Stateless/Partial-state 1:N Network Address and Protocol Translation between IPv4 and IPv6 Nodes

X. Li, C. Bao, C. Metz

2010-03-25

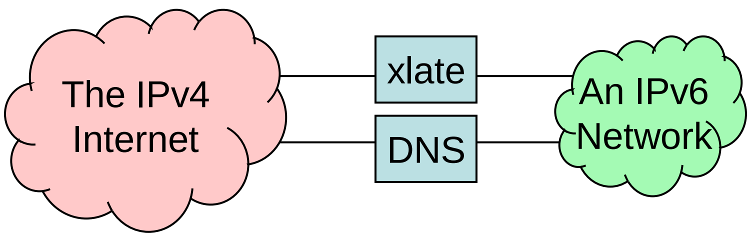
Outline

- Introduction
- Stateless/Partial-state 1:N translation
  - Concept
  - Scenarios supported
  - Comparisons
  - Why call it partial-state
  - Implementation
- Deployment Considerations
- Example

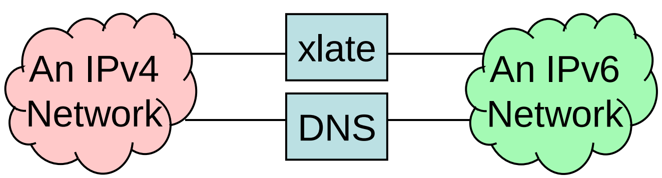
Introduction

- Stateless [draft-ietf-behave-v6v4-xlate], etc
  - Support both IPv6 initiated and IPv4 initiated communications
  - Can not use IPv4 addresses effectively
- Stateful [draft-ietf-behave-v6v4-xlate-stateful], etc
  - Use IPv4 addresses effectively
  - Only support IPv6 initiated communication
  - Need to maintain states
- Partial-state 1:N translation
  - Support both IPv6 initiated and IPv4 initiated communications
  - Use IPv4 addresses effectively
  - Less state and complexity than full-blown stateful
  - Require less work to log translation bindings

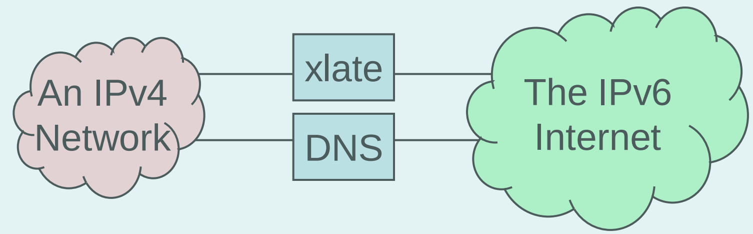
Scenarios supported



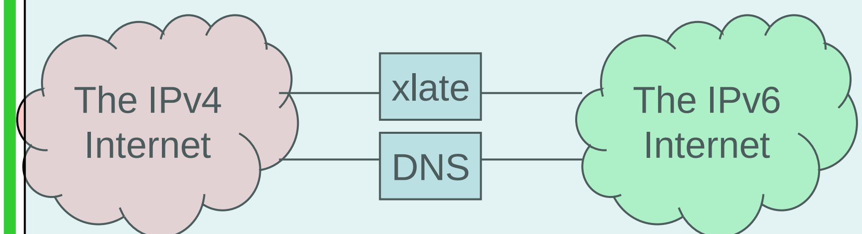
SL { Scenario 1 “an IPv6 network to the IPv4 Internet” **< SF**
Scenario 2 “the IPv4 Internet to an IPv6 network”



SL { Scenario 5 “an IPv6 network to an IPv4network” **< SF**
Scenario 6 “an IPv4 network to an IPv6 network”

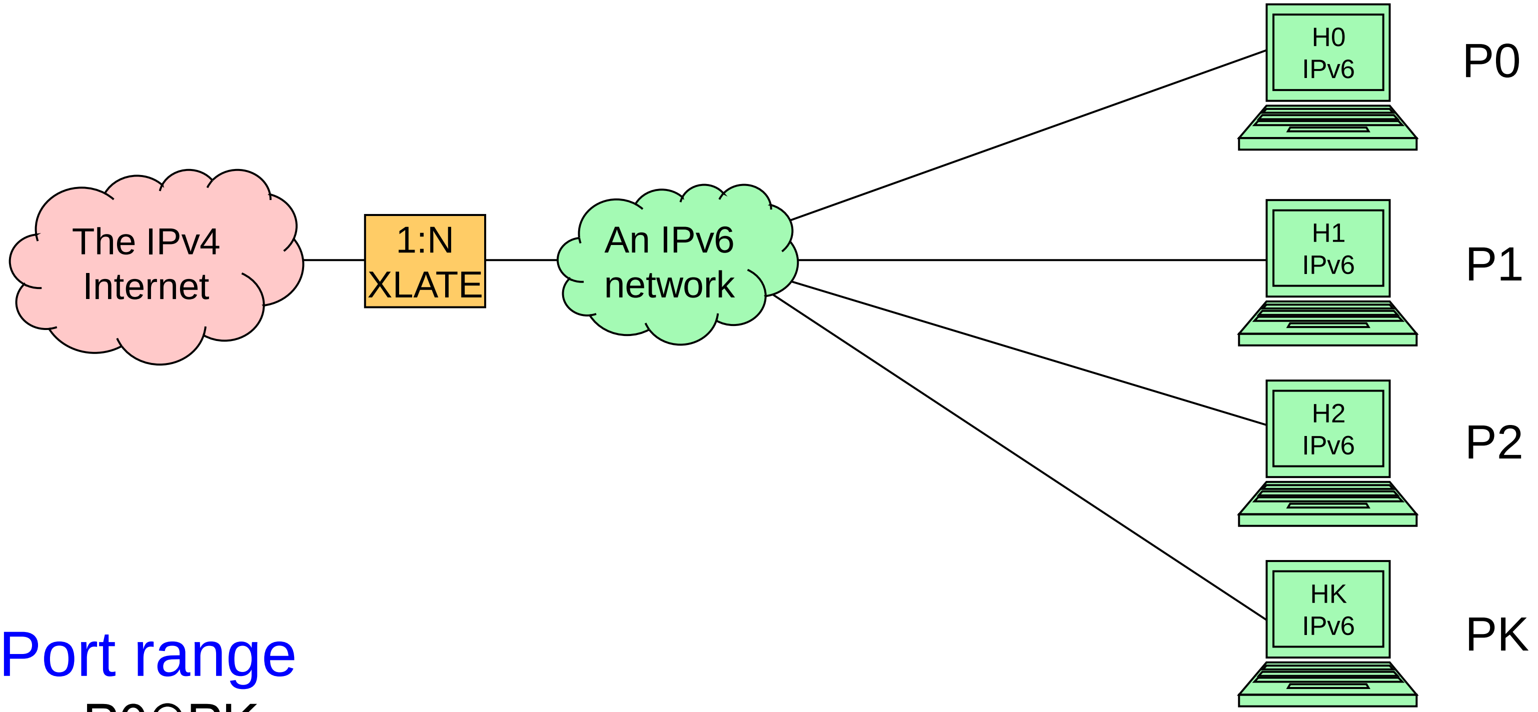


Scenