch1

45 users

Router 1

IPv4

S1 - 192.25.7.193

Serial - Net0

S0 - 192.25.7.194

Router 3

IPv4

Eth: 195.25.7.65

Switch 3



25 users

Serial - Net 4

Router 2

IPv4

Serial - Net 8

Eth: 195.25.7.128

Switch 2



45 users

Net0

195.25.7.192 /30 4 addresses

192.25.7.192 - 192.25.7.195

192.25.7.192 - network

192.25.7.193 - Router1 (S1)

192.25.7.194 - Router3 (S0)

192.25.7.195 - broadcast

IPv6 /126 Prefix

- So, what does a /126 look like?

/126

```
11111111111111111111.11111111111111111111.  
11111111111111111111.11111111111111111111.  
11111111111111111111.11111111111111111111.  
11111111111111111111.11111111111111111111xx
```

```
0000:0000:0000:0000:0000:0000:0000:00xx  
FFFF:FFFF:FFFF:FFFF:FFFF:FFFF:FFFF:FFxx
```

How many addresses are we talking about?

00000000000000000000 –
00000000000000000011

4 addresses – none used for network or broadcast.

- Let's look at an example

```
2001:4801:1BFD:1234:5678:90AB:CDEF:0000 –  
2001:4801:1BFD:1234:5678:90AB:CDEF:0003
```

IPv6 /127 Prefix

The usage of the /127 addresses, is not valid and should be strongly discouraged as documented in RFC3627(Use of /127 Prefix Length Between Routers Considered Harmful). Using /127 can be especially harmful on a point-to-point link when Subnet-router anycast address is implemented.

/127

```
11111111111111111111.11111111111111111111.  
11111111111111111111.11111111111111111111.  
11111111111111111111.11111111111111111111.  
11111111111111111111.11111111111111111111x
```

```
0000:0000:0000:0000:0000:0000:0000:000x  
FFFF:FFFF:FFFF:FFFF:FFFF:FFFF:FFFF:FFFx
```

How many addresses are we talking about?

```
00000000000000000000 –  
00000000000000000001
```

2 addresses – none used for network or broadcast.

- Let's look at an example

```
2001:4801:1BFD:1234:5678:90AB:CDEF:0000 –  
2001:4801:1BFD:1234:5678:90AB:CDEF:0001
```

IPv6 /128 Prefix

- The 128 bit address prefix may be used in those situations where we know that one, and only one address is sufficient. Example usage would be the off-link loopback address of a network device.
- When choosing a 128 bit prefix, it is recommended to take the "u" and "g" bits into consideration and to make sure that there is no overlap with either the following well-known addresses:
 - Subnet Router Anycast Address
 - Reserved Subnet Anycast Address
 - Mobile Home Agent Addresses
 - ISATAP Addresses

IPv6 /128 Prefix

/128

```
11111111111111111111.11111111111111111111.  
11111111111111111111.11111111111111111111.  
11111111111111111111.11111111111111111111.  
11111111111111111111.11111111111111111111
```

```
0000:0000:0000:0000:0000:0000:0000:0000  
FFFF:FFFF:FFFF:FFFF:FFFF:FFFF:FFFF:FFFF
```

How many addresses are we talking about?

```
00000000000000000000 –  
00000000000000000000
```

1 address – none used for network or broadcast.

- Let's look at an example

```
2001:4801:1BFD:1234:5678:90AB:CDEF:0000 –  
2001:4801:1BFD:1234:5678:90AB:CDEF:0000
```

From ARIN IPv6 Wiki

- Separate address block for infrastructure from other uses (enterprise, loopbacks)
- No subnets will use prefixes longer than /64.
- Separate address block for router loop-back interfaces
 - Generally number all loopbacks out of one /64
 - /128 per loopback
- Assign a /64 per LAN / VLAN / subnet
- Organizations with multiple /48 allocations should consider enterprise-wise aggregation levels of /60 or larger blocks for the administration of enterprise policies for common functions such as:
 - DMZ
 - Realtime traffic, such as voice & video
 - Network loopback addresses and Link space
- IETF expects that you will assign a /64 for point-to-point links
 - Fewer typos because all subnets are the same size
 - You can use longer prefixes but what's the point?
 - /126 will break Mobile IPv6 Home Agent discovery
 - /112 leaves final 16 bits free for Node IDs
 - Use /64 unless you have read and understand [RFC 3627](#)

- ARIN has a Wiki for IPv6.
- Some helpful documents.

Last Rule...

1. Use /49 - /63 for addressing structure.
2. Aggregate – don't fragment.
3. Remember security!
4. Leave some room to grow.
5. Watch out for reserved addresses.
6. Anyone can add to a Wiki.

How to Get An IPv6 Address

Template: ARIN-NET-END-USER-IPv6-4.1

** Detailed instructions are located below the template.

01. Prefix Length Requested: **/48**

02. Org ID: **XXXXX**

03. Org Name: **XXXXX**

04. Network Name: **XXXXX**

** OPTIONAL FIELDS

05. Origin AS:

06. Hostname of DNS Reverse Mapping Nameserver:

06. Hostname of DNS Reverse Mapping Nameserver:

07. Tech POC Handle:

08. Abuse POC Handle:

09. NOC POC Handle:

10. Public Comments:

END OF REGISTRATION SECTION


- In the U.S., as an end-user, you may get an IPv6 assignment from ARIN.

OR

- You can get an IPv6 address from an ISP.

Justification for an IPv6 Address

INITIAL ASSIGNMENT JUSTIFICATION SECTION

11. Have you been issued IPv4 addresses by ARIN on or after December 22, 1997? **YES** 

Indicate YES or NO. If YES, skip 12., 13., and 14.

12. List all transit providers and any peers.

13. Indicate all IPv4 addresses in use in your network today.

14. Provide a complete numbering topology detailing how you are currently utilizing IPv4 addresses:

IP address/subnet description # of addresses in use

15. If you are requesting a /47 or larger, provide a proposed numbering topology detailing how you will utilize IPv6 addresses. If you are requesting a /48, skip this question.

- The biggest issue is whether you have a 'legacy' address range or not. (A 'legacy' address range is assigned before December 22, 1997 when ARIN came into existence.)

- If you are unfortunate enough to have that, you will have to do some legal work & possibly some justification of how you are using IPv4 addresses today.

Returned From ARIN

You have been approved for an IPv6 /48. This approval is valid for 90 days. To receive the IP addresses, complete the following steps:

- (1) Complete the billing form, found at: https://www.arin.net/cgi-bin/cc/credit_card.cgi?form=V6-EU-NEW

Your ticket number is: 20nnxxxx.xxx

Your Organization ID is: xxxxx

Category Size: Extra Small

Amount owed for this approval: \$1250

- You have to decide what size block you want. (End users can get only /48)
- Once you are approved, you will have to pay.

- (2) Pay the registration fee(s) listed above. Note there is also an annual renewal fee associated with this registration. For more information, see: http://www.arin.net/billing/fee_schedule.html#ipv6_assign

- (3) Complete the fields in the right-hand column of the signature page of the attached PDF copy of the contract (RSA) your organization must sign.

What is ARIN Anyway?

- **Internet Registry (IR)**

An Internet Registry (IR) is an organization that is responsible for distributing IP address space to its members or customers and for registering those distributions.

- **Regional Internet Registry (RIR)**

Regional Internet Registries (RIRs) are established and authorized by respective regional communities, and recognized by the IANA to serve and represent large geographical regions. The primary role of RIRs is to manage and distribute public Internet address space within their respective regions. Examples: ARIN, RIPE, APNIC.

- **National Internet Registry (NIR)**

A National Internet Registry (NIR) primarily allocates address space to its members or constituents, which are generally LIRs organized at a national level. NIRs exist mostly in the Asia Pacific region.

- **Local Internet Registry (LIR)**

A Local Internet Registry (LIR) is an IR that primarily assigns address space to the users of the network services that it provides. LIRs are generally ISPs, whose customers are primarily end users and possibly other ISPs.

What IPv6 Address Range?

- (RFC2373, RFC2373bis) designate 2000::/3 to be global unicast address space that IANA may allocate to the RIRs. (2000 – 3FF)
- The first ranges of global unicast IPv6 address space are from the 2001::/16 address block to the existing RIRs. (2001::0000 – 2001::FFFF)

2000:: /3

```
111xxxxxxxxxxxxxxxxx . xxxxxxxxxxxxxxxxxxxx .  
xxxxxxxxxxxxxxxxxxxx . xxxxxxxxxxxxxxxxxxxx .  
xxxxxxxxxxxxxxxxxxxx . xxxxxxxxxxxxxxxxxxxx .  
xxxxxxxxxxxxxxxxxxxx . xxxxxxxxxxxxxxxxxxxx
```

