

# airheads

## TECH TALK *LIVE*

aruba  
a Hewlett Packard  
Enterprise company

Aruba and IPv6  
Joe Neville

Sept 19

#ArubaAirheads

# Agenda

Do we still need IPv6

IPv6 Crash Course

Watch out for...

Aruba & IPv6

# Do we still need IPv6?

- World IPv6 Day 06 June 2012
  - IPv4 address exhaustion headlines have been and gone
- But we still all use IPv4
- Major tech companies (twitter) don't have IPv6
- “No one cares about IPv6” - a guy in Sweden Oct 2018
- My IPv6 videos were youtube kryptonite – lowest views on the channel

# Explain this

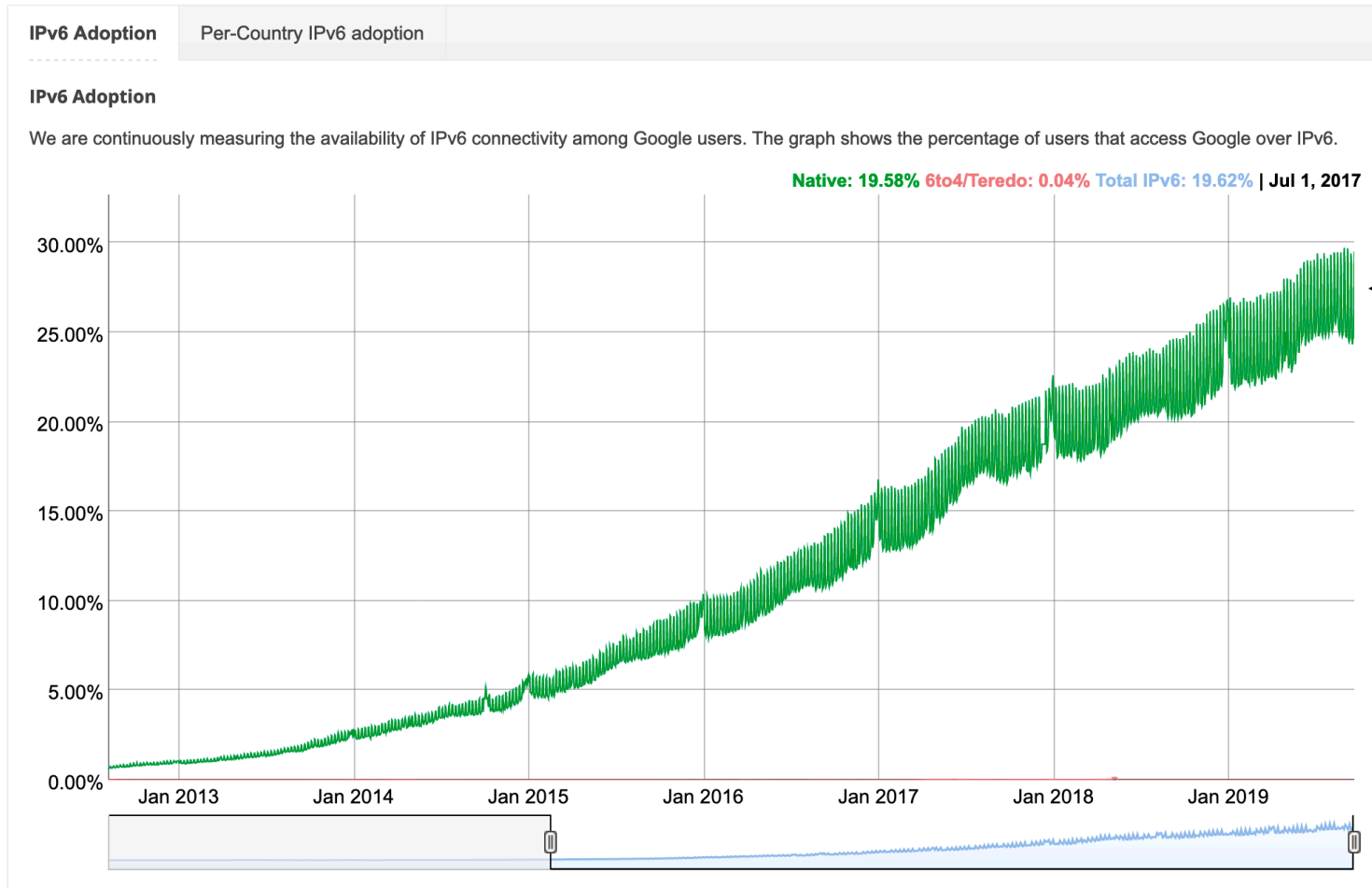
- My mum watches youtube over IPv6
- MSFT tells gamers that IPv6 is preferable over IPv4

## What if my Xbox One isn't connected using IPv6?

Your Xbox will work normally without IPv6 connectivity. However, for the best possible experience, we recommend enabling IPv6 on your network. Several Xbox One features already make use of IPv6, and we're building more.

- T-Mobile US is IPv6 only

# Lies, damn lies, and statistics



← Just shy of 30%

# “Livin’ in an IPv6 world”

“Yeah, but that’s not my network!”

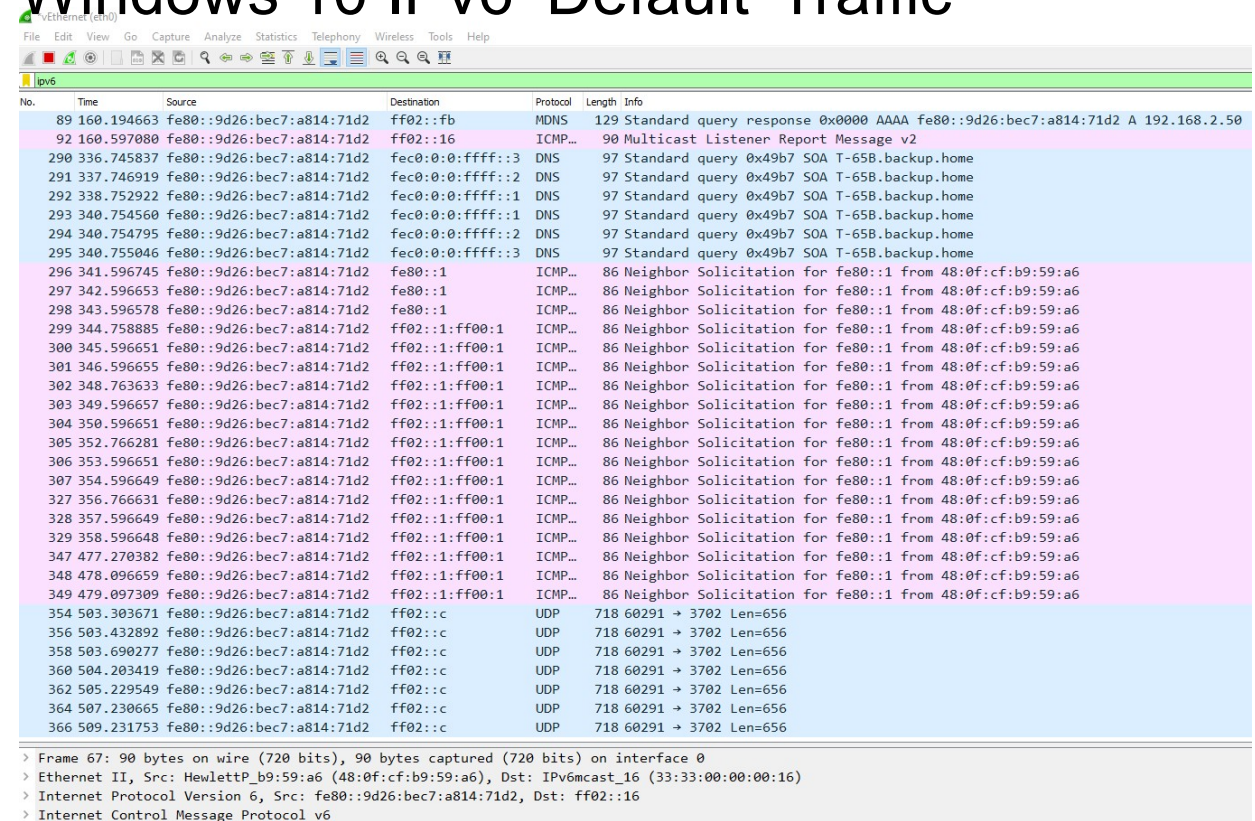
–IPv6 in the wild:

- Home
- Cloud
- Mobile
- Service Provider
- Content Provider

# “Yeah but that’s not my network!”

- Don’t be so sure!
- IPv6 has been the preferred protocol in Windows since Vista.
- There are no IPv4 only networks, you have v6 traffic, you just aren't aware.

## Windows 10 IPv6 ‘Default’ Traffic

A screenshot of a Wireshark network traffic capture. The top pane shows the packet list with columns for No., Time, Source, Destination, Protocol, Length, and Info. The bottom pane shows the packet details for the selected packet (No. 366). The traffic is primarily IPv6, showing various protocols like MDNS, ICMPv6, and UDP. The source and destination addresses are mostly fe80::9d26:bec7:a814:71d2 and ff02::c. The packet details pane shows the structure of the selected packet, including Ethernet II, Internet Protocol Version 6, and Internet Control Message Protocol v6.

