Mapping of Address and Port using Translation (MAP-T)

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What is MAP-T?

One of two transport modes of MAP

- Mapping of Address and Port with Encapsulation (MAP-E) is the other transport mode

IPv4/IPv6 stateless translation

- Used to support IPv4 network to IPv4 connectivity over an IPv6 network

Supports N:1 IPv4 address sharing

- Competing technology in the CGN/LSN solution space
- Different than other CGN/LSN solutions as state remains on the subscriber's router
- Subscriber router is assigned a public IPv4 address (logically) with a unique set of layer-4 ports

Interest by Vertical

Content Provider

- Shared IPv4 address versus dedicated addressing per subscriber
  - Licensing
  - Reputation
  - Possibly geolocation (depends on implementation)
- Layer-4 port multiplexing scale (not 16-Bit)
- Peer-to-peer traffic
  - Triangular routing
  - Implication for UPnP/IGD and static port forwarding
  - UDP hole punching techniques are not impacted
- IPv6 strategy

Service Provider

- Potential for adoption
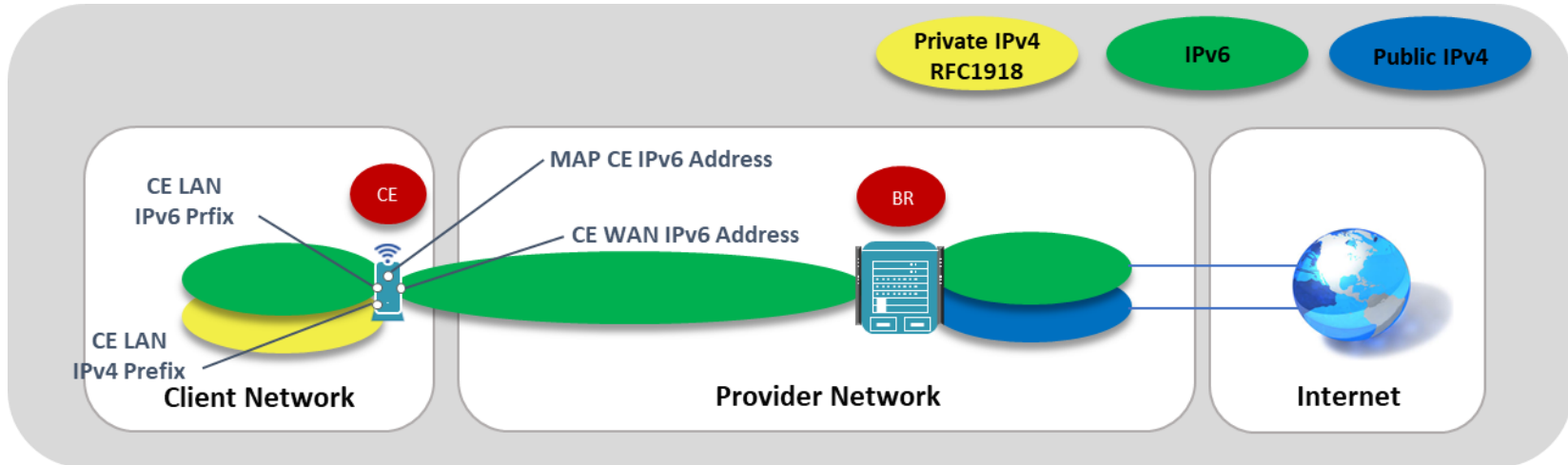
MAP-T Components in Context
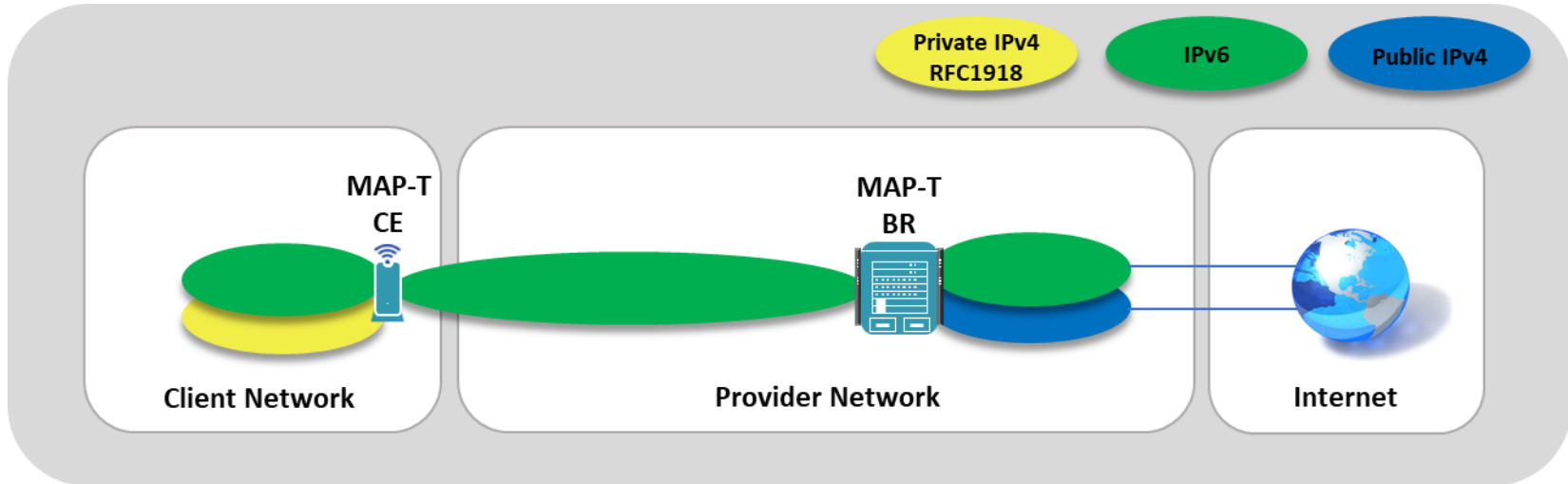
MAP-T Customer Edge (MAP-T CE)

- A home gateway (wireless router, cable modem + router, etc.)
- Provides IPv4/IPv6 stateless translation as well as native IPv6 forwarding

MAP-T Border Relay (MAP-T BR)

- Provider side component which supports the IPv4/IPv6 stateless translation

MAP-T Subscriber Addressing

IPv4 MAP-T CE Addressing

- Subscriber assigned IPv4 prefix on LAN/WLAN segment (RFC1918)

IPv6 CE Addressing

- Provider facing interface is an IPv6 address that is independent of MAP-T
- MAP-T address is derived from assigned end-user prefix
- LAN/WLAN prefix is allocated from assigned end-user prefix

MAP-T Terminology

Mapping Rule

- Associates IPv4 prefix to an IPv6 prefix
  - The IPv4 prefix is a prefix used for the "IPv4 NAT Pool" or shared IPv4 address(s)
  - The IPv6 prefix is the aggregate of the prefixes assigned to individual subscribers
- Used by MAP-T CE to determine its IPv4 address and optionally the layer-4 port allocation
- Allows a MAP-T BR to support IPv4/IPv6 stateless translation

Base Mapping Rule

- The mapping rule(s) used by a MAP-T CPE given a list of mapping rules

Default Mapping Rule (DMR) or BR Prefix

- An IPv6 prefix used to embed IPv4 destination addresses (RFC 6052)
- Similar to IPv4 default route

MAP-T Terminology

MAP Domain

- A mechanism to group a set of MAP-T CEs with a set of MAP-T BRs
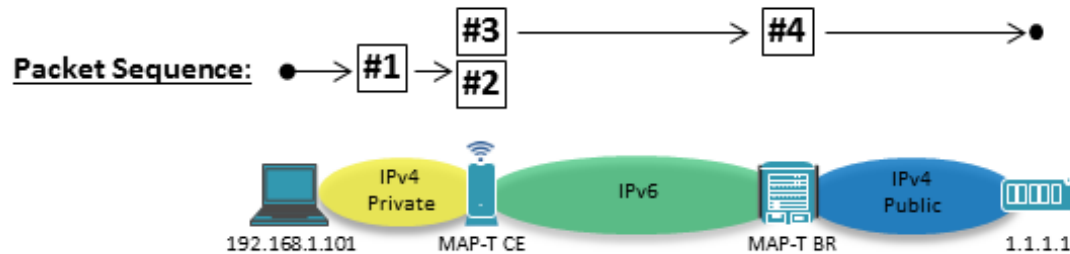
Embedded Address (EA) bits

