IPv6: More than Meets the Eye

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Stuff Everyone Knows

- IPv6 is a lot bigger than IPv4
- IPv6 packets cannot be fragmented in transit
- ICMPv6 replaces ARP, IGMP, and IRDP
- Stateful NAT66 and IPv6 MSDP don't exist
Things IPv4 Can't Do Easily

- Signal hop-limit (TTL) and MTU to clients
- Statelessly generate unique addresses
- Statelessly communicate non-address information
- Dynamically allocate entire prefixes
- Embed in-address information
Architecture 1: Unlimited Scale WAN
Unlimited Scale WAN Overview

- Requirements:
  - Any-to-any at scale
  - Minimal OAM
  - Easy client onboarding
  - Optional encryption
  - IPv4 interworking
- Solution
  - 6rd overlay / GETVPN
  - Stateless DHCPv6
  - SLAAC
How It Works

6rd prefix: 2001:db8::/32
IPv4 prefix length: 16 bits
65,536 available subnets

Site prefix:
2001:db8:20b::/48

198.51.2.11

IPv4

Site prefix:
2001:db8:10a::/48

IPv6

198.51.1.10

BR

6rd

198.51.3.12

Site prefix:
2001:db8:30c::/48

IPv6 Inner
S=2001:db8:10a:11
D=2001:db8:30c:33

IPv4 Outer
S=198.51.1.10
D=198.51.3.12

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Securing the Transport

Proxy ACL:
permit 198.51.0.0/16
towards 198.51.0.0/16

Key Server

IPv6

BR
198.51.1.10

6rd

Group Members

198.51.2.11

198.51.3.12

GETVPN Registration
Architecture 2: Low-touch Mobile Sites
Low-touch Mobile Sites Overview

- Requirements:
  - Hub-to-spoke at scale
  - Multiple transports
  - Fully dynamic sites
  - Top-down automation

- Solution
  - IPv6 BGP over DMVPN
  - DHCPv6 PD
  - Stateless DHCPv6
  - SLAAC
Obtaining an IPv6 Prefix

- Site requests prefix
- Server issues prefixes
  - Stateful mapping
- Can include options:
  - Domain name
  - DNS server
  - SNTP servers
Upstream BGP Routing

- Spokes initiate to hubs
- Advertise PD prefixes
- Receive default route
- Improves resilience:
  - Allows multi-link sites
  - Allows multi-transport
Addressing the Endpoints

IPv4 SLAAC (EUI-64)
2001:db8:e4:9ca:a8bb:ccff:fe00:430

Router Solicitation (RS)

Router Advertisement (RA):
2001:db8:e4:9ca::/64

IPv6

Prefix: 2001:db8:e4:9ca::/64
Domain name: njruscnc.net
DNS servers:
- 2001:4860:4860::8888
- 2001:4860:4860::8844

DHCPv6 Info-request
- Domain name
- DNS servers

DHCPv6 Reply
What About Automation?

• On-box:
  • Autoconfig hostname
  • Autoconfig EUI-64 /128
  • Send /128 via BGP to hub

• Centralized:
  • Parse /128 from router
  • Build /128 from MACs
  • Do whatever afterwards!

```python
resp = conn.send_command("show bgp all", use_genie=True)
v6_rte = resp["address_family"]["ipv6 unicast"]["routes"]

# Initialize Ansible YAML inventory dictionary
ansible_inv = {"all": {"children": {"remotes": {"hosts": {}}}}}  

# Iterate over all collected BGP prefixes
for index, prefix in enumerate(v6_rte.keys()):

    # Create an IPv6 network representing the specific prefix
    prefix_net = IPv6Network(prefix.lower())

    # Test for subnet containment and for /128 mask
    if prefix_net.subnet_of(mgmt_net) and prefix.endswith("/128"):

        # Assemble inventory item and update inventory dict
        prefix_str = DoubleQuoted(prefix_net.network_address)
        ansible_inv["all"]['children']['remotes']['hosts'].update{
            {"node_{index + 1}": {"ansible_host": prefix_str}}
        }
```
Some Samples ... It's Cool!

ans_inv_from_eui64.py

```python
all:
    children:
        remotes:
            hosts:
                node_1:
                    ansible_host: "2001:db8::a2bb:ccff:fe00:0300"
                    original_mac: "a0bbcc000300"
                node_3:
                    ansible_host: "2001:db8::a0bb:ccff:fe00:0300"
                    original_mac: "a2bbcc000300"
```

ans_inv_from_bgp.py

```python
all:
    children:
        remotes:
            hosts:
                node_1:
                    ansible_host: "2001:db8:aaaa:aaaa::1"
                node_2:
                    ansible_host: "2001:db8:aaaa:aaaa::2"
                node_3:
                    ansible_host: "2001:db8:aaaa:aaaa::3"
```
Thank you

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References

Architecture 1: Unlimited Scale WAN:  
http://njrusmc.net/pub/6rd_getvpn.pdf

Architecture 2: Low-Touch Mobile Sites  
http://njrusmc.net/pub/csfc_macp.pdf

Code Samples:  
https://github.com/nickrusso42518/ipv6-tools