2001:: /16

```
111111111111111111 . xxxxxxxxxxxxxxxxxxxx .  
xxxxxxxxxxxxxxxxxxxx . xxxxxxxxxxxxxxxxxxxx .  
xxxxxxxxxxxxxxxxxxxx . xxxxxxxxxxxxxxxxxxxx .  
xxxxxxxxxxxxxxxxxxxx . xxxxxxxxxxxxxxxxxxxx
```


IPv6 Assignments

Prefix	Who	Date	
-----	-----	-----	
2001:0000::/23	IANA	01 Jul 99	
2001:0200::/23	APNIC	01 Jul 99	
2001:0400::/23	ARIN	01 Jul 99	
2001:0600::/23	RIPE NCC	01 Jul 99	
2001:0800::/23	RIPE NCC	01 May 02	
2001:0A00::/23	RIPE NCC	02 Nov 02	
2001:0C00::/23	APNIC	01 May 02	
2001:0E00::/23	APNIC	01 Jan 03	
2001:1200::/23	LACNIC	01 Nov 02	
2001:1400::/23	RIPE NCC	01 Feb 03	
2001:1600::/23	RIPE NCC	01 Jul 03	
2001:1800::/23	ARIN	01 Apr 03	
2001:1A00::/23	RIPE NCC	01 Jan 04	
2001:1C00::/22	RIPE NCC	01 May 04	
2001:2000::/20	RIPE NCC	01 May 04	
2001:3000::/21	RIPE NCC	01 May 04	
2001:3800::/22	RIPE NCC	01 May 04	
2001:3C00::/22	RESERVED	11 Jun 04	
2001:4000::/23	RIPE NCC	11 Jun 04	

Prefix	Who	Date	
-----	-----	-----	
2001:4200::/23	AfriNIC	01 Jun 04	
2001:4400::/23	APNIC	11 Jun 04	
2001:4600::/23	RIPE NCC	17 Aug 04	
2001:4800::/23	ARIN	24 Aug 04	
2001:4A00::/23	RIPE NCC	15 Oct 04	
2001:4C00::/23	RIPE NCC	17 Dec 04	
2001:5000::/20	RIPE NCC	10 Sep 04	
2001:8000::/19	APNIC	30 Nov 04	
2001:A000::/20	APNIC	30 Nov 04	
2001:B000::/20	APNIC	08 Mar 06	
2002:0000::/16	6to4	01 Feb 01	
2003:0000::/18	RIPE NCC	12 Jan 05	
2400:0000::/12	APNIC	03 Oct 06	
2600:0000::/12	ARIN	03 Oct 06	
2610:0000::/23	ARIN	17 Nov 05	
2620:0000::/23	ARIN	12 Sep 06	
2800:0000::/12	LACNIC	03 Oct 06	
2A00:0000::/12	RIPE NCC	03 Oct 06	
2C00:0000::/12	AfriNIC	03 Oct 06	

Allocate vs. Assign

- **Allocate and Assign**

ISPs are "allocated" address space, while end-users are "assigned" address space.

- Allocate - To allocate means to distribute address space to IRs for the purpose of subsequent distribution.
- Assign - To assign means to delegate address space to an ISP or end-user, for specific use within the Internet infrastructure they operate. Assignments must only be made for specific purposes documented by specific organizations and are not to be sub-assigned to other parties.

An end-user organization will get an assignment – not an allocation!

- **End-user**

An end-user is an organization receiving assignments of IP addresses exclusively for use in its operational networks.

- **Multihomed**

An organization is multihomed if it receives full-time connectivity from more than one ISP and has one or more routing prefixes announced by at least two of its upstream ISPs.

Who Qualifies?

Direct assignments from ARIN to end-user organizations

- **Criteria**

- To qualify for a direct assignment, an organization must:
- not be an IPv6 LIR; and
- qualify for an IPv4 assignment or allocation from ARIN under the IPv4 policy currently in effect.

- **Initial assignment size**

Organizations that meet the direct assignment criteria are eligible to receive a direct assignment. The minimum size of the assignment is /48. Organizations requesting a larger assignment must provide documentation justifying the need for additional subnets.

What do you get?

