dIVI-pd: Dual-Stateless IPv4/IPv6 Translation with Prefix Delegation

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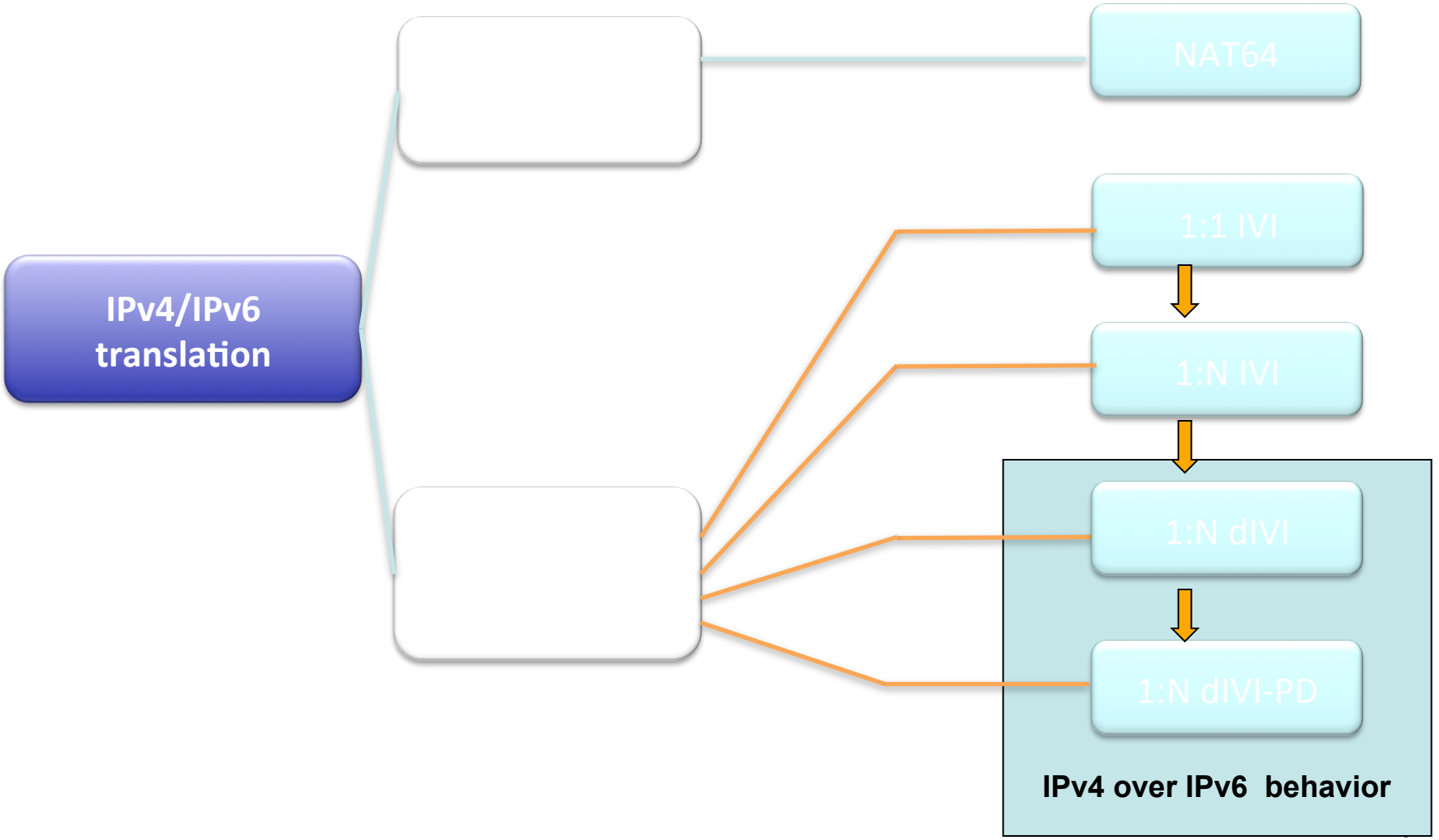
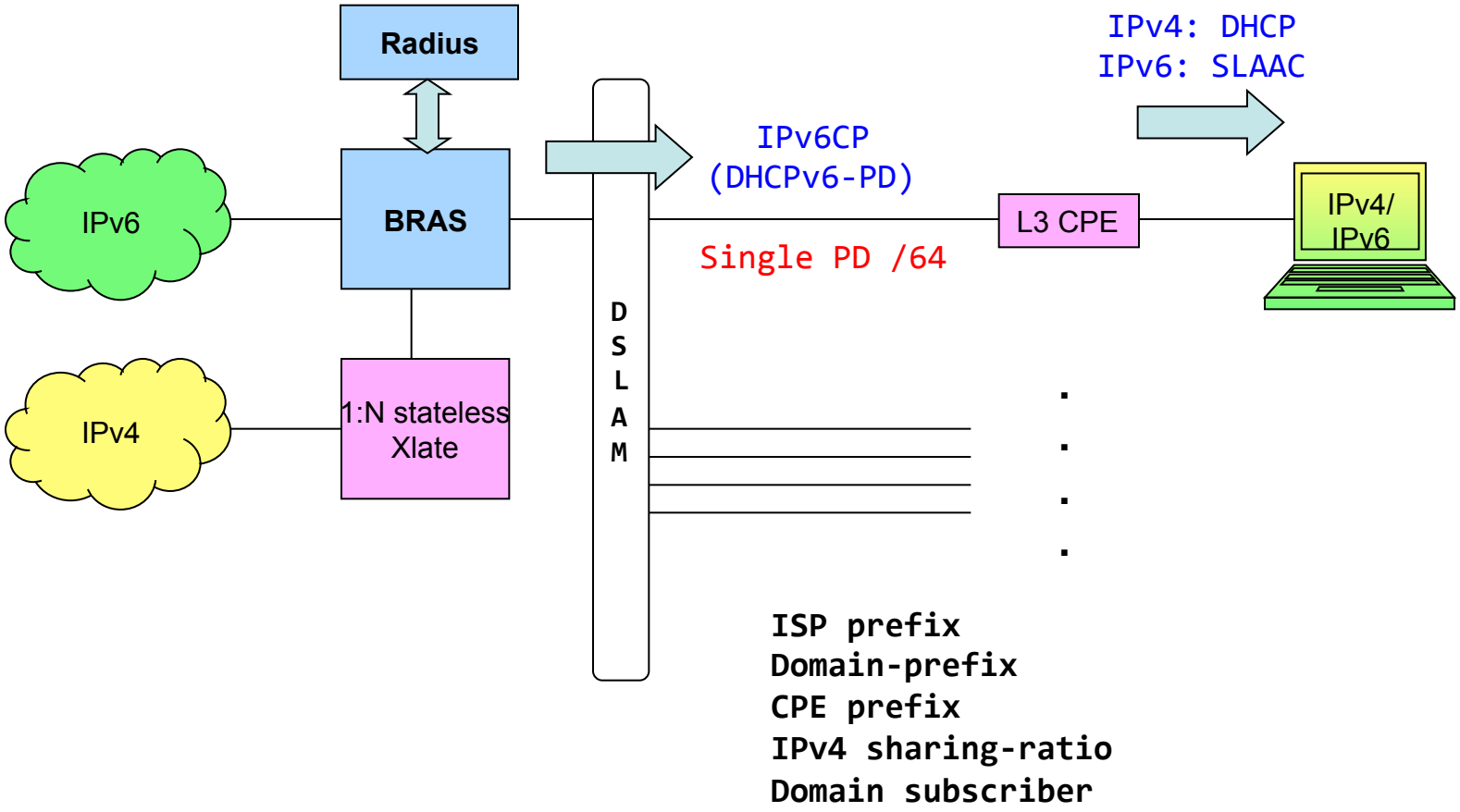
Introduction

