IPv6 address planning

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Our plan

- Hexadecimal: learn it [WIKIPEDIA], love it! 😍
- Importance of IPv6 address planning
- IPv6 address types, sizes and subnetting
- IPv6 address structure
- Planning the subnet bits
- Configuring the local bits
- DNS server and router addresses
- Organizations with subdivisions
- Questions?

Importance of IPv6 address planning

- You *will* have to make an IPv6 address plan
  - the only question is how many...
- Ideal world:
  1. create the perfect IPv6 address plan
  2. request address space
  3. roll out IPv6
  4. profit

Importance of IPv6 address planning

- Real world: you will make mistakes, so try to build in flexibility and adjust quickly
- At least you have some address space to waste
  - so err on too big rather than too small
    - get rid of "IPv4 thinking"!
- Change is hard, so it's only worth it to make *big* changes
- Or try out IPv6 in a small way first to figure it out
  - but have the discipline to throw out your test setup and start from scratch!

IPv6 address types

- Link-local: not unique
  - created and used automatically
  - *do not try to manage or use these yourself*
- Global unicast: "regular" IPv6 addresses
  - you use these 99% (100%?) of the time
- Unique Site Local (ULA): unique, but not routable over the internet
  - a bit like RFC 1918 addresses but without NAT
  - very specific use cases

Assignment size

- (Assignment is RIPE-speak for the address block you get from your ISP)
- Home users often get /56, /60 or even /64
- For organizations, default size is **/48**
  - that means: 48 of the 128 address bits are given/fixed
    - you can fill in the remaining 80 bits yourself
  - even if you really don't need that much: smaller than /48 makes address planning harder
- Also: ISPs usually only accept /48 and larger blocks in BGP
  - so provider independent addresses *must* be at least /48

Subnetting

- IPv6 is classless: routers can deal with any size
- But: IPv6 addressing architecture [RFC 4291] says that the host part of the address must be 64 bits
- So 48 bits are given and 64 bits are used to number devices, this leaves 128 - 48 - 64 = 16 bits to number *subnets*

IPv6 address structure

(Remember IPv6 address notation [RFC 5952])