- A set of bits within a IPv6 user prefix which identify a unique or shared IPv4 address and a index into the associated set of layer-4 ports

  - Mapping rule provides the offset information for these bits

MAP-T Terminology in Context
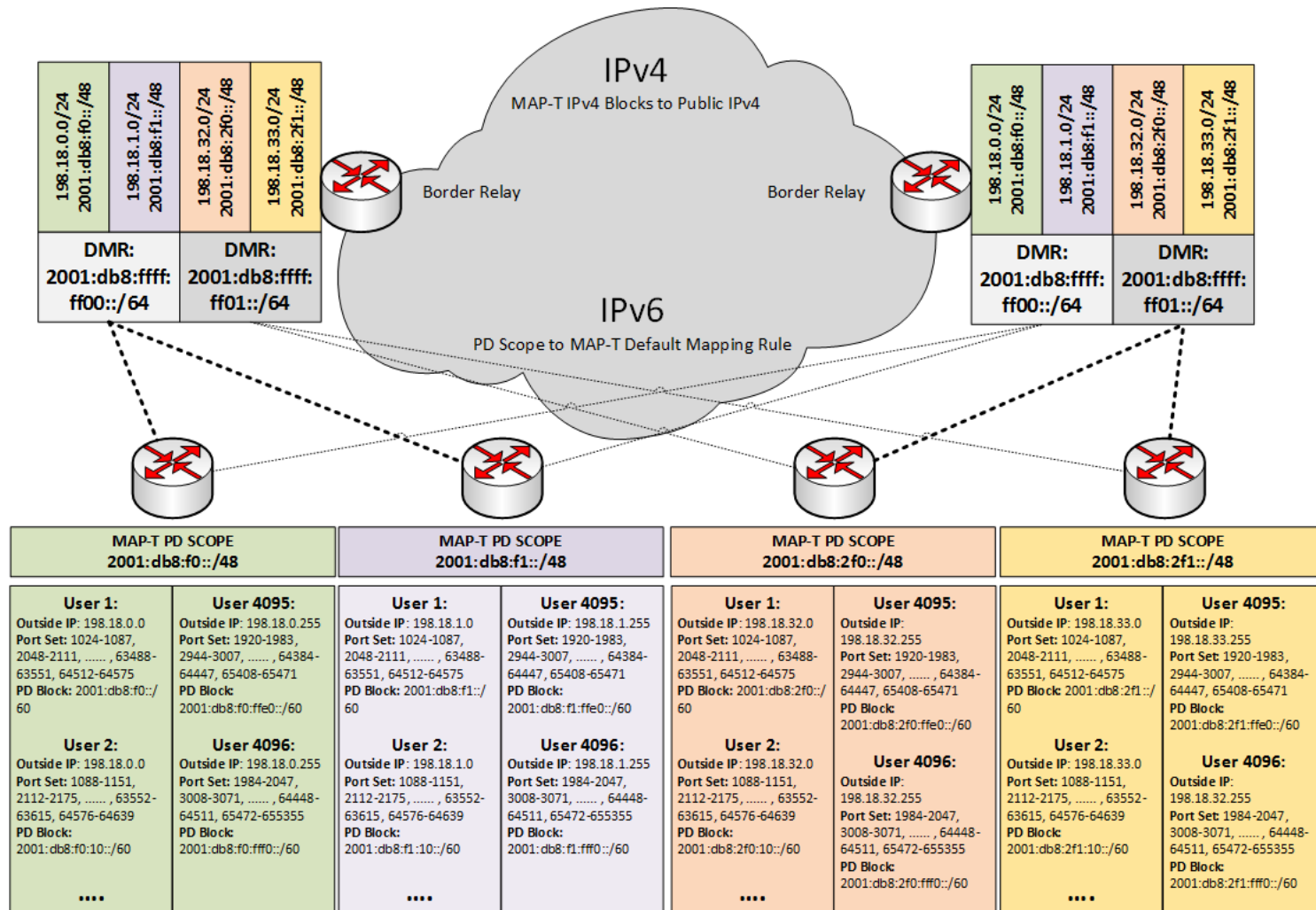
MAP-T in Action – Subscriber to Internet