- The dIVI-PD is an extension of stateless IPv4/IPv6 translation with address sharing
  - RFC6052: IPv6 Addressing of IPv4/IPv6 Translators
  - RFC6145: IP/ICMP Translation Algorithm
- The dIVI-PD is compatible with MAP design
  - Mapping of Address and Port (MAP)
  - DHCPv6 Options for Mapping of Address and Port

IPv4/IPv6 translation



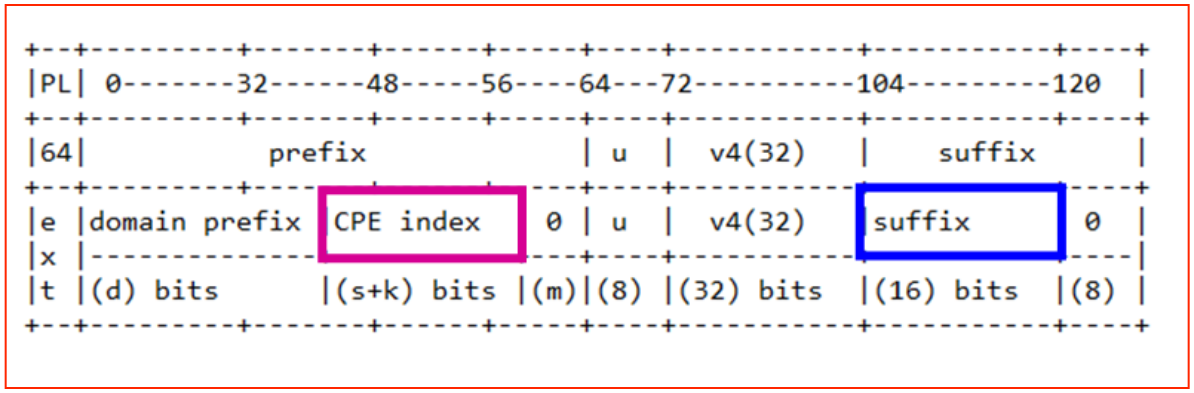
dIVI-PD scenario



https://datatracker.ietf.org/doc/draft-xli-softwire-divi-pd

Original design of dIVI-PD

- Address format



- Port mapping algorithm

The algorithm used to derive available port-set for a specific CPE, or by XLAT1 to construct, per domain, the CPE index based on an IPv4 address and TCP/UDP port.

For a domain's multiplexing ratio N, the port-set numbers of a CPE with port-set-id K is composed of P=j*N + K + 1024, for all the values of j=0, 1, ..., (65536-N)/N.

For a destination port number (P), the port-set-id of a given CPE with port-set-id K is determined by the modulo operation: K=((P-1024)%N) (% is the Modulus Operator).

- Suffix coding

ratio	suffix range	# of Ports
1	0000 - 0000	65,536
2	1000 - 1001	32,768
4	2000 - 2003	16,384
8	3000 - 3007	8,192
16	4000 - 400f	4,096
32	5000 - 501f	2,048
64	6000 - 603f	1,024
128	7000 - 707f	512
256	8000 - 80ff	256
512	9000 - 91ff	128
1,024	a000 - a3ff	64
2,048	b000 - b7ff	32
4,096	c000 - cfff	16

Figure 3: Suffix for Port Range Encoding

MAP

- Basic Mapping Rule (BMR)

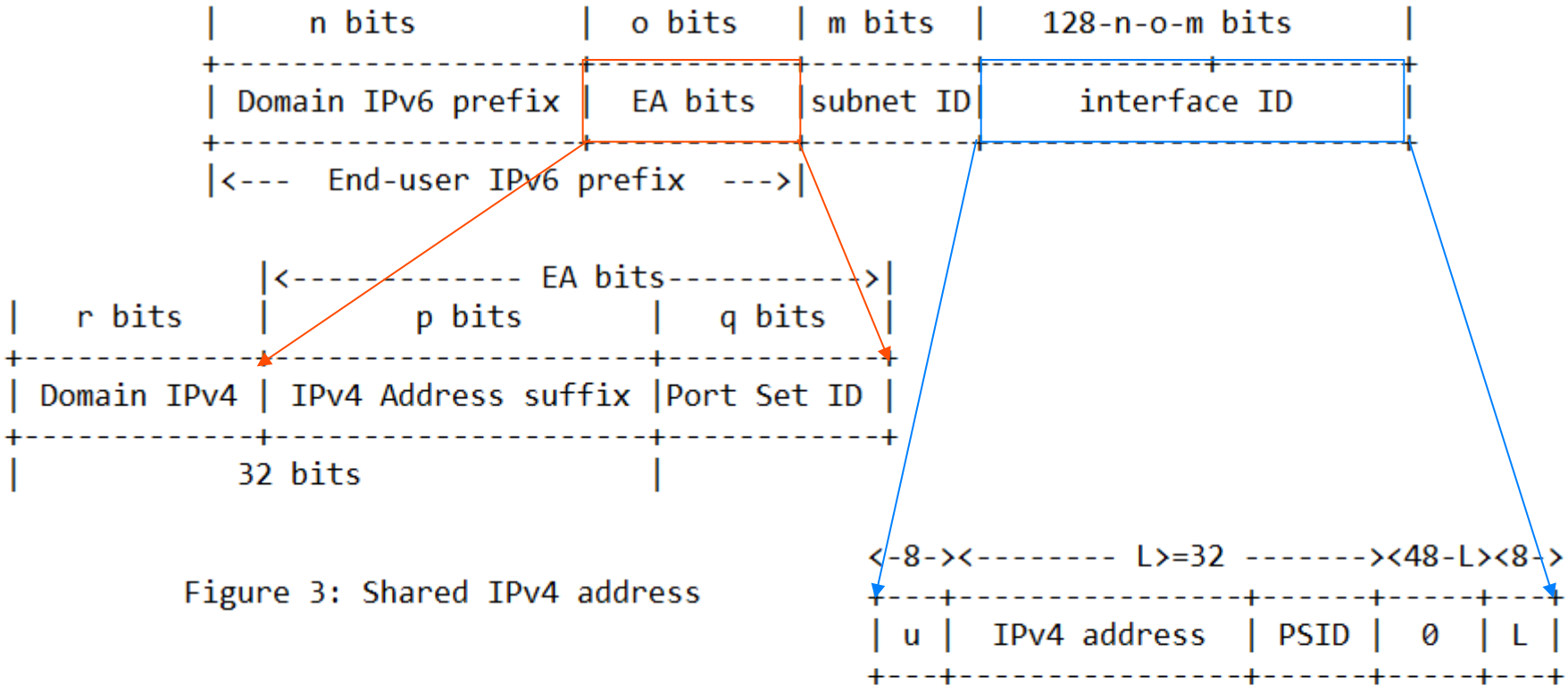
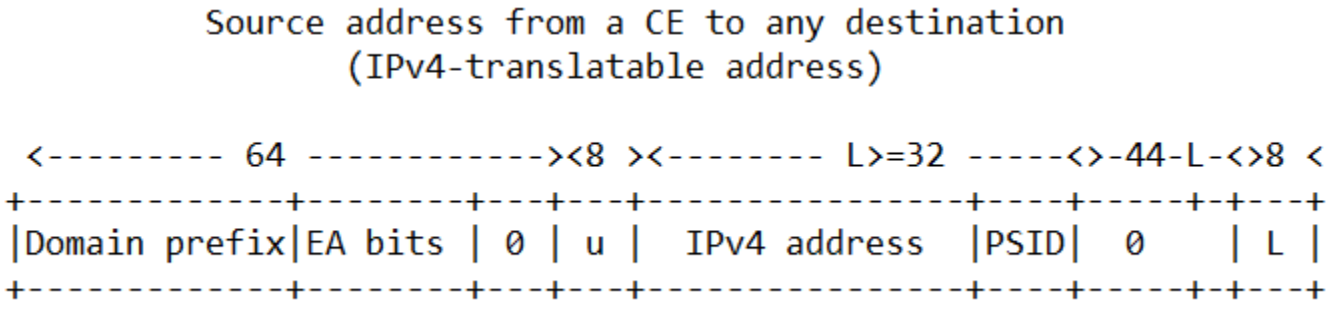


Figure 3: Shared IPv4 address

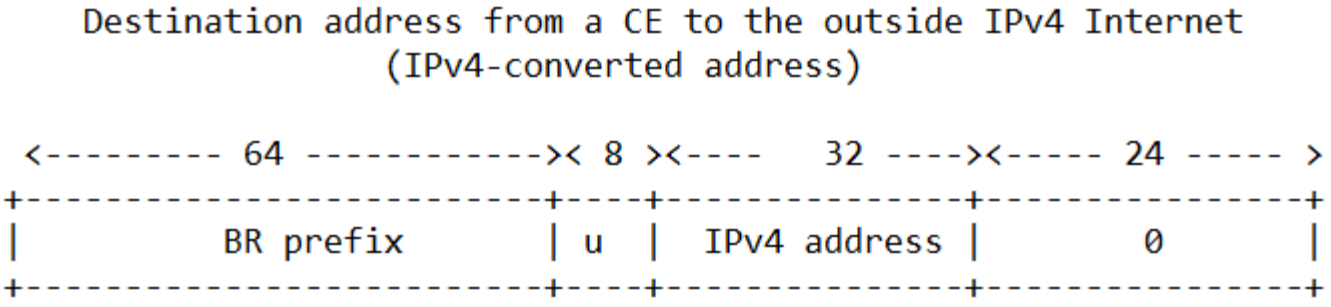
Figure 4: Interface ID

dIVI-PD and MAP (1)

- Basic Mapping Rule (BMR)

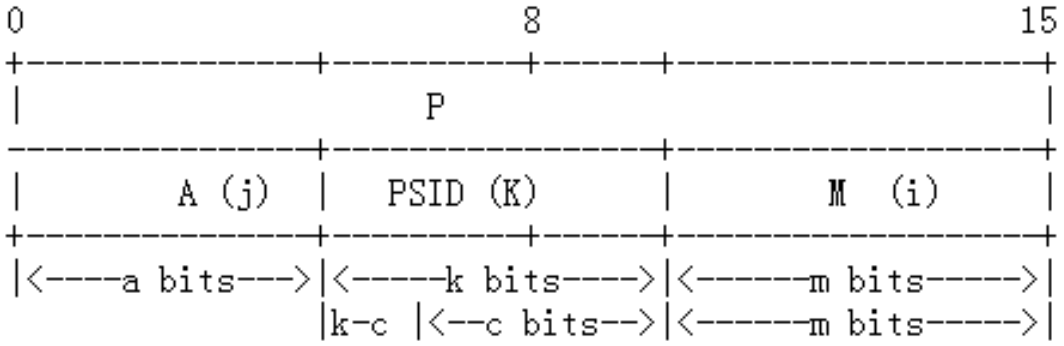


- Default Mapping Rule (DMR)



dIVI-PD and MAP (2)

- Generalized modulus algorithm (GMA)
  - P = R * M * j + M * K + i
  - K = (floor(P/M)) % R



- R=0-65535 → k bits
- M<=65536/R → m bits

→ a bits

dIVI-PD: R=0-4096, M=1, a=4 bits

DHCP options

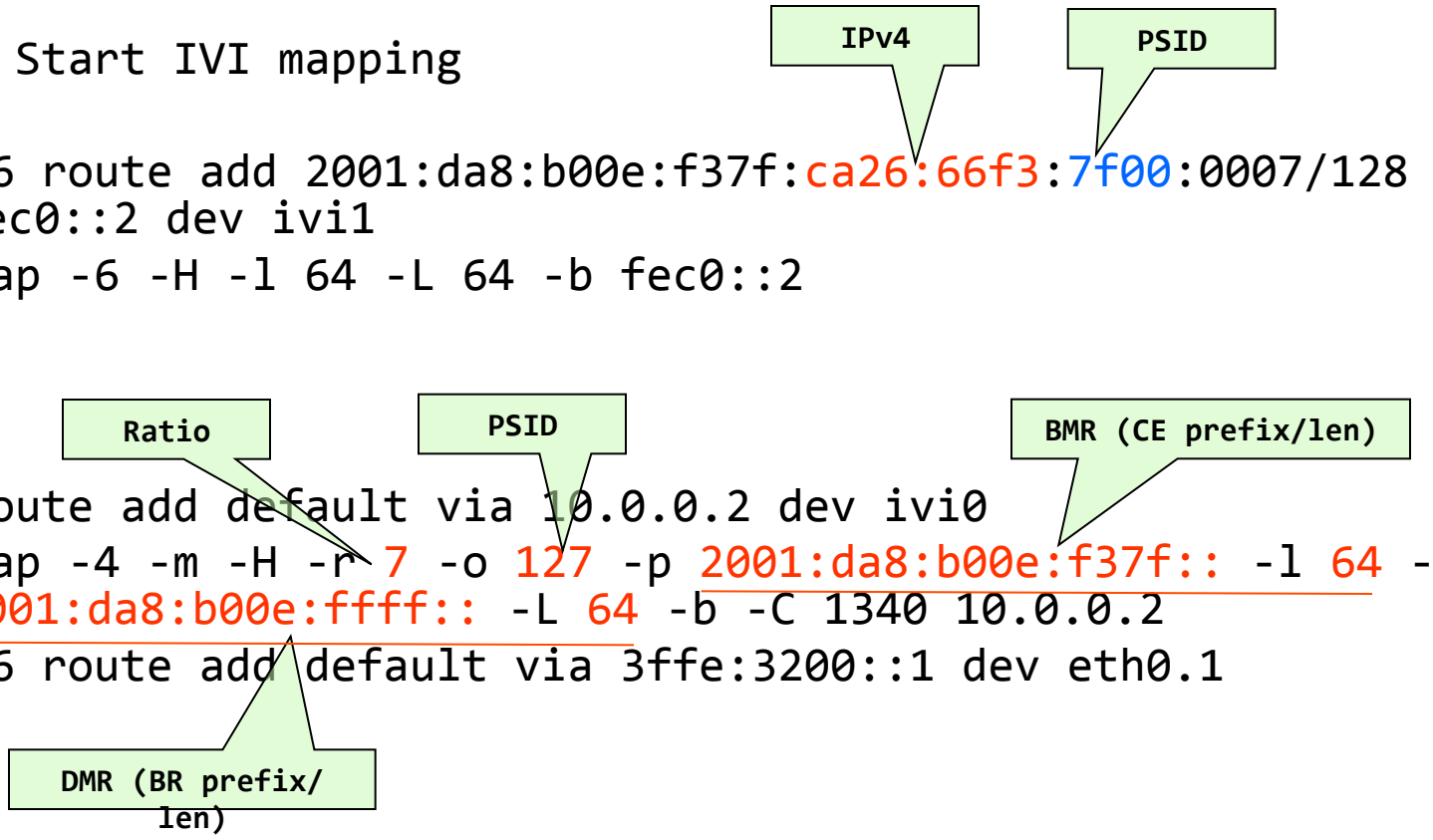
- Without default
  - The IPv6 prefix/length
  - The BR prefix/length
  - The IPv4 address
  - The PSID (K)
  - The sharing ratio (R=128)
- With default
  - The maximum number of continue ports (M=1)
  - The PSID length (c=7)

dIVI-PD OpenWRT configuration example

```
echo Start IVI mapping

ip -6 route add 2001:da8:b00e:f37f:ca26:66f3:7f00:0007/128 via
   fec0::2 dev ivi1
ivimap -6 -H -l 64 -L 64 -b fec0::2

ip route add default via 10.0.0.2 dev ivi0
ivimap -4 -m -H -r 7 -o 127 -p 2001:da8:b00e:f37f:: -l 64 -P
   2001:da8:b00e:ffff:: -L 64 -b -C 1340 10.0.0.2
ip -6 route add default via 3ffe:3200::1 dev eth0.1
```



Dual stateless translation is not harmful

- IPv4
  - Options
    - Dropped (no harm)
  - Type of service
    - Copied to traffic class
  - MTU and fragmentation
    - Processed according to RFC6145/RFC6146
  - ICMP/ICMPv6
    - Processed according to RFC6145
  - Transport layer (TCP, UDP)
    - Processed according to RFC6145

Experimental data

Options

	packets	ratio	%
total	40702507685	1	
option	1255	3.08335E-08	0.000003
ICMP	176	4.32406E-09	
TCP	1079	2.65094E-08	

Fragmentation

	packets	ratio	%
total	40702507685	1	
frag	41990319	0.00103164	0.103163961
TCP	5843	1.43554E-07	1.43554E-05
ICMP	18414278	0.000452411	0.045241139
UDP	22786760	0.000559837	0.055983676
GRE	783259	1.92435E-05	0.001924351

DF=1 & MF=1

	sum	TCP	UDP	ICMP
Total	5822765423	3.38E+09	2.35E+09	24401444
fragmentation	36789444	395808	36392302	133
DF=1 & MF=1	65752	56582	9169	0
DF=1 & MF=1 %	0.0011	0.0017	0.0004	0.0000

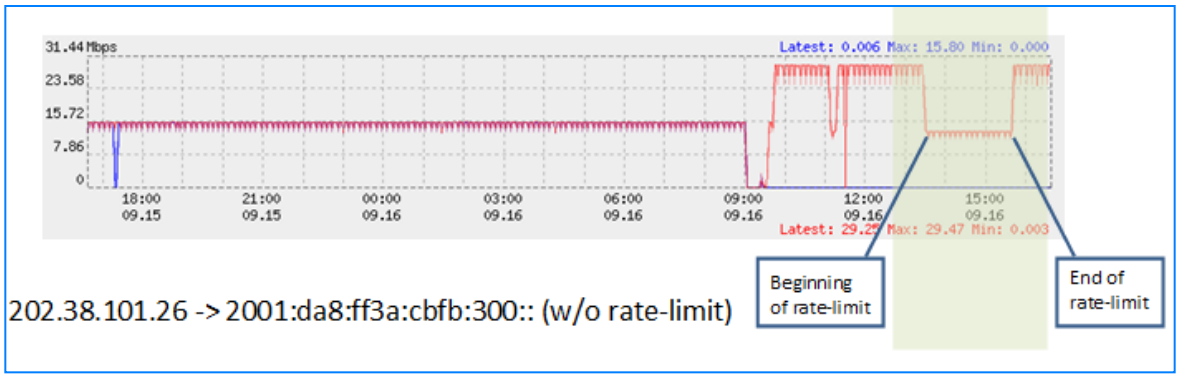
ICMP/ICMPv6

RFC6145				packets	ratio	notes
v4type	v4code	v6type	v6code	11332799		
3	14	1	无	0	0	DROP
4		n/a		644	5.683E-05	DROP
5		n/a		26438	0.0023329	DROP
6		n/a		0	0	DROP
9		n/a		0	0	DROP
10		n/a		0	0	DROP
12	1	4		0	0	DROP
12	others			0	0	DROP
13		n/a		10	8.824E-07	DROP
14		n/a		1	8.824E-08	DROP
15		n/a		0	0	DROP
16		n/a		1	8.824E-08	DROP
17		n/a		2	1.765E-07	DROP
18		n/a		0	0	DROP
				27096	0.002391	

It can use existing tools for O&M

- Null route
- ACL
- eACL
- PBR
- QoS
- Caching

Rate limit example



Experimental Evaluation

Core translator BRAS CPE

- It is tested at Tsinghua University and in China Telecom lab

Remarks

- dIVI-PD is an extension of IPv6/IPv6 stateless translation
- dIVI-PD provides unique features for OPEX value
- dIVI-PD is compatible with MAP design