IPv6 In Amateur Radio HamWAN Tampa Bay

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Who am I?

Bryan Fields, W9CR

- Originally from Chicago/North West Indiana
  - Ran the first Wireless ISP in North West Indiana (2000)
  - Background in microwave network design
  - Carrier IP/Optical network Engineer
  - Relocated to St Petersburg, Florida in 2005
- Sr. Consulting Engineer in IP/Optical Networks – Nokia
- AMPRnet Technical Advisory Committee member

Introduction

History of IPv4

Why does ham radio have a /8?

- Allocation in History
- Internet Growth
- IPv4 end days

IPv6 overview

IPv6 – “The Next Generation”

- Development in the late 90s
- Huge number space
- Some niceties from OSI
- Auto addressing, etc.

HamWAN Tampa IPv6 Deployment

HamWAN Tampa

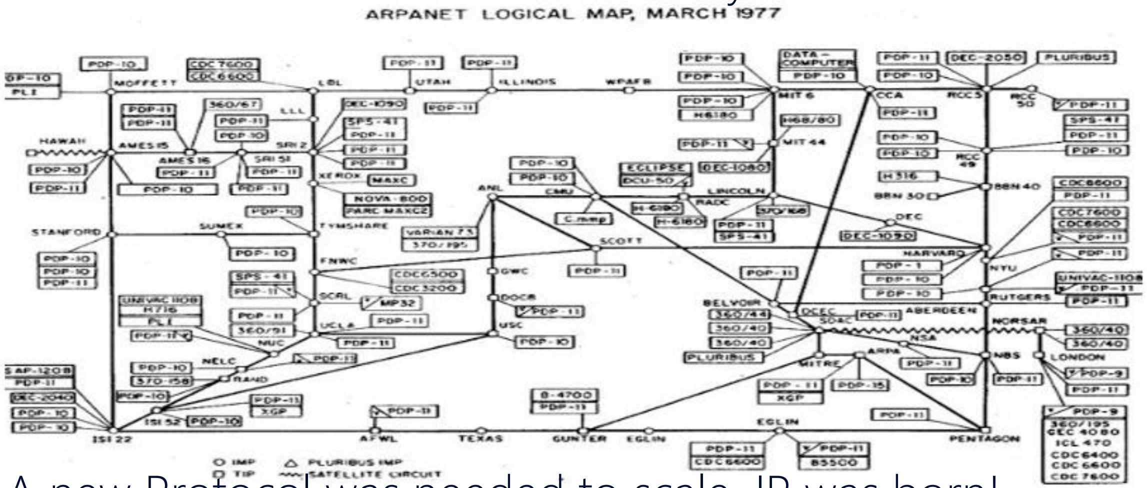
- Online since May 2016
- /20 for IPv4, /48 IPv6
- Active clients on IPv6
- Deployment plan

IPv4 History

A Ham's perspective

IPv4 History

- The Internet originally spoke Network Control Protocol
    - NCP had serious scale issues even by the internet of the Day



- A new Protocol was needed to scale, IP was born!
- On Jan 1, 1983 Flag Day took place, NCP was shut off, IP turned on.
- Hams get 44/8 thanks to Hank Magnuski, KA6M – Circa 1981

IPv4 History
Circa 1995

- We face limits of our protocols once again
- By the mid 1990's the internet exploded in growth
    - .IPv4 is allocated on a classful basis – Classless to the rescue in 1994
        - Routing Protocols move from EGP to BGPv4 In IOS 10!
    - Even with CIDR, allocation is still growing
    - The first major hack breaking the internet takes place
        - Many to One Network Address Translation (NAT/PAT)
    - Routing tables grow exponentially – Routers cross the 64k boundary
        - Piecemeal allocation exacerbates this growth.
    - A new protocol is needed once again

IPv4 History

IP "The Next Generation" and run out

- IPng working group begins work in 1993 – IPv6 in 1995!
- The dot-com crash sees IPv4 allocations level off
  - NAT reduces the pressure on IPv4
  - IPv6 does not take off as expected – due to confusion & apathy
- By 2008 IP exhaustion is on most large ISP's Radar
  - "I'll be dead by time we need IPv6" and "Just use NAT" are commonly heard by non carrier network staff personnel.
    - Say it again, "NAT breaks the Internet"
  - Large Eyeball ISP's have 10/8 used 6 to 8 times over internally.
  - IANA and the RIR's establish a policy for IPv4 end times

IPv4 History

IPv4 run out timeline

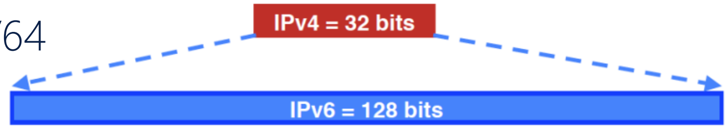
- 31-Jan-2011: IANA allocates two /8 blocks to APNIC.
  - This triggers the IANA run out policy.
  - 3-Feb-2011: "The IANA IPv4 Free Pool is Now Depleted"
- ARIN enacts policy to further restrict IP requests from it's members
  - Legacy assigned IP space commands a premium. 44/8 is one of these blocks
  - IPv4 Becomes a commodity and has a real cost on various market places
- ARIN is still allocating space and by April 2014 reaches its last /8
  - The end allocation policies go into effect, a /24 is the largest initial request
  - June 2015 sees ARIN have it's first unable to allocate issue with a /17 request
- 24-Sep-2015: The ARIN Address Pool reaches zero
- This is the end of the v4 Internet growth – 44/8 is worth >100M USD now!

IPv6 to the Rescue

An Introduction

IPv6 a Path Forward

- IPv6 is the de facto path forward; not open to debate in 2016!
- Improvements in IPv6
    - Larger number space 2^128 but smallest subnet is /64
        - Each Human on earth has 100M of these subnets!
        - ISP's are allocated large blocks keeping the global routing table under 32k prefixes, vs. 625k for IPv4

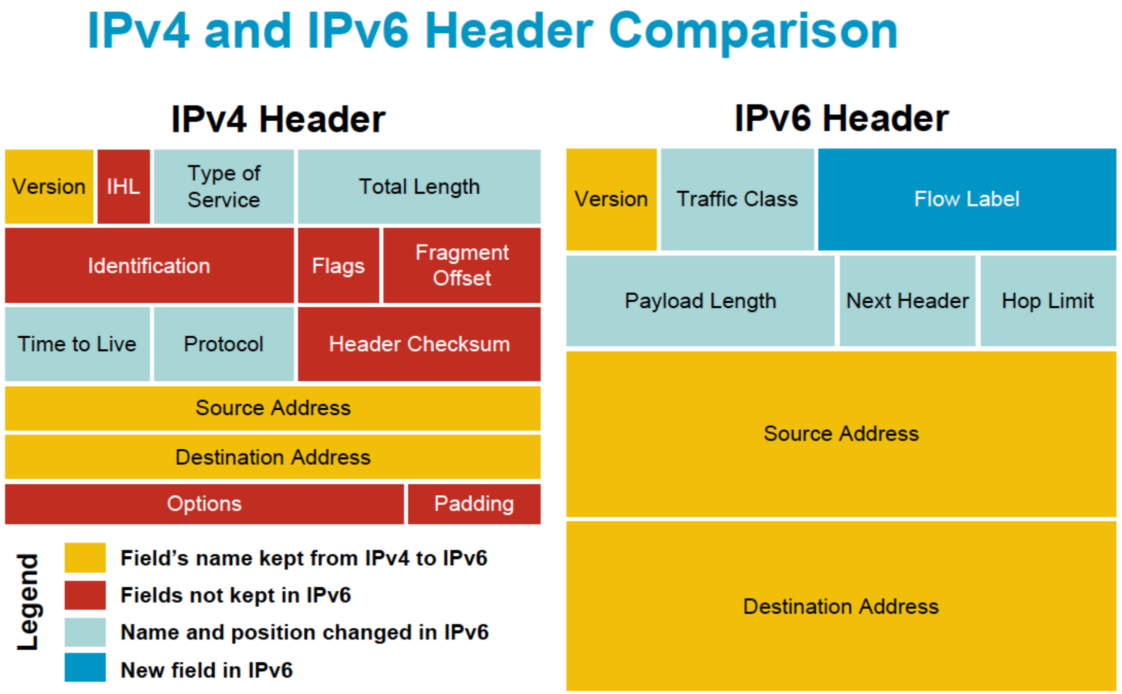


    - Auto-Configuration with out DHCP (and with it if you choose)
- New types of IPv6 space
    - Link-Local – only valid on the Ethernet segment
    - Global-Unicast – what you will receive from an ISP for use
    - Multicast improvements – it's possible to make use of it with out much config
- IPSEC is mandated – Hams may use AH mode only and be secure without obscuring communications

IPv6 a Path Forward

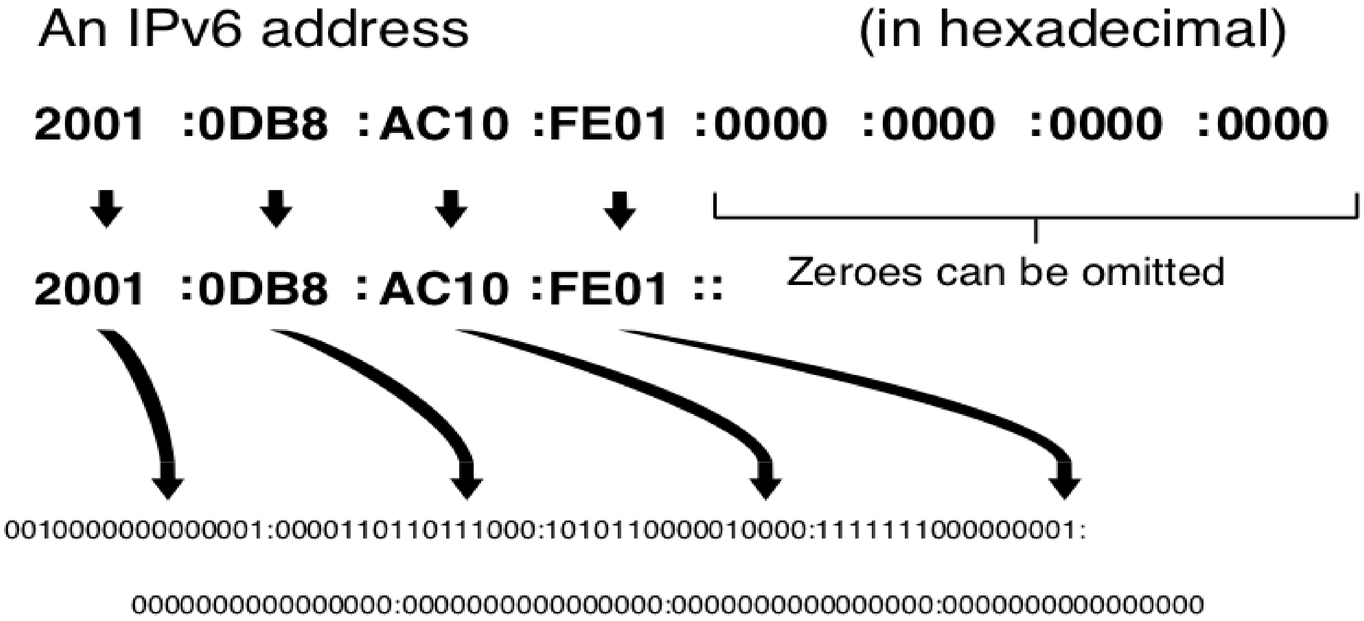
Improvements continued

- The header is simplified allowing easy switching in custom ASICs



IPv6 a Path Forward

- IPv6 is written as 8 blocks of 4 Hexadecimal numbers
- You can simplify zeros once in an address to "::"



IPv6 a Path Forward
Subnetting in IPv6

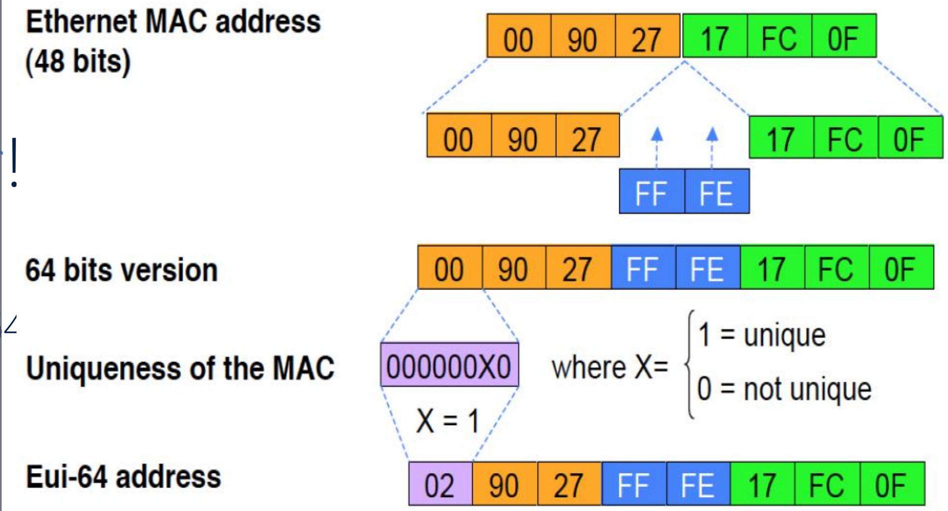
- Subnetting is a bit different in IPv6 as the smallest subnet should be a /64
  - This is to enable Auto Configuration of addresses by hosts
  - A /127 is valid (2 hosts), but this will break auto configuration.
  - Many routers and chipsets cannot handle large numbers of >/64 routes
- The smallest MTU is increased to 1280 vs. 64 bytes for v4
  - All routers assume a 1280 byte packet will work without segmentation
  - Path MTU discovery can be omitted if <1280 byte packets
  - Packets of up to 4gb can be supported too!
- Broadcasts are replaced with Multicast
  - Broadcast storms are a thing of the past
  - ARP is dead – Long live Neighbor Discovery protocol!