- The IPv6 xSmall assignment - or /48 will allow for 2^{16} or 65,536 subnets. Each subnet can support at least 2^{64} host/interface/device addresses

/48

```
11111111111111111111 . 11111111111111111111 .  
11111111111111111111 . xxxxxxxxxxxxxxxxxxxxxx .  
xxxxxxxxxxxxxxxxxxxxxxxx . xxxxxxxxxxxxxxxxxxxxxx .  
xxxxxxxxxxxxxxxxxxxxxxxx . xxxxxxxxxxxxxxxxxxxxxx
```

```
0000:0000:0000::  
FFFF:FFFF:FFFF::
```

- What kind of address prefix are you likely to get? In the U.S, since it is assigned by ARIN, you may get something like:

```
2001:4801:1BFD::
```

- Remember, ARIN has the address block: 2001:4800::/23

Is This Enough?

- With a /48, that leaves 80 bits for host addresses (and or subnetting). So the number of addresses you get is 2 to 80th power.
- 2 to the 80th power is called a yottabyte (yobibyte), or 1,208,925,819,614,629,174,706,176.

It can be estimated as 10 to the 24th power, or 1,000,000,000,000,000,000,000,000 bytes. The yottabyte is the largest unit of measurement for computer data, consisting of 1,024 zettabytes. Fortunately for those of us finite beings, yottabytes are not used very often. The prefix "yotta" was chosen since it is the second to last letter of the Greek alphabet. Though it seems more fitting that "yotta" refers to a "lotta" bytes.

In 1998, the International Electrotechnical Commission (IEC) introduced new units of measurement. The new IEC units are listed below:

byte (B)

kibibyte (KiB) - 2^{10}

mebibyte (MiB) - 2^{20}

gibibyte (GiB) - 2^{30}

tebibyte (TiB) - 2^{40}

pebibyte (PiB) - 2^{50}

exbibyte (EiB) - 2^{60}

zebibyte (ZiB) - 2^{70}

yobibyte (YiB) - 2^{80}

Exponential Growth (Powers of 2)

20	1048576	104.9×10^{-3}	quarter of the Sears tower (440m)
25	33554432	3.4×10^0	past the Matterhorn
30	1073741824	107.4×10^0	outer limits of the atmosphere
35	34359738368	3.4×10^3	
40	1099511627776	109.9×10^3	
45	35184372088832	3.5×10^6	
50	1125899906842624	112.5×10^6	~ distance to sun (95 million miles)
55	36028797018963968	3.6×10^9	
60	1152921504606846976	115.3×10^9	size of the solar system?
65	36893488147419103232	3.7×10^{12}	one-third of a light year
70	1180591620717411303424	118.1×10^{12}	11 light years
75	37778931862957161709568	3.8×10^{15}	377 light years
80	1208925819614629174706176	120.9×10^{15}	12,000 light years
85	38685626227668133590597632	3.9×10^{18}	4x the diameter of our galaxy
90	1237940039285380274899124224	123.8×10^{18}	12 million light years
95	39614081257132168796771975168	4.0×10^{21}	
100	1267650600228229401496703205376	126.8×10^{21}	(12 billion light years) approx. radius of the known universe?

How Much Does It Cost?

- ARIN charges an initial registration fee to organizations that receive an assignment of IPv6 address space directly from ARIN.
- The initial registration fee is based on the amount of address space assigned as outlined below.

Category	Initial Registration Fee (US Dollars)	Assignment Block Size
X-small/ Micro- allocation	\$1,250	blocks from a /48 to a /41 in size
Small	\$2,250	blocks equal to or larger than a /40, up to and including a /32
Medium	\$4,500	blocks from a /31 to a /30 in size
Large	\$9,000	blocks equal to or larger than a /29, up to and including a /27
X-large	\$18,000	blocks equal to or larger than a /26, up to and including a /22
XX-Large	\$36,000	blocks larger than a /22

Do We Have to Use the Addresses?

IPv4

- **Validity**

IP address allocations are valid as long as the utilization and other relevant criteria continue to be met, and the yearly fee is submitted.

- **Invalidation**

ARIN may invalidate any IP allocation if it determines that the requirement for the address space no longer exists.

- **Recall**

In the event of address space recall, ARIN will make every reasonable effort to inform the organization that the addresses are being returned to the free pool of IPv4 address space.

- For IPv4, there is a utilization criteria.

- For IPv6, there is no utilization criteria.

Summary

- IPv6 provides network administrators with a significantly larger address space, enabling them to be very creative in how they can define logical and practical address plans. The subnetting of assigned prefixes can be done based on various logical schemes.
- What do you need to do?
 - Break out address by ‘subnets’ or regions
 - Assign addresses to types of devices? (servers, firewalls, etc)
 - In IPv4, subnet masking is often used. Does not exist in IPv6.
- Best practices are still being defined
- Security must be considered.