No.	Time	Source	Destination	Protocol	Length	Info
89	160.194663	fe80::9d26:bec7:a814:71d2	ff02::fb	MDNS	129	Standard query response 0x0000 AAAA fe80::9d26:bec7:a814:71d2 A 192.168.2.50
92	160.597080	fe80::9d26:bec7:a814:71d2	ff02::16	ICMPv6	90	Multicast Listener Report Message v2
290	336.745837	fe80::9d26:bec7:a814:71d2	fec0:0:0:ffff::3	DNS	97	Standard query 0x49b7 SOA T-65B.backup.home
291	337.746919	fe80::9d26:bec7:a814:71d2	fec0:0:0:ffff::2	DNS	97	Standard query 0x49b7 SOA T-65B.backup.home
292	338.752922	fe80::9d26:bec7:a814:71d2	fec0:0:0:ffff::1	DNS	97	Standard query 0x49b7 SOA T-65B.backup.home
293	340.754560	fe80::9d26:bec7:a814:71d2	fec0:0:0:ffff::1	DNS	97	Standard query 0x49b7 SOA T-65B.backup.home
294	340.754795	fe80::9d26:bec7:a814:71d2	fec0:0:0:ffff::2	DNS	97	Standard query 0x49b7 SOA T-65B.backup.home
295	340.755046	fe80::9d26:bec7:a814:71d2	fec0:0:0:ffff::3	DNS	97	Standard query 0x49b7 SOA T-65B.backup.home
296	341.596745	fe80::9d26:bec7:a814:71d2	fe80::1	ICMPv6	86	Neighbor Solicitation for fe80::1 from 48:0f:cf:b9:59:a6
297	342.596653	fe80::9d26:bec7:a814:71d2	fe80::1	ICMPv6	86	Neighbor Solicitation for fe80::1 from 48:0f:cf:b9:59:a6
298	343.596578	fe80::9d26:bec7:a814:71d2	fe80::1	ICMPv6	86	Neighbor Solicitation for fe80::1 from 48:0f:cf:b9:59:a6
299	344.758885	fe80::9d26:bec7:a814:71d2	ff02::1:ff00:1	ICMPv6	86	Neighbor Solicitation for fe80::1 from 48:0f:cf:b9:59:a6
300	345.596651	fe80::9d26:bec7:a814:71d2	ff02::1:ff00:1	ICMPv6	86	Neighbor Solicitation for fe80::1 from 48:0f:cf:b9:59:a6
301	346.596655	fe80::9d26:bec7:a814:71d2	ff02::1:ff00:1	ICMPv6	86	Neighbor Solicitation for fe80::1 from 48:0f:cf:b9:59:a6
302	348.763633	fe80::9d26:bec7:a814:71d2	ff02::1:ff00:1	ICMPv6	86	Neighbor Solicitation for fe80::1 from 48:0f:cf:b9:59:a6
303	349.596657	fe80::9d26:bec7:a814:71d2	ff02::1:ff00:1	ICMPv6	86	Neighbor Solicitation for fe80::1 from 48:0f:cf:b9:59:a6
304	350.596651	fe80::9d26:bec7:a814:71d2	ff02::1:ff00:1	ICMPv6	86	Neighbor Solicitation for fe80::1 from 48:0f:cf:b9:59:a6
305	352.766281	fe80::9d26:bec7:a814:71d2	ff02::1:ff00:1	ICMPv6	86	Neighbor Solicitation for fe80::1 from 48:0f:cf:b9:59:a6
306	353.596651	fe80::9d26:bec7:a814:71d2	ff02::1:ff00:1	ICMPv6	86	Neighbor Solicitation for fe80::1 from 48:0f:cf:b9:59:a6
307	354.596649	fe80::9d26:bec7:a814:71d2	ff02::1:ff00:1	ICMPv6	86	Neighbor Solicitation for fe80::1 from 48:0f:cf:b9:59:a6
327	356.766631	fe80::9d26:bec7:a814:71d2	ff02::1:ff00:1	ICMPv6	86	Neighbor Solicitation for fe80::1 from 48:0f:cf:b9:59:a6
328	357.596649	fe80::9d26:bec7:a814:71d2	ff02::1:ff00:1	ICMPv6	86	Neighbor Solicitation for fe80::1 from 48:0f:cf:b9:59:a6
329	358.596648	fe80::9d26:bec7:a814:71d2	ff02::1:ff00:1	ICMPv6	86	Neighbor Solicitation for fe80::1 from 48:0f:cf:b9:59:a6
347	477.270382	fe80::9d26:bec7:a814:71d2	ff02::1:ff00:1	ICMPv6	86	Neighbor Solicitation for fe80::1 from 48:0f:cf:b9:59:a6
348	478.096659	fe80::9d26:bec7:a814:71d2	ff02::1:ff00:1	ICMPv6	86	Neighbor Solicitation for fe80::1 from 48:0f:cf:b9:59:a6
349	479.097309	fe80::9d26:bec7:a814:71d2	ff02::1:ff00:1	ICMPv6	86	Neighbor Solicitation for fe80::1 from 48:0f:cf:b9:59:a6
354	503.303671	fe80::9d26:bec7:a814:71d2	ff02::c	UDP	718	60291 → 3702 Len=656
356	503.432892	fe80::9d26:bec7:a814:71d2	ff02::c	UDP	718	60291 → 3702 Len=656
358	503.690277	fe80::9d26:bec7:a814:71d2	ff02::c	UDP	718	60291 → 3702 Len=656
360	504.203419	fe80::9d26:bec7:a814:71d2	ff02::c	UDP	718	60291 → 3702 Len=656
362	505.229549	fe80::9d26:bec7:a814:71d2	ff02::c	UDP	718	60291 → 3702 Len=656
364	507.230665	fe80::9d26:bec7:a814:71d2	ff02::c	UDP	718	60291 → 3702 Len=656
366	509.231753	fe80::9d26:bec7:a814:71d2	ff02::c	UDP	718	60291 → 3702 Len=656

> Frame 67: 90 bytes on wire (720 bits), 90 bytes captured (720 bits) on interface 0  
> Ethernet II, Src: HewlettP\_b9:59:a6 (48:0f:cf:b9:59:a6), Dst: IPv6mcast\_16 (33:33:00:00:00:16)  
> Internet Protocol Version 6, Src: fe80::9d26:bec7:a814:71d2, Dst: ff02::16  
> Internet Control Message Protocol v6



# Enterprise Networks – The IPv4 Island

Cloud

Mobile

ISP

Campus  
IPv4

Data  
Center

Home

Content  
Provider





# IPv6 Is Unevenly Distributed

## –‘Early’ Adopters:

- V Large Scale – facing RFC1918 exhaustion
- Universities – Students need the latest technology in CS Dept, rolls out across campus
- Industrial – car industry & anyone dealing with IoT at all!
  
- This is changing – **many** more requests inbound
- Companies needing to formulate an IPv6 strategy
- MSFT IPv6 Corp Network project – provides a use case

# Best time to get into IPv6 is yesterday

	Urgent	Not Urgent
Important	Problem	Best to be here
Not Important		

## – Companies

- Still benefit from being late adopter (let others work out bugs)
- That time is coming to an end
- Certain industries no benefit because must be active (cloud, IoT)

## – Engineers

- No benefit in waiting
- Increased demand, shortage of skills, higher salary offers (usually).

# IPv6 Crash Course

- 128-bits of address space vs. 32 for IPv4



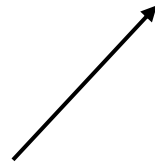
# IPv6 Crash Course

- Leading zeros and all zero 16-bits can be abbreviated:

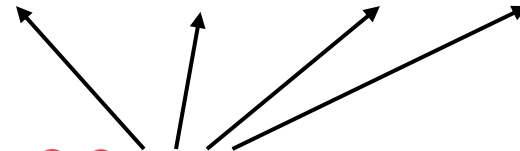
2b00:23a4:2b1d:0001:0000:0000:0000:0001



Snip!



Snip!



# IPv6 Crash Course

- Leading zeros and all zero 16-bits can be abbreviated:

2b00:23a4:2b1d:1::1

**Not so ugly!**



# IPv6 Crash Course

- Address planning is very different:
- /64 is the LAN subnet, required for SLAAC
- That's 18,446,744,073,709,551,616 IPv6 addresses per interface!

IPv4 World




IPv6 World




# IPv6 Crash Course

- Recommendation is to **GO BIG!**
- Home networks have a /56 (256 subnets)
- Small enterprise = /40 - /48
- /48 = 65,536 LANs!


<https://www.youtube.com/watch?v=fuGe7P-LsuQ>



Drew Conry-Murray  
Packet Pushers

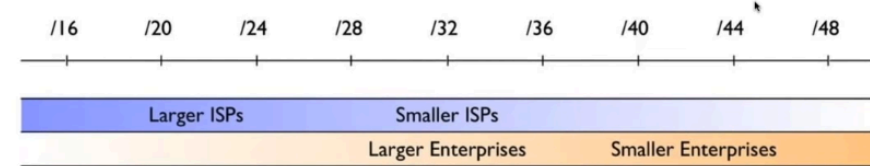


Ethan Banks  
Packet Pushers



Tom Coffeen


## HOW BIG SHOULD MY ORGANIZATIONAL IPv6 ALLOCATION BE?



- Most enterprises receive a /32 to a /44
- A /48 is assigned per site within the organization

27

©2019 HexaBuild Inc



# IPv6 Crash Course

- Assign a /48 per site
- Site being a logical entity in your network.

/48

Data Centre 1



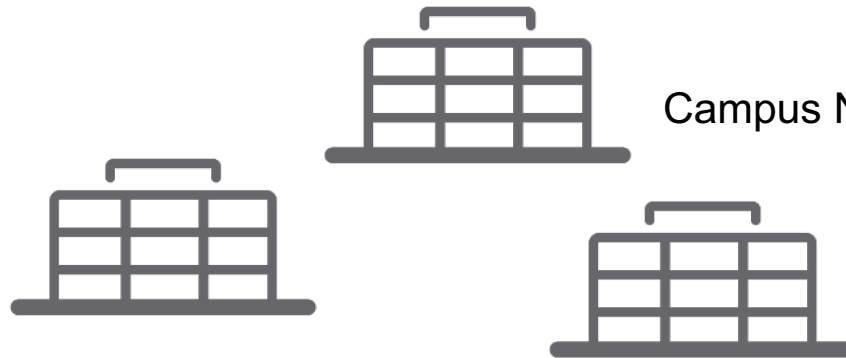
/48

Data Centre 2



/48

Campus Network

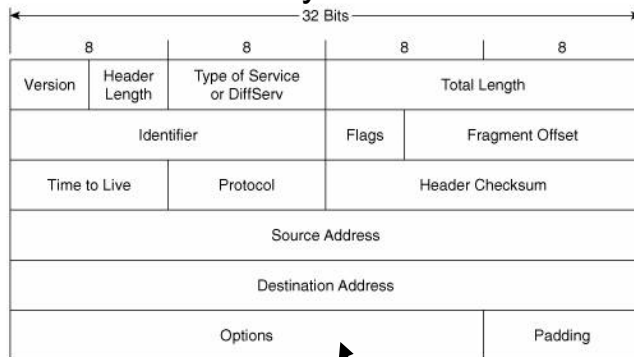


# IPv6 Crash Course

## More major differences:

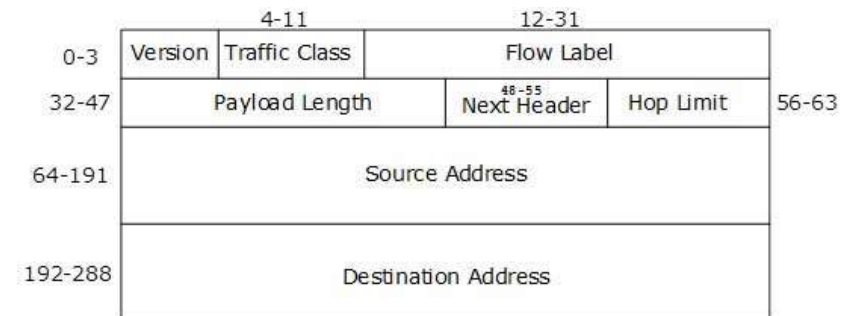
- All-new header

IPv4: 20 – 60 bytes



What is this anyway?

IPv6 – fixed 40 bytes



# IPv6 Crash Course

## More major differences:

### – Extension Headers

Extension Header	Type	Description
<i>Hop-by-Hop Options</i>	0	Options that need to be examined by all devices on the path.
<i>Destination Options</i> (before routing header)	60	Options that need to be examined only by the destination of the packet.
<i>Routing</i>	43	Methods to specify the route for a datagram (used with <a href="#">Mobile IPv6</a> ).
<i>Fragment</i>	44	Contains parameters for fragmentation of datagrams.
<i>Authentication Header (AH)</i>	51	Contains information used to verify the authenticity of most parts of the packet.
<i>Encapsulating Security Payload (ESP)</i>	50	Carries encrypted data for secure communication.
<i>Destination Options</i> (before upper-layer header)	60	Options that need to be examined only by the destination of the packet.
<i>Mobility</i> (currently without upper-layer header)	135	Parameters used with <a href="#">Mobile IPv6</a> .
<i>Host Identity Protocol</i>	139	Used for <a href="#">Host Identity Protocol</a> version 2 (HIPv2). <sup>[11]</sup>
<i>Shim6 Protocol</i>	140	Used for <a href="#">Shim6</a> . <sup>[12]</sup>
Reserved	253	Used for experimentation and testing. <sup>[13][4]</sup>
Reserved	254	Used for experimentation and testing. <sup>[13][4]</sup>

Source: [https://en.wikipedia.org/wiki/IPv6\\_packet](https://en.wikipedia.org/wiki/IPv6_packet)



# IPv6 Crash Course

## More major differences:

- No more ARP!
- Neighbor Discovery Protocol

### **Router Solicitation (Type 133)**

Hosts inquire with Router Solicitation messages to locate routers on an attached link.<sup>[3]</sup> Routers which forward packets not addressed to them generate Router Advertisements immediately upon receipt of this message rather than at their next scheduled time.

### **Router Advertisement (Type 134)**

Routers advertise their presence together with various link and Internet parameters either periodically, or in response to a Router Solicitation message.

### **Neighbor Solicitation (Type 135)**

Neighbor solicitations are used by nodes to determine the link layer address of a neighbor, or to verify that a neighbor is still reachable via a cached link layer address.

### **Neighbor Advertisement (Type 136)**

Neighbor advertisements are used by nodes to respond to a Neighbor Solicitation message.

### **Redirect (Type 137)**

Routers may inform hosts of a better first hop router for a destination.

Source: [https://en.wikipedia.org/wiki/Neighbor\\_Discovery\\_Protocol](https://en.wikipedia.org/wiki/Neighbor_Discovery_Protocol)

# IPv6 Crash Course

## More major differences:

- Forget 1 interface = 1 address
- Multiple addresses per interface are encouraged!
  - Link-local
  - Global Unicast
  - Privacy Extensions
  - ULA (?)



# IPv6 - Four to remember

## Key points:

1. Address Allocation
2. WLAN IPv6 Deployment
3. Dual-stack hardware exhaustion
4. First Hop Security



# 1. IPv6 Address Allocation – Many Moving Parts

## IPv4:

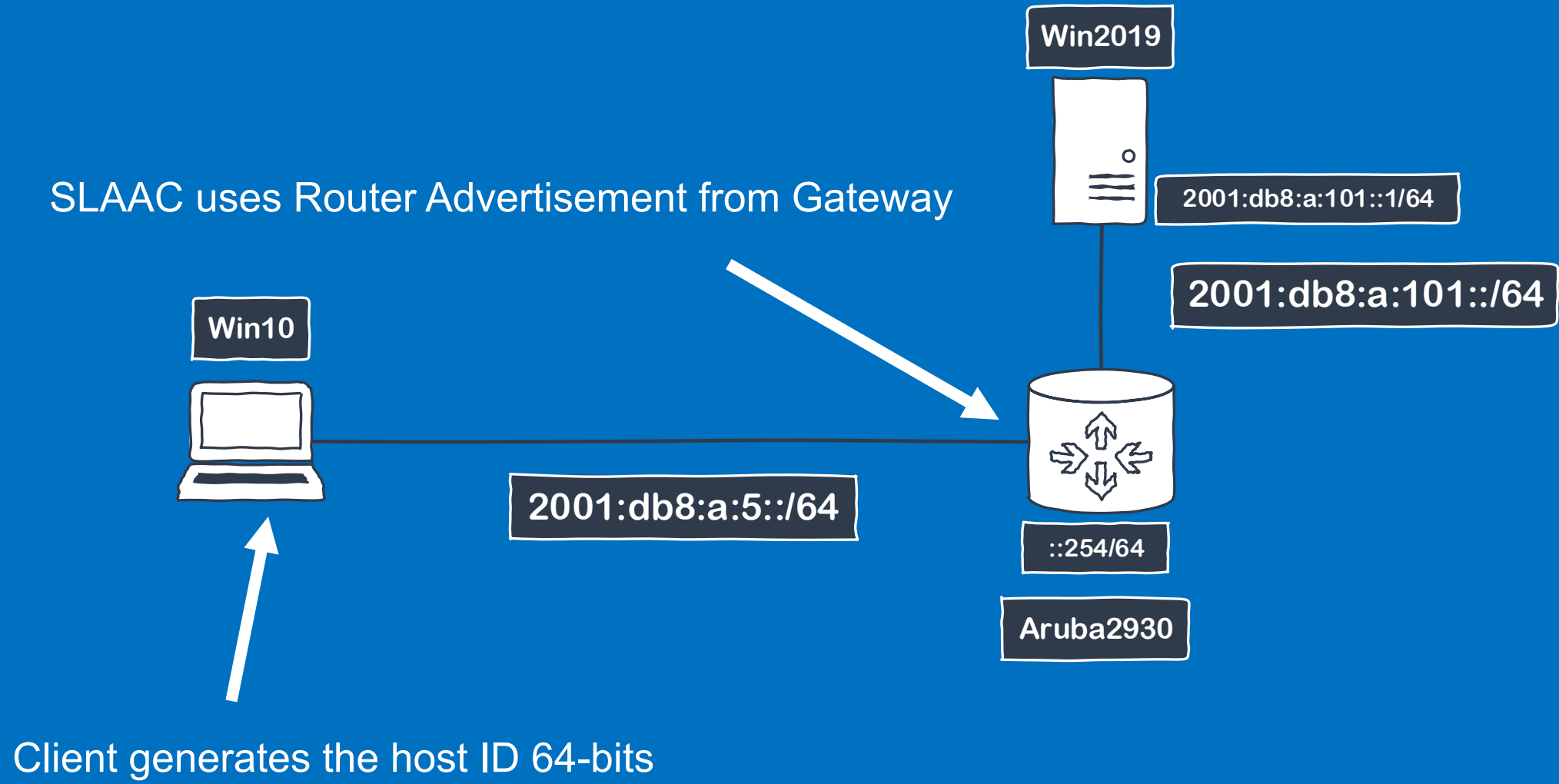
1. Static & DHCPv4
2. DHCPv4 options contain DNS servers and Default Gateway

## IPv6:

1. Stateless AutoConfiguration – SLAAC
2. DHCPv6 Stateful – Address and Other info (DNS)
3. DHCPv6 Stateless – Address from SLAAC, other info from DHCPv6 server
4. Static

# SLAAC

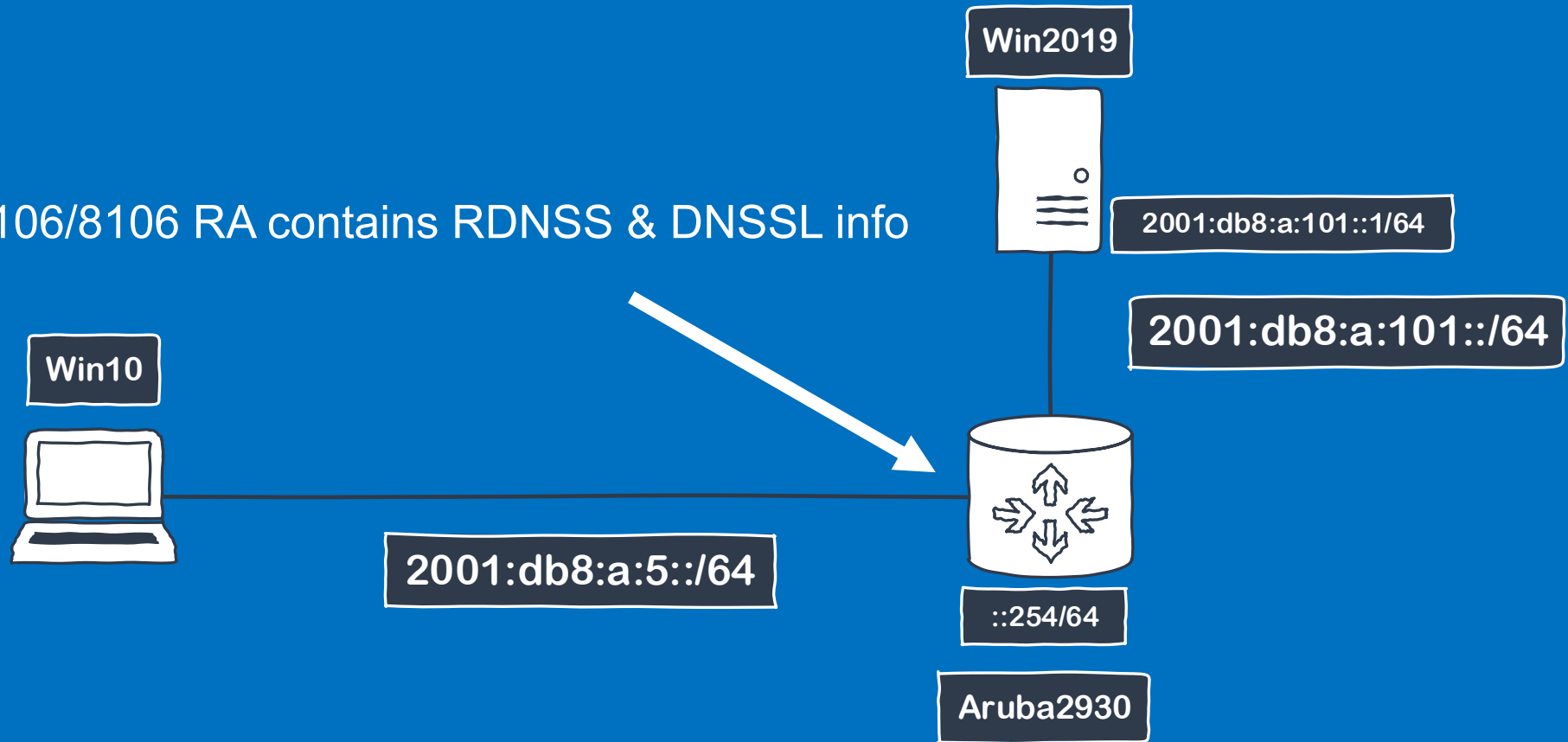
SLAAC uses Router Advertisement from Gateway





# SLAAC

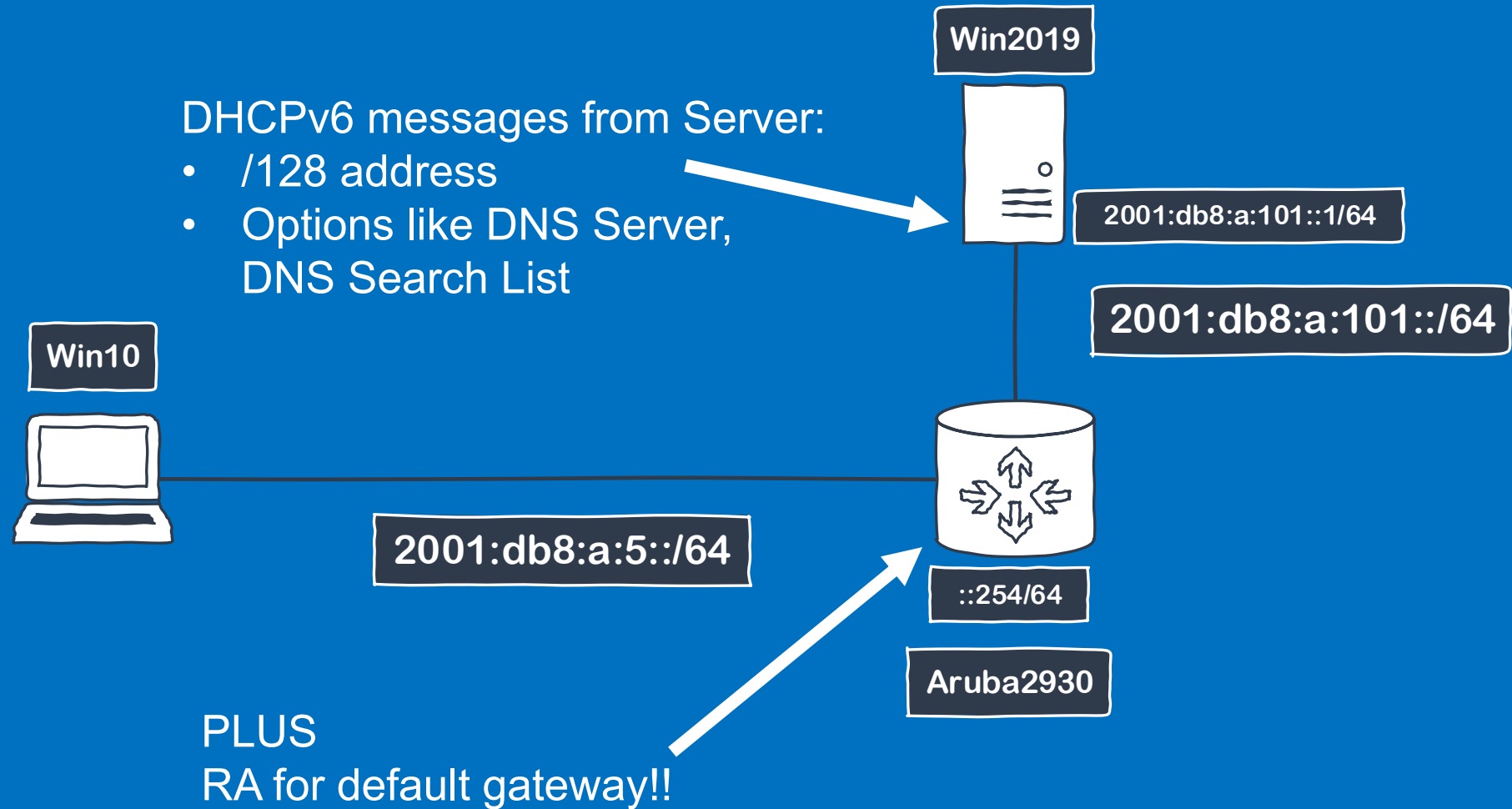
RFC6106/8106 RA contains RDNSS & DNSSL info



# DHCPv6 Stateful

DHCPv6 messages from Server:

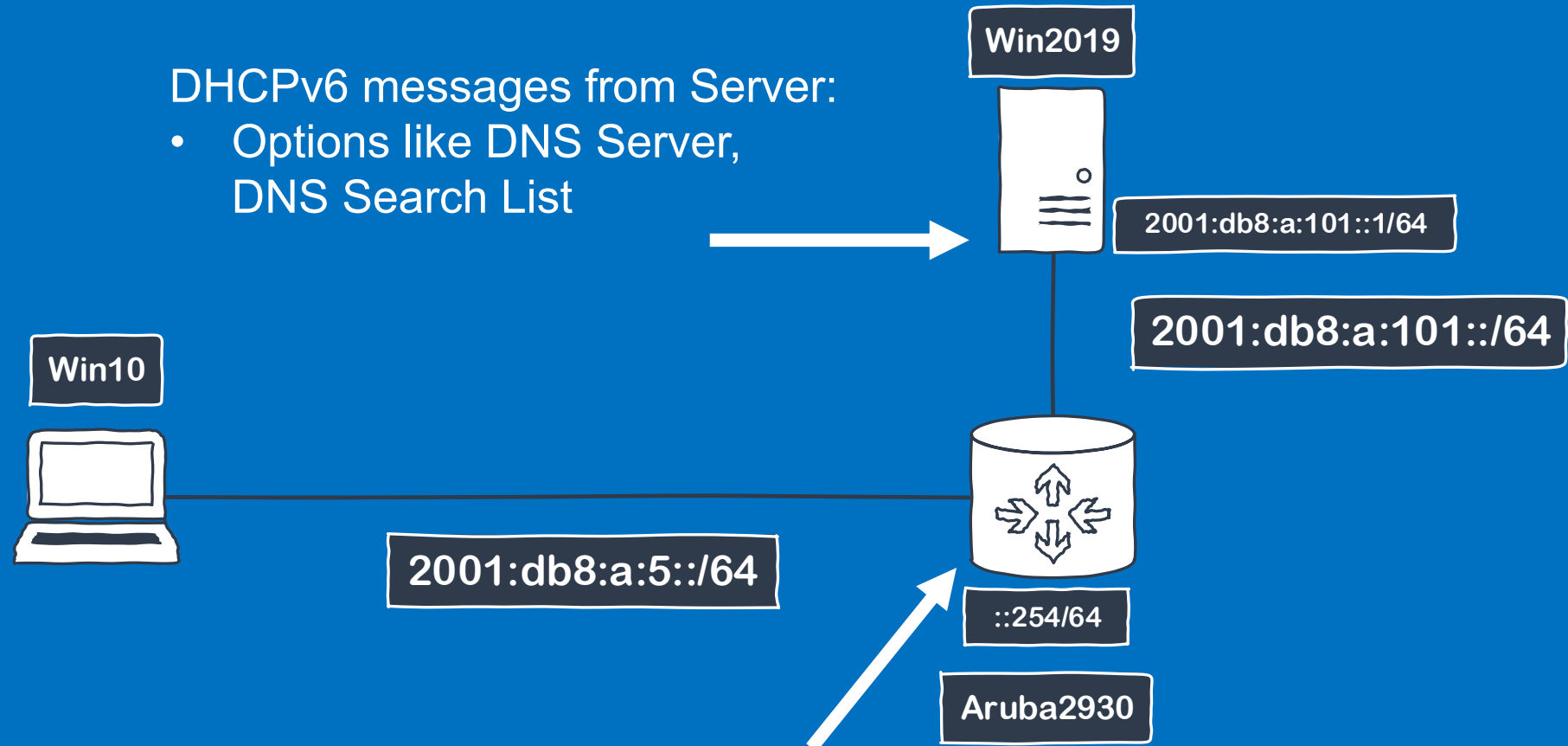
- /128 address
- Options like DNS Server, DNS Search List



# DHCPv6 Stateless

DHCPv6 messages from Server:

- Options like DNS Server, DNS Search List



RA for prefix and default gateway!!

## 2. Aruba AP Deployment & IPv6

# WLAN & IPv6 Address Allocation – *Even More Moving Parts*

## IPv6:

1. Stateless AutoConfiguration – SLAAC
2. DHCPv6 Stateful Address and Other info (DNS)
3. DHCPv6 Stateless – Address from SLAAC, other info from DHCPv6 server
4. Static



## AP Controller Discovery

1. ADP
2. DNS Options
3. CAPWAP-AC-V6 Option

Multiple possible combinations



# WLAN & IPv6 Address Allocation – *Even More Moving Parts*

## Currently Supported

### IPv6:

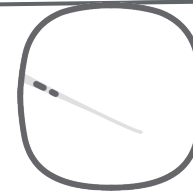
1. DHCPv6 Stateful Address and Other info (DNS)
2. DHCPv6 Stateless – Address from SLAAC, other info from DHCPv6 server



### AP Controller Discovery

1. DNS Options
2. CAPWAP-AC-V6 Option

# AP Controller Discovery Process



## Requirements

- IP Address

To source the query traffic

- DNS Server

To send the aruba-master query

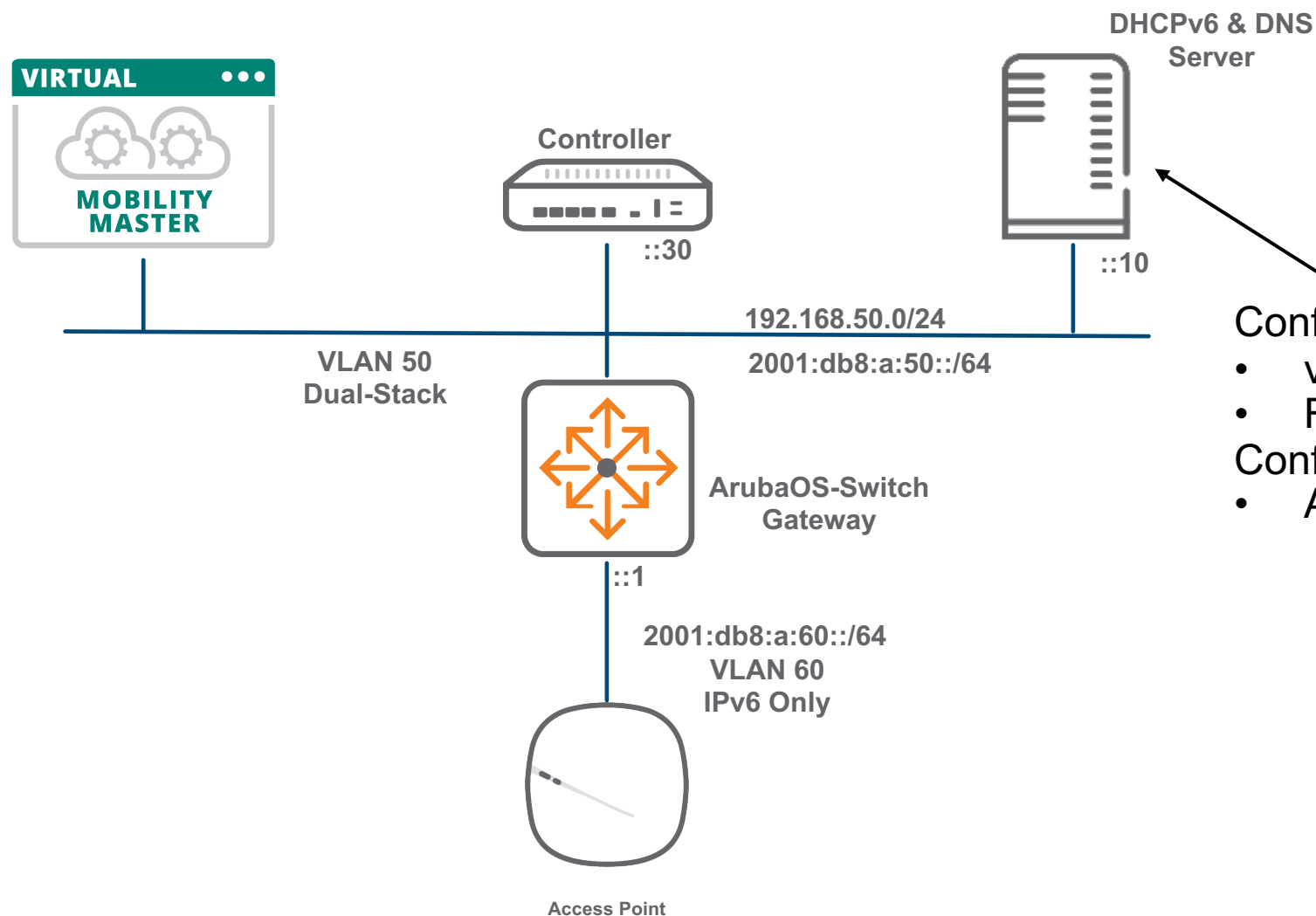
- DNS Search-List

FQDN for query

- Controller Address

To build IPSEC tunnel

# Stateful DHCPv6 with DHCP Options RDNSS 23 & DNSSL 24



- Configure DHCPv6:
- v6 address
  - RDNSS & DNSSL
- Configure DNS:
- AAAA for aruba-master

# Stateful DHCPv6 with DHCP Options RDNSS 23 & DNSSL 24 Gateway Config

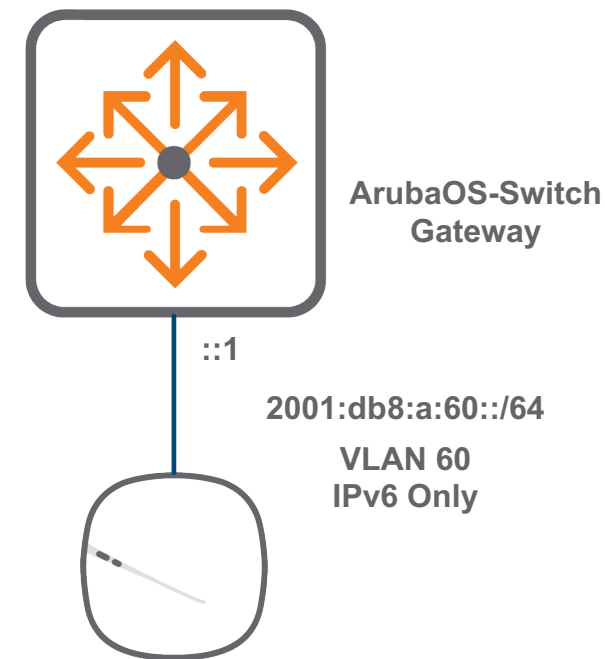
```
ipv6 unicast-routing  
vlan 50
```

```
    ipv6 enable  
    ipv6 address fe80::1 link-local  
    ipv6 address 2001:db8:a:50::1/64  
    ipv6 nd ra managed-config-flag  
    ipv6 nd ra prefix 2001:db8:a:50::/64 infinite no-autoconfig  
    ipv6 helper-address unicast 2001:db8:a:50::1
```

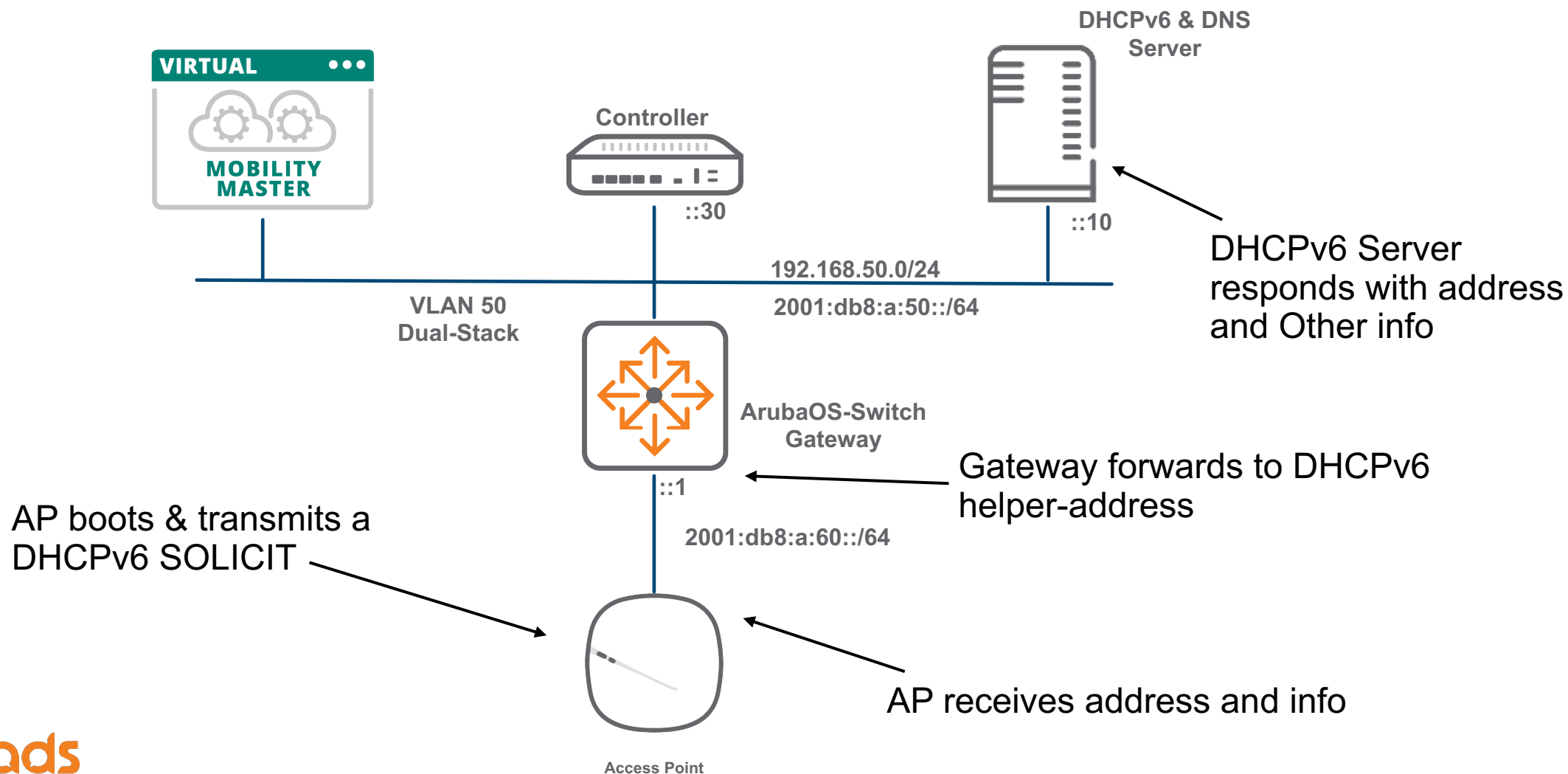
DHCPv6 helper address

M flag set – Get Address and  
Other info from DHCPv6

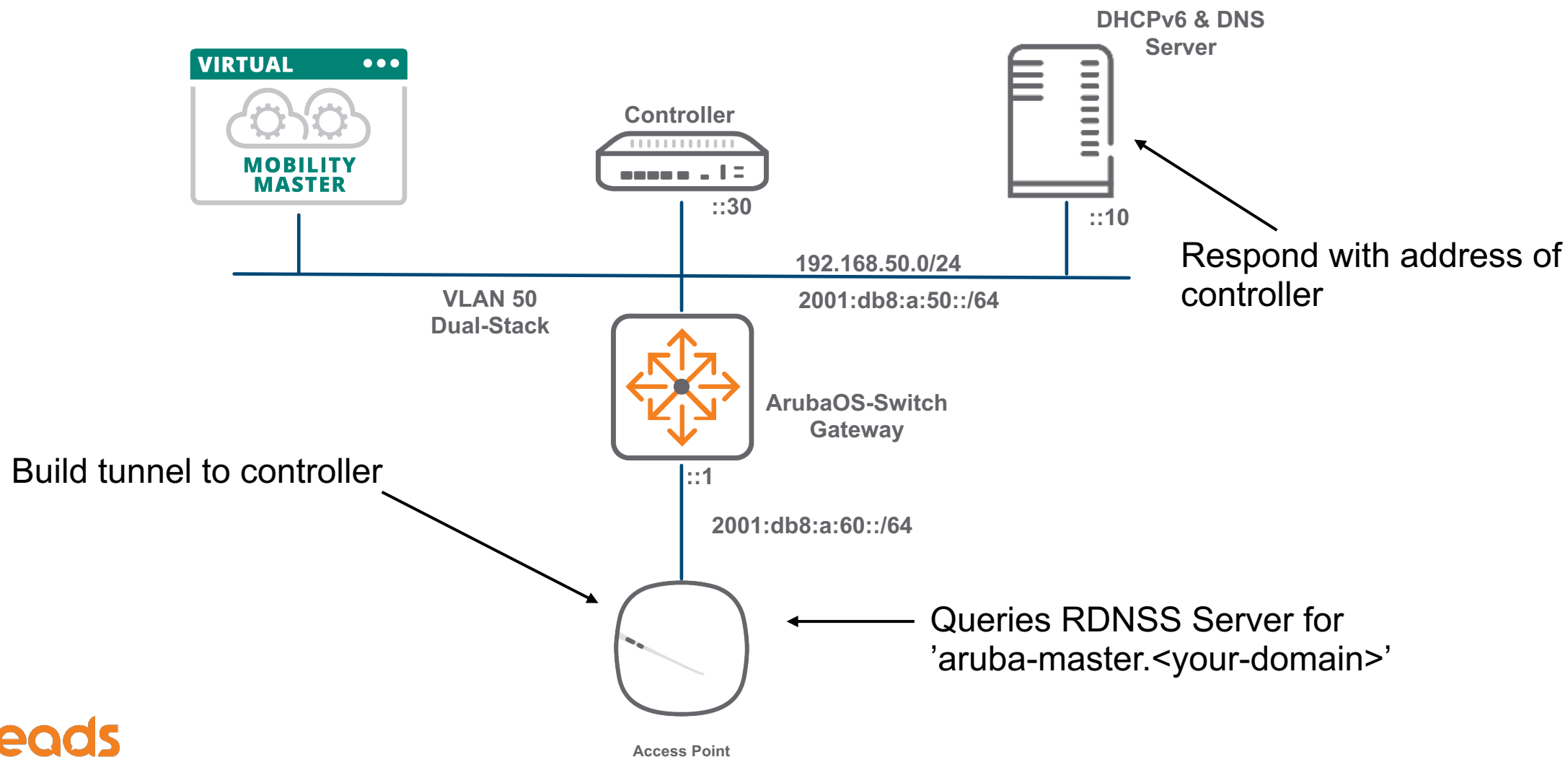
Prefix sent with L flag on and  
A flag off



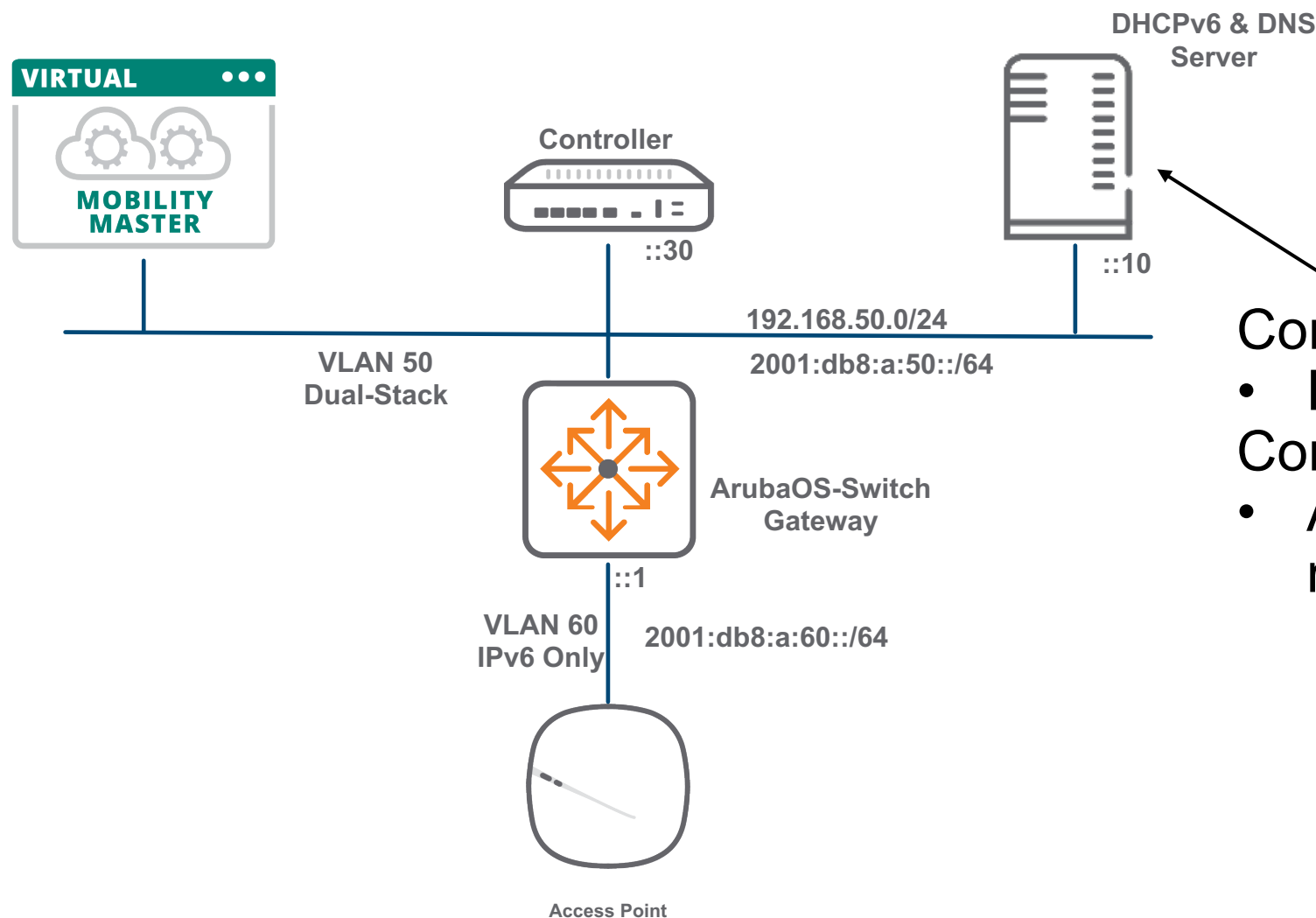
# Stateful DHCPv6 with DHCP Options RDNSS 23 & DNSSL 24



# Stateful DHCPv6 with DHCP Options RDNSS 23 & DNSSL 24



# Stateless DHCPv6 with DHCP Options RDNSS 23 & DNSSL 24



Configure DHCPv6:

- RDNSS & DNSSL

Configure DNS:

- AAAA for aruba-master

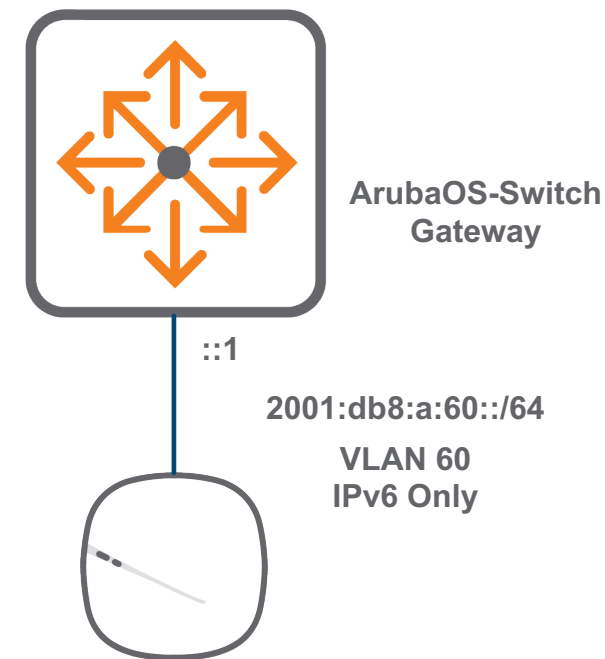


# Stateless DHCPv6 with DHCP Options RDNSS 23 & DNSSL 24 Gateway Config

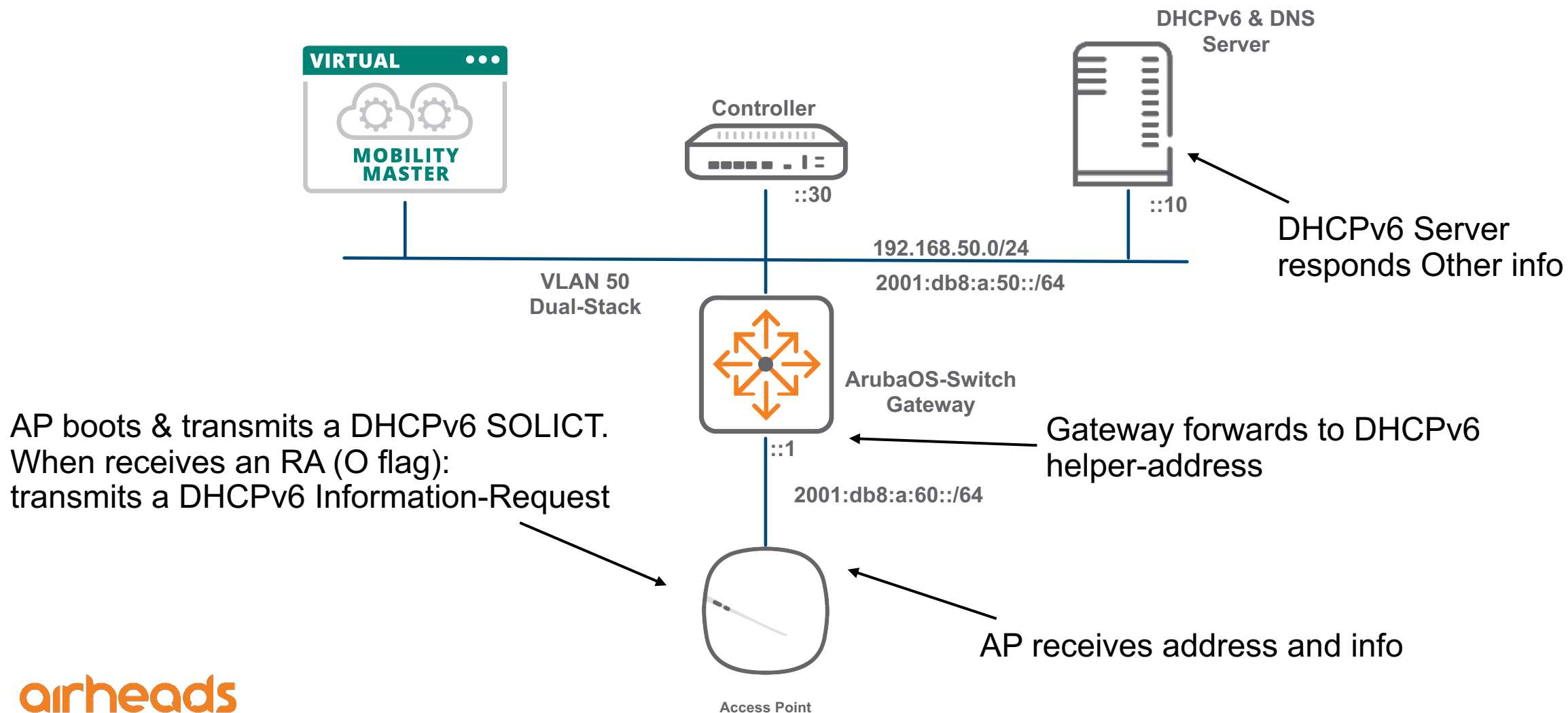
```
ipv6 unicast-routing
vlan 50
  ipv6 enable
  ipv6 address fe80::1 link-local
  ipv6 address 2001:db8:a:50::1/64
  ipv6 nd ra other-config-flag
  ipv6 helper-address unicast 2001:db8:a:50::1
```

Prefix sent with L flag on and A flag ON. /64 = SLAAC!

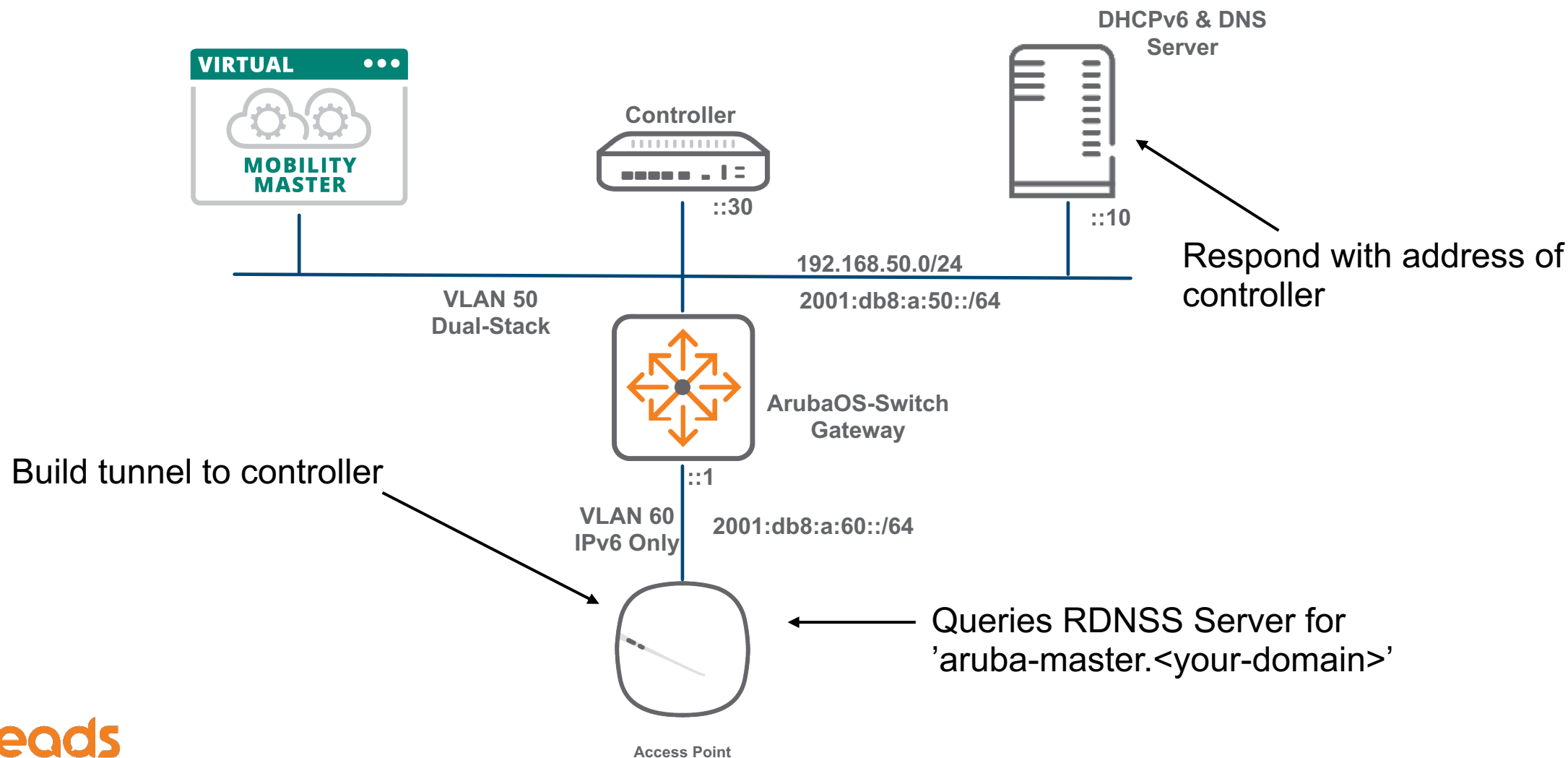
Other flag on



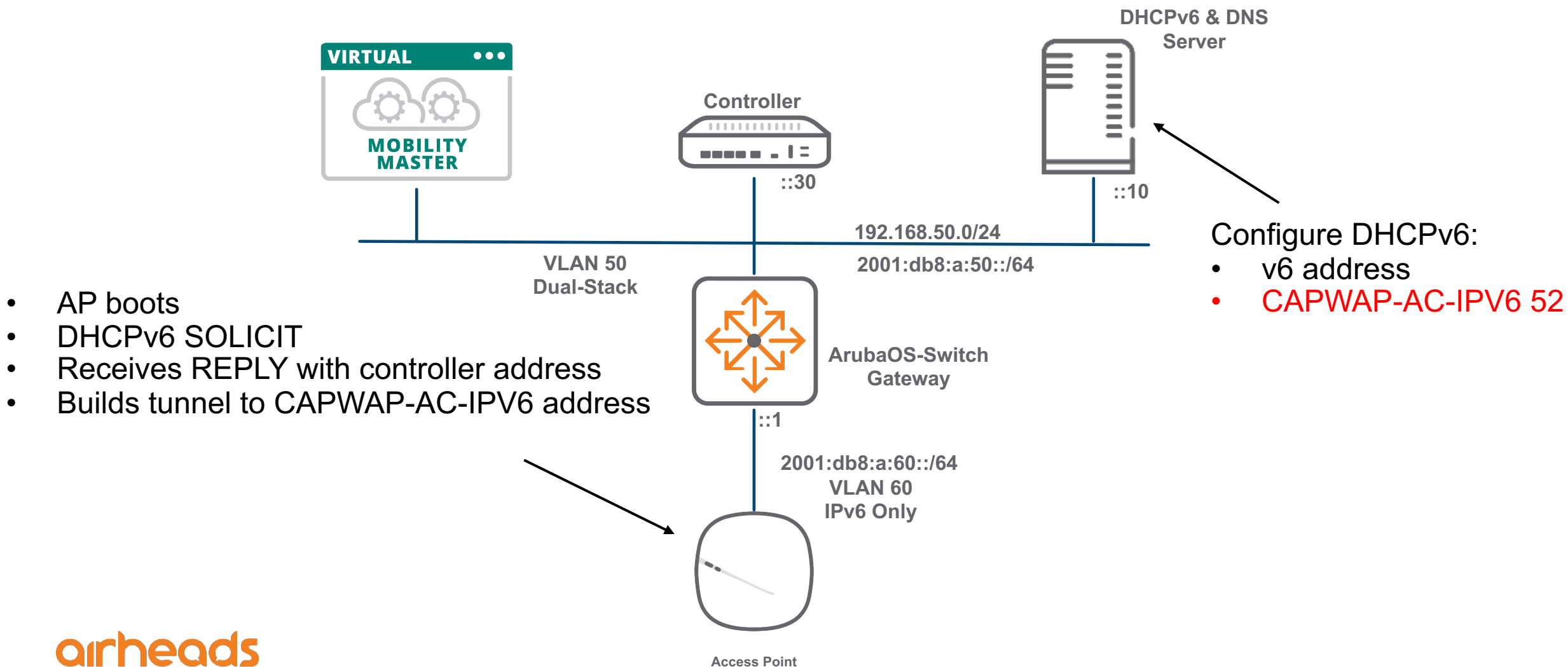
# Stateless DHCPv6 with DHCP Options RDNSS 23 & DNSSL 24



# Stateless DHCPv6 with DHCP Options RDNSS 23 & DNSSL 24



# DHCPv6 with DHCP Options CAPWAP-AC-IPV6 52



# IPv6 Address Allocation Issues!

## SLAAC Issues:

- RFC6106 support is not universal.
- Windows Creator Update and later (1703).

Sidenote – 2018 People told me of WinsXP client on their network

[Security Update for Windows XP SP3 \(KB4012598\)](#)

Windows XP

Security  
Updates

5/13/2017

n/a

665 KB

Download

[Security Update for Windows XP SP3 for XPe \(KB4500331\)](#)

Windows XP  
Embedded

Security  
Updates

5/9/2019

n/a

519 KB

Download

2017



2019



# IPv6 Address Allocation Issues!

## DHCPv6 NOT SUPPORTED ON ANDROID

- This is by design
- Issue tracker opened June 2012:  
<https://issuetracker.google.com/issues/36949085>
- 277 comments, no change
- Impacts address allocation – many go with SLAAC & DHCPv6

That leads us on to the next point



### 3. Dual-stack hardware exhaustion

#### IPv4:

1. Usually one address per host

#### IPv6:

1. Multiple prefixes per interface by design
2. DHCPv6 = 2 prefixes, 1 link-local, 1 GUA
3. SLAAC = 3 prefixes, 1 link-local, 2 GUA
4. Mixed OS environment: 4 prefixes or more!
5. IPv6 addresses take up more resources!

Impacts the networking hardware resources, only have finite routing and IPv6 neighbour tables.

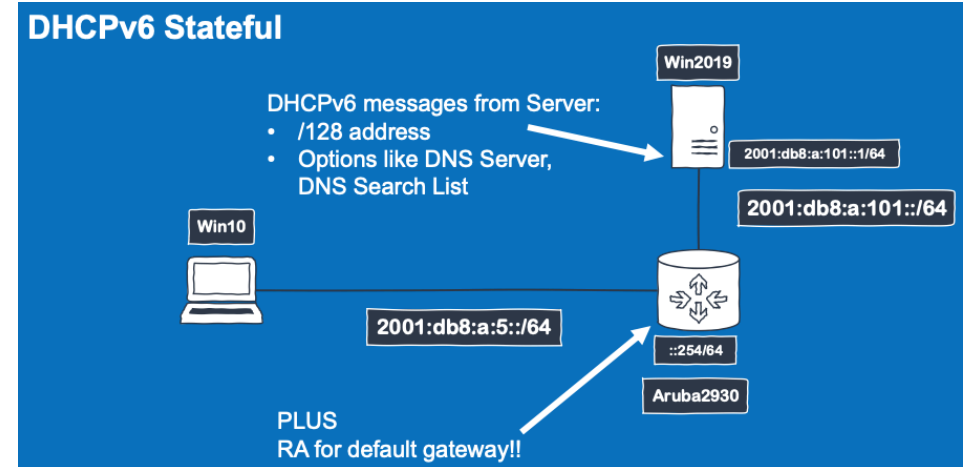
Dual-stack makes this even worse!

## 4. First Hop Security

### New Attack Vectors

- All those options, packets and the whole new NDP create new opportunities for exploits.
- Spoofing DHCPv6 and NDP pkts for man-in-the-middle & DoS attacks.
- RA is like the crown jewels of the LAN network – crucial because it controls addressing and the default gateway!

Mitigation tools like RA Guard are fundamental requirements.  
As is a IPv6 specific security plan.  
Understanding IPv6 is vital to understanding how to secure it!





# Aruba & IPv6



## IPv6 Open for Business

- Good support on AOS-Switch, Layer 3 Gateway support on ArubaOS-CX
- Dual-stack supported on AOS8 & Aruba Instant. APs can boot and discover MD in IPv6 only network.
- Mgmt and Provisioning needs work. We are aware and working on this. Watch this space.

# Aruba & IPv6



## IPv6 Open for Business

- Live IPv6 deployments across the globe, airheads 'pink' series focused on Wins and v6 wired.
- Working with PLM & Aruba CTO office to plug v6 gaps in Aruba portfolio.
- AOS8 & Instant IPv6 write-up:

<https://github.com/Joe-Neville/aos-ipv6/blob/master/aruba-ap-ipv6-deployment.md>

# airheads

TECH TALK *LIVE*