IPv6 a Path Forward

Auto Configuration

- IPv6 has Auto Configuration for Global and Link-Local built in
  - IPv6 enabled hosts will talk without any configuration or a router!
  - With a router on the subnet a host will receive default routes as well.
  - The MAC address is used to create a EUI-64 format address
  - Only works on /64 subnets – Why every subnet should be a /64
  - Ideal for Ham networks
  - DHCPv6 can be used too

EUI-64



- EUI-64 address is formed by inserting FFFE and OR'ing a bit identifying the uniqueness of the MAC address

IPv6 a Path Forward

DNS and 2^64 IP address in a Zone

- DNS is a requirement for all IPv6 Deployments
  - 3006:D00D:6ATE:BEEF::45 is bad enough to remember
- A new record is added for IPv6, the AAAA
  - Pronounced “Quad-A” record, an AAAA, but a Quad-A
  - If a resolver finds an AAAA record it will prefer IPv6 in most cases.
- Reverse DNS is still a PTR, but under ip6.arpa.
  - Each digit in the address is it’s own field and no summation is allowed for zeros
    - 2006:bd8:c18:1::2 is 2.0.0.0.0.0.0.0.0.0.0.0.0.0.0.0.1.0.0.0.8.1.c.0.8.b.d.0.6.0.0.2.ip6.arpa.
  - Generally not setup for all IP’s in a subnet, as the zone file would be over 400 EiB in size.
    - Only real hosts are entered in the zone
  - There are some plans to enable on the fly creation of RDNS, however security issues due to cache memory limits have stalled this idea.

~~IPv6: A Path Forward~~ NAT Works and I don't care!

Srsly u guys, can't we just do NAT?

NAT is Evil

- NAT breaks end-to-end connectivity between all nodes
- NAT is not a firewall!
- NAT must maintain a state
- NAT obscures the source of connections
- Carrier Grade NAT breaks inbound connections with no contro over port forwarding.
- Scaling of NAT is hard to do
  - Ignoring me doesn't make it less true.

Applying IPv6 in ham radio

- Ham radio has 44/8 and most networks don't need IPv6 to talk to other hams
  - They need it to talk to the Internet!
- NAT is making it hard to deploy other end to end connections over the internet.
  - Port forwarding is needed for almost every application hams run
- In many cases the apps hams want don't support IPv6
  - Ask your vendors about IPv6 support. Demand it
  - We tend to run applications for a long time. IPv6 will be needed to run applications on the Internet in 3-5 years. Many in Europe do not have native IPv4 from their providers now..
  - A VPN overlay is not a valid solution.
  - Mobile apps need IPv6 support now.