0	16	32	48	64	80	96	112	127
2001:	db8:	188:	301:	145:	0:	2:	10	

0	16	32	48	64	80	96	112	127
3ffe:	4700:	1f0b:	1289:	cd06:	e4b7:	247e:	1cfe	

IPv6 address structure

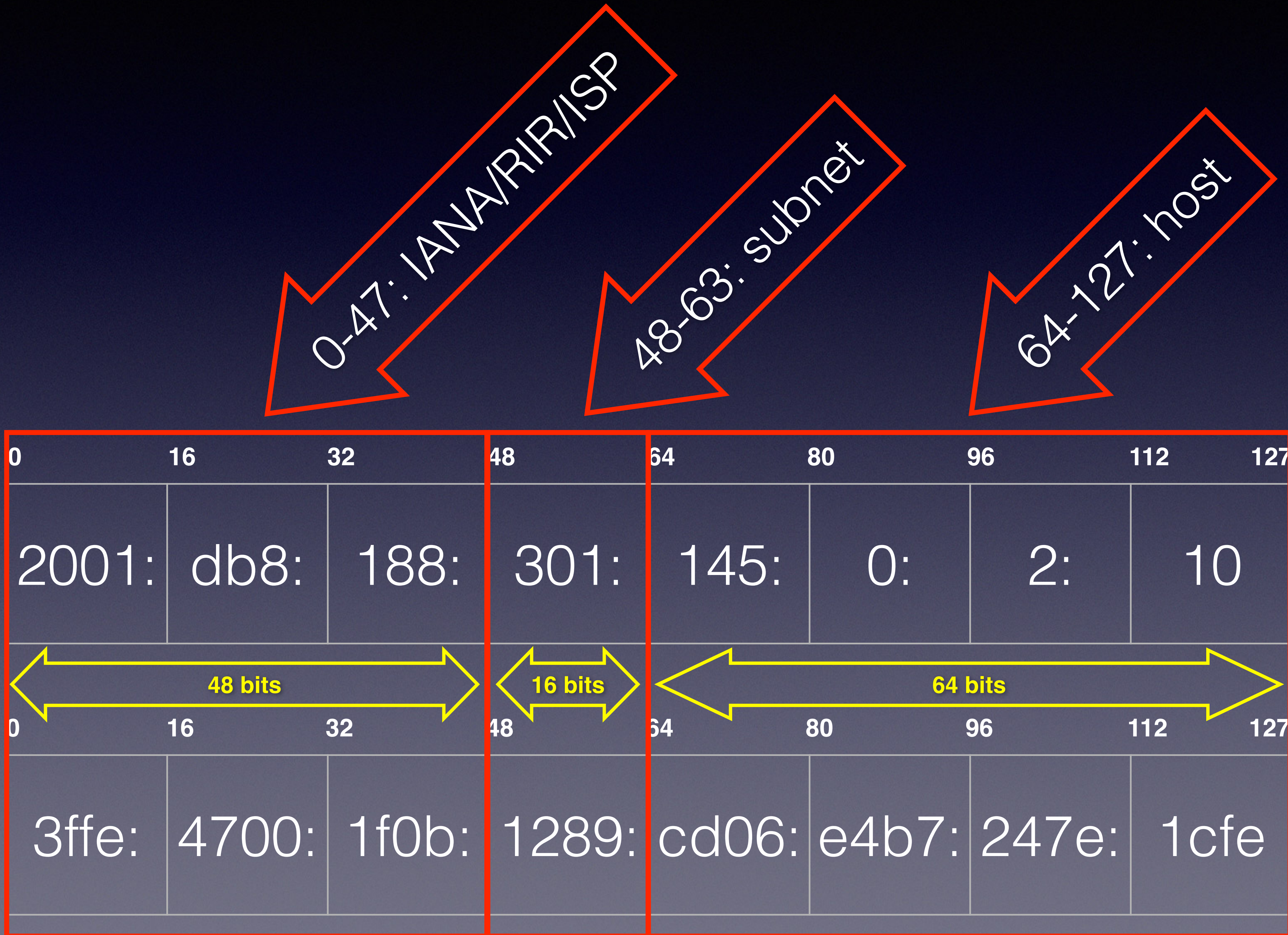
(Every digit in the IPv6 address is exactly 4 bits)

0	16	32	48	64	80	96	112 – 127
2001:	db8:	188:	301:	145:	0:	2:	10

48 bits | 16 bits | 64 bits

0	16	32	48	64	80	96	112 – 127
3ffe:	4700:	1f0b:	1289:	cd06:	e4b7:	247e:	1cfe

IPv6 address structure



Planning the subnet bits

- Why do we need to split our network into subnets?
  - to allow efficient / effective / robust routing, like:
    - each floor its own subnet
    - each rack in the datacenter its own subnet
    - each subnet must be confined to one location
  - for security, like:
    - guest network subnet(s)
    - work station subnet(s)
    - front end server subnet(s)
    - back end server subnet(s)

The easy way: VLAN IDs

- If it's nice outside and you want to leave work early instead of address planning the rest of the day...
- Put the VLAN ID in the subnet bits, like:
    - VLAN **1**: 2001:db8:edca:**1**::/64
    - VLAN **28**: 2001:db8:edca:**28**::/64
    - VLAN **3040**: 2001:db8:edca:**3040**::/64
- Still leaves all subnet values with a - f in them and above 4095
- Of course pay attention to your VLAN numbering!

Subnetting examples

Location	Type	Instance
Old city center office	Guest Wi-Fi	Floor 0
	BYOD Wi-Fi	
	Managed workstations	
	Printers	Floor 0 and 1
	Guest Wi-Fi	Floor 1
	BYOD Wi-Fi	
	Managed workstations	
New tower office	Guest Wi-Fi	Floor 23
	BYOD Wi-Fi	
	Managed workstations	
	Printers	Floor 23 and 24
	BYOD Wi-Fi	Floor 24
	Managed workstations	

Location	Type	Instance
Datacenter DC1	Front end servers	Rack 11
	Database servers	
	Storage servers	
	Front end servers	Rack 13
	Database servers	
	Storage servers	
Datacenter DC2	Front end servers	Rack A4
	Database servers	
	Storage servers	
	Front end servers	Rack A5
	Database servers	
	Storage servers	

Location or type first

- Location bits come first, then type bits:
  - smaller routing tables but larger firewall tables
- Type bits come first, then location bits:
  - smaller firewall tables but larger routing tables
- In general: routers can handle large tables better than firewalls

Location or type first

Location first

Subnet	Location	Type	Instance
1C1	1 = DC1	C = Front ends	1 = Rack 11
1C2			2 = Rack 13
1D1		D = Databases	1 = Rack 11
1D2			2 = Rack 13
1E1		E = Storage	1 = Rack 11
1E2			2 = Rack 13
2C1	2 = DC2	C = Front ends	1 = Rack A04
2C2			2 = Rack A05
2D1		D = Databases	1 = Rack A04
2D2			2 = Rack A05
2E1		E = Storage	1 = Rack A04
2E2			2 = Rack A05

Type first

Subnet	Type	Location	Instance
C11	C = Front ends	1 = DC1	1 = Rack 11
C12			2 = Rack 13
C21		2 = DC2	1 = Rack A04
C22			2 = Rack A05
D11	D = Databases	1 = DC1	1 = Rack 11
D12			2 = Rack 13
D21		2 = DC2	1 = Rack A04
D22			2 = Rack A05
E11	E = Storage	1 = DC1	1 = Rack 11
E12			2 = Rack 13
E21		2 = DC2	1 = Rack A04
E22			2 = Rack A05

Let's assume 4 bits = 0 - 15 / 0 - F for everything right now. This works well in small networks, will need to use the right number of bits in larger networks.

Location or type first

Location first

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1E2			2 = Rack 13
2C1	2 = DC2	C = Front ends	1 = Rack A04
2C2			2 = Rack A05
2D1		D = Databases	1 = Rack A04
2D2			2 = Rack A05
2E1		E = Storage	1 = Rack A04
2E2			2 = Rack A05

Type first

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Configuring the local bits

- IPv6 has *all* the address configuration mechanisms
  - stateless autoconfiguration
    - least stable address, but most automatic
    - hard to add to DNS and don't know which device has which address
  - DHCPv6
    - not in Android and dependency on DHCPv6 server
  - manual configuration
    - most stable address, but not automatic

Configuring the local bits

- Guest/BYOD etc. Wi-Fi:
  - stateless autoconfig
    - in order to be compatible with Android
- Managed work stations:
  - stateless autoconfig or DHCPv6
    - DHCPv6 for DNS registration or address logging
- Servers:
  - *probably* manual configuration

Configuring the local bits

- These are just suggestions to keep things simple
- Manual configuration:
  - ::1 for default route address (probably VRRP, with maybe :11 for router 1 and :12 for router 2)
  - use service port number: ::53 for DNS, ::80 for HTTP
  - matching IPv4:
    - 192.0.2.1 → 2001:db8:edca:8001:192:0:2:1
    - (but 2001:db8:edca:8001::192.0.2.1 is something different!)
- DHCPv6:
  - ::2000 - ::2fff keeps addresses short (allows for 4096 DHCPv6 addresses)

Local bits examples

- 2001:db8:edca:8001::1
- 2001:db8:edca:8001::11
- 2001:db8:edca:8001::12
- 2001:db8:edca:8001::80
- 2001:db8:edca:8001::2005
- 2001:db8:edca:8001:203::113:127
- 2001:db8:edca:8001:5054:18ff:fedb:d4a4
- 2001:db8:edca:8001:c139:b4c1:6850:12e5

Local bits examples

- 2001:db8:edca:8001::1 → default gateway (VRRP)
- 2001:db8:edca:8001::11 → router 1
- 2001:db8:edca:8001::12 → router 2
- 2001:db8:edca:8001::80 → HTTP server
- 2001:db8:edca:8001::2005 → DHCPv6
- 2001:db8:edca:8001:203::113:127 → manual from 203.0.113.127
- 2001:db8:edca:8001:5054:18ff:fedb:d4a4 → stateless autoconfig from MAC
- 2001:db8:edca:8001:c139:b4c1:6850:12e5 → stateless autoconfig + privacy

DNS server addresses

- DNS addresses are the only addresses you can't look up in the DNS!
  - (at least, those *should* be the only ones)
  - so need to be easy to type/remember and avoid renumbering them
- So give each their own /64 (so they can be moved independently) with low subnet #, such as:
  - DNS server 1: 2001:db8:edca:1::53/64
  - DNS server 2: 2001:db8:edca:2::53/64
  - DNS server 3: 2001:db8:edca:3::53/64

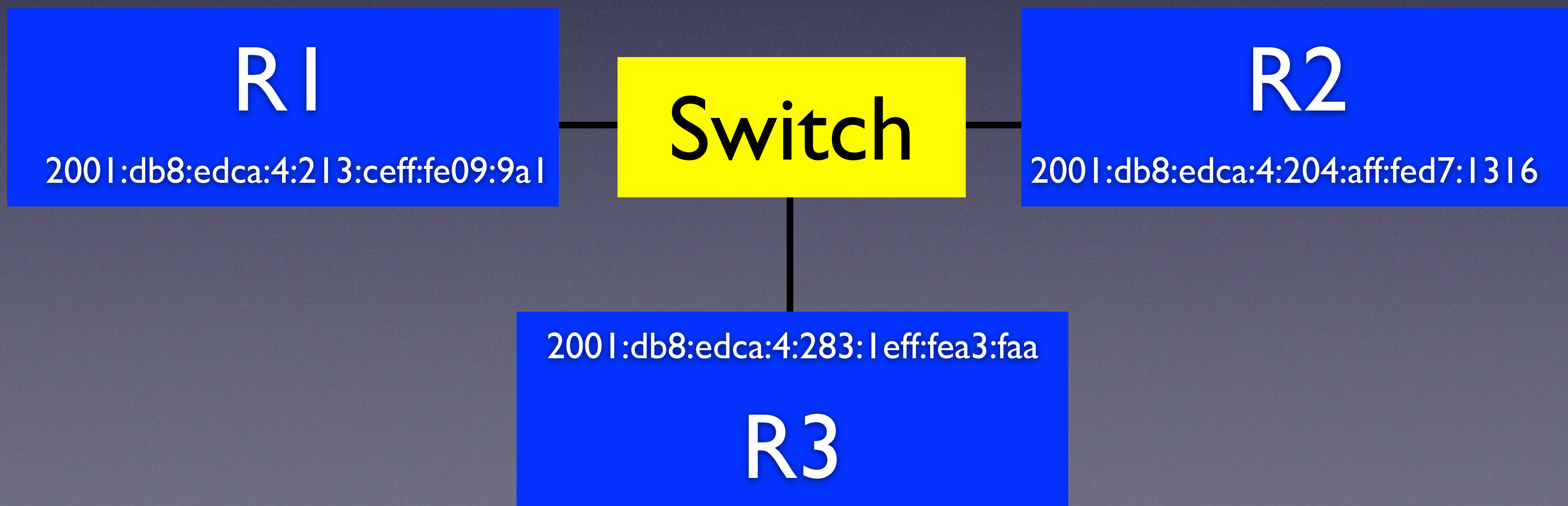
Router addresses

- Subnets with only internal routers:
  - OSPF etc. don't need global addresses, can use just link-local addresses
- Subnets with stateless autoconfig and/or DHCPv6:
  - EUI-64 addressing (or even link-local only)
- Subnets with manually configured hosts:
  - manually configured default gateway for hosts

Router EUI-64 addressing

- Each router has the same configuration, but they all create a unique IPv6 address from the subnet /64 and their MAC address

```
!
interface Ethernet0
 ipv6 address 2001:db8:ecda:4::/64 eui-64
!
```



Organizations with subdivisions

- Big organizations that are made up from different sub-organizations in different locations, such as:
  - a multinational enterprise
  - a national government
- Having one big prefix and a unified numbering plan can help with security
- But the sub-organizations probably need to connect to the internet on their own

Organizations with subdivisions

- Get an LIR prefix (such as /29) from RIPE NCC
- Give out /48s (or larger... talk to the NCC) to sub-organizations
  - smaller than /48 won't be routable
- Where do the security bits go?
  - "below" /48 = location before type = large firewall tables
  - "above" /48 = type before location, so each location must have multiple (/48?) prefixes
    - may not fit with RIPE IPv6 assignment policies
- There is an NCC contact for governments for these issues

Questions?

- Much of this based on the Surfnet IPv6 address planning guide:
  - https://www.ripe.net/support/training/material/IPv6-for-LIRs-Training-Course/Preparing-an-IPv6-Addressing-Plan.pdf/at_download/file
- Also available in Dutch:
  - https://wiki.surfnet.nl/download/attachments/11211103/rapport_201309_IPv6_numplan_NL.pdf
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