Packet #1: IPv4 private connected workstation transmits a packet to a destination server 1.1.1.1

1025	80	TCP	192.168.1.101	1.1.1.1

Packet #2: MAP-T CE performs NAPT

4000	80	TCP	192.0.2.2	1.1.1.1

Packet #3: MAP-T CE translates post NAPT IPv4 header to a IPV6 header and forwards it towards the MAP BR

4000	80	TCP	2001:db8:101:2e8:0:c000:202:3a	2001:db8::1:101:0100:0

Packet #4: MAP-T BR translates IPv6 header to the post NAPT IPv4 header and forwards it towards the destination address

4000	80	TCP	192.0.2.2	1.1.1.1

MAP-T in Action – Internet to Subscriber

src=1.1.1.1:80
dst=192.0.2.2:4000

IPv4 Private   IPv6   IPv4 Public
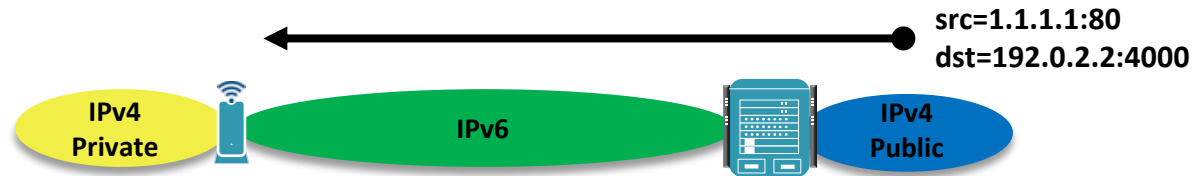
- Incoming packet src=1.1.1.1:80 dst=192.0.2.2:4000
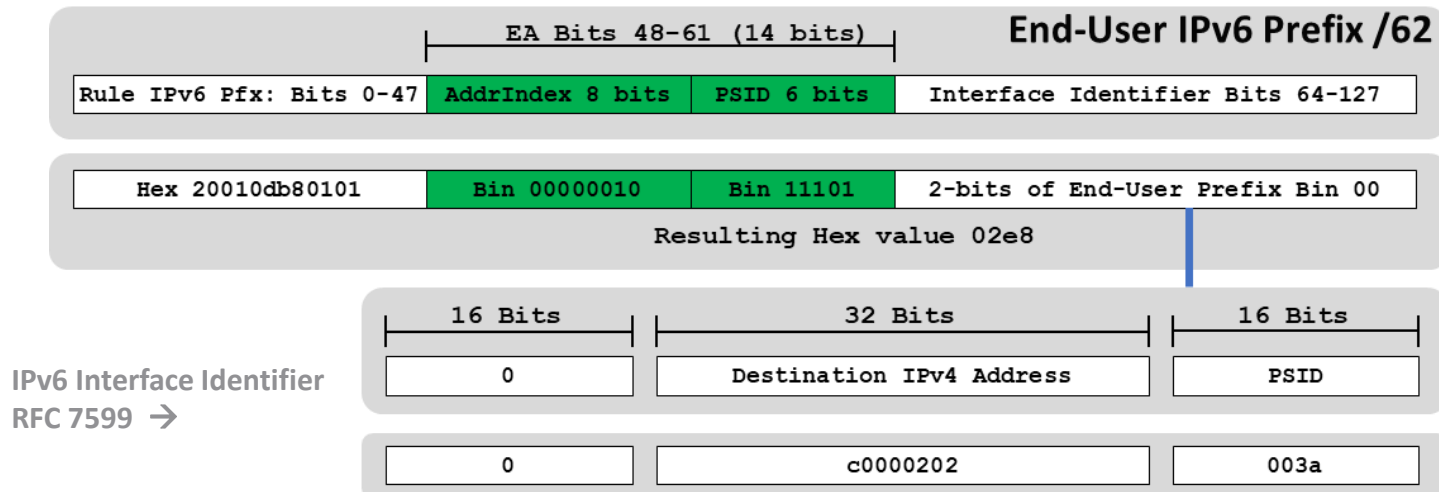
- BR Prefix: 2001:db8::/64

- Mapping Rule

  - Rule IPv6 Prefix: 2001:db8:101::/48

  - Rule IPv4 Prefix: 192.0.2.0/24

  - EA Length: 14

- Source stateless translation – Easy!

  - Embed 1.1.1.1 in BR Prefix 2001:db8::/64 = 2001:db8::1:101:0100:0

- Result

80	4000	TCP	2001:db8::1:101:0100:0	Destination

MAP-T in Action – Internet to Subscriber

- Destination stateless translation (Translate to MAP-T CE address)
  - Find mapping rule by matching longest match against Rule IPv4 prefix
  - EA bits contain index value to destination IPv4 and index value to port set which contains the destination port (PSID)
    - Destination port 4000 belongs to PSID index value 58 (hex 3a)

EA Bits 48-61 (14 bits)		End-User IPv6 Prefix /62	
Rule IPv6 Pfx: Bits 0-47	AddrIndex 8 bits	PSID 6 bits	Interface Identifier Bits 64-127

Hex 20010db80101	Bin 00000010	Bin 11101	2-bits of End-User Prefix Bin 00

Resulting Hex value 02e8

IPv6 Interface Identifier RFC 7599 →

16 Bits	32 Bits	16 Bits
0	Destination IPv4 Address	PSID
0	c0000202	003a

- Result

80	4000	TCP	2001:db8::1:101:0100:0	2001:db8:101:2e8::c000:202:3a

MAP-T Benefits

Nearly stateless border relay

- Fragment forwarding

Nearly seamless alignment with IPv6 deployment

- No additional logging overhead
- DHCPv6 provisioning delta is option 95
- Supports existing 5-tupple use cases
  - Classification
  - ECMP
  - Filtering

Simple integration with existing deployment

- No need for separate forwarding logic (routing instance/VPN/policy-routing)
- Asymmetrical forwarding is supported (no pinning required)

IPv4-Mapped IPv6 Address

- Resources such as CDN can be IPv6 addressed and accessed by IPv4 clients without traversing the BR

Transition Technology Comparison

	MAP-T	NAT444	MAP-E lw4over6	DS-Lite
Subscriber Assigned Address Scalability	IPv6	RFC6598	IPv6	IPv6
Asymmetrical Forwarding	Yes	No	Yes	Yes
5-Tuple Visibility	Yes	Yes	No	No
CPE Software Required	Yes	No	Yes	Yes
Address Allocation and NAT Efficiency	Fixed	Dynamic	Fixed Dynamic	Dynamic
Support for IPv4 client access of IPv6 resources without gateway	Yes	No	No	No
Encapsulation Overhead	28 Bytes	None	40 Bytes	40 Bytes
Provisioning integration required with NAT or gateway/relay	No	Yes - PCP	No Yes	Yes - PCP

MAP-T at Charter Communications

MAP-T CPE

- Implementations from 5 commercial vendors
  - Hardware acceleration from 3
- Support for base mapping rule from 16 mapping rules

MAP-T BR

- Implementation from 3 commercial vendors
- 150 Gbps per 1U

Provisioning

- Existing provisioning platform extended to support provisioning multiple mapping rules

Early Field Trial Underway

Resources

MAP-T RFC – RFC 7599

Cablelabs MAP Technical Report:

- https://apps.cablelabs.com/specification/14954

MAP Python Package:

- https://github.com/ejordangottlieb/pyswmap
  - Used for test traffic generation and validation
  - Basis for regulatory web service which resolves a public IPv4 address and port to a particular subscriber

Questions/Comments