Applying IPv6 in ham radio

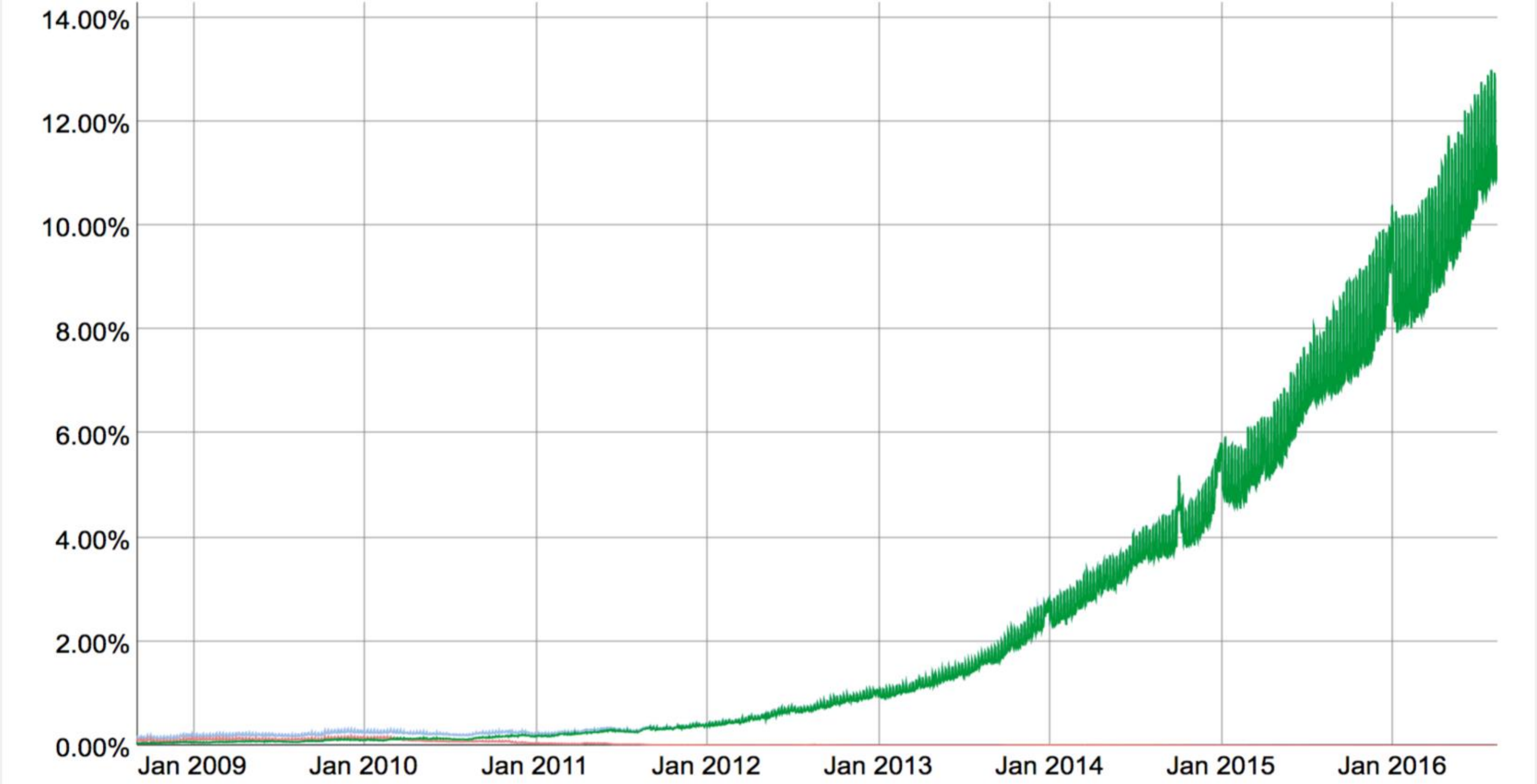
Continued

- Amateur developers will need to learn and implement IPv6 in their programs
  - Embedded systems will be hard hit by this
  - Raspberry Pi support ipv6 out of the box (it's Linux!)
- Your webpages need to support it – FCC.GOV works on IPv6!
  - ARRL and TAPR don't
- Networking Standards for Ham Radio vary in support
  - Broadband Hamnet – No support but someone was talking about it.
  - ARDEN – No support and everything must use NAT. IPv6 is ideal for them!
  - AX.25 – Really?
  - HamWAN – dual stack today if so enabled

Current Use of IPv6

- World IPv6 Day – created to raise awareness to the community
  - 6-Jun-2012 – IPv6 coming out party
- Since this time IPv6 has gone from mostly ping and traceroute to 15% of global traffic
  - Mobile networks are over 90% IPv6 enabled
  - 50% of all traffic on mobile networks is delivered by IPv6
- Over 30% of all end users have IPv6 in the US
  - Most of Europe is now forced into MAP-T, DS-Lite and Carrier Grade NAT
    - They do not have native IPv4 on their routers!
  - Major Cable Companies in the US are leading with IPv6 to customers
  - Every commercial co-lo and service provides dual-stack v4/v6 now.

Current Use of IPv6 – Global to Google



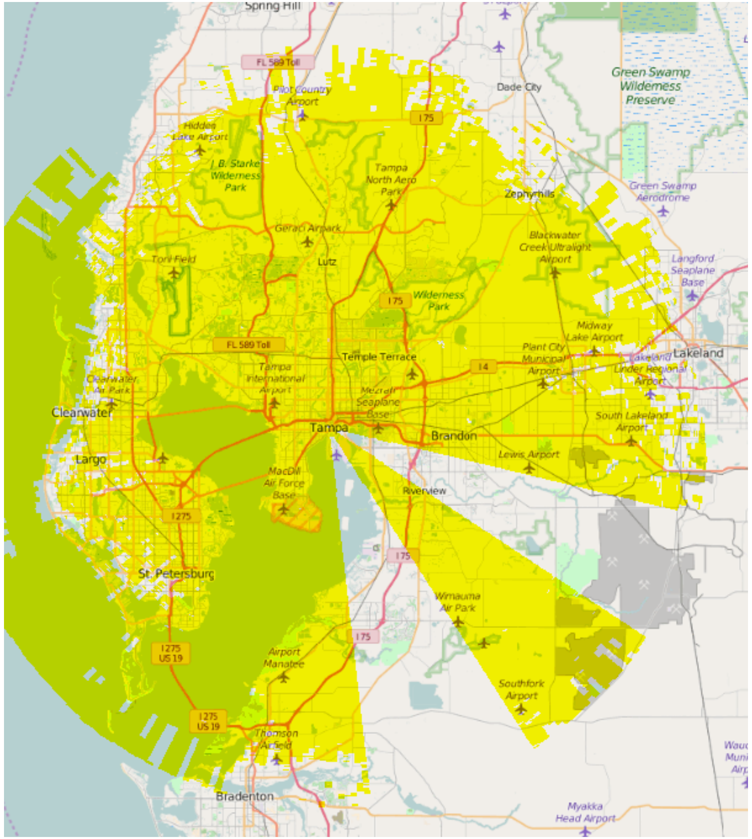
HamWAN Tampa Bay

Update and IPv6 Plan

HamWAN Tampa Bay

A modern multi-megabit network covering most of Tampa Bay

- Online since May 2016
- 500′ up in downtown Tampa
- Providing real IPv4 access, with the plan to do IPv6
- /20 from ARDC and a /48 of IPv6 from our upstream
- Plans to expand south to St Petersburg and Sarasota in the next year.
- Run under the umbrella of Florida Simulcast Group, a 501(c)3



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Example IPv6 strategy

- /48 from our provider as most will receive
- /64 is the smallest subnet, and we want to give a number of /64's to our clients
  - Prefix delegation – must run DHCPv6 for this
  - At least a /60 or 16, /64 subnets for a client
- This means we must divide up our /48 in a logical manner
  - Should divide on nibble boundaries, makes IPv6 addressing logical
- How many future sites? 16 is a reasonable number
  - /52 for a site - 16 in our /48
  - /60 for a client – 256 per site
- If we exceed this, ask the provider for another /48

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Example IPv6 strategy

- /52 for a site
  - See how we align on a single hex digit:
  - 16 sites

```
2607:f3f0:0002:0000::/52   Site 1   2607:f3f0:0002:c000::/52   Site 13
2607:f3f0:0002:2000::/52   Site 2   2607:f3f0:0002:d000::/52   Site 14
2607:f3f0:0002:3000::/52   Site 3   2607:f3f0:0002:e000::/52   Site 15
2607:f3f0:0002:4000::/52   Site 4   2607:f3f0:0002:f000::/52   Site 16
```

A central DHCPv6 server assigns /60 blocks to clients. Each site can support a 256 clients in a /52.

Typically use one /60 for loopbacks and addressing per site, making the number of clients 255. This would be an amazing scale for HamWAN Tampa

```
Site example 2607:f3f0:0002:b000::/52 > /60 Clients
Network     - 2607:f3f0:0002:b000:0000:0000:0000:0000
Network     - 2607:f3f0:0002:b010:0000:0000:0000:0000
Network     - 2607:f3f0:0002:b020:0000:0000:0000:0000
Network     - 2607:f3f0:0002:b030:0000:0000:0000:0000
SNIP
Network     - 2607:f3f0:0002:bfc0:0000:0000:0000:0000
Network     - 2607:f3f0:0002:bfd0:0000:0000:0000:0000
Network     - 2607:f3f0:0002:bfe0:0000:0000:0000:0000
Network     - 2607:f3f0:0002:bff0:0000:0000:0000:0000
                             ^^
```

Note the ^ ^ and how only those digits change
This makes it easy to identify the subnet to human eyes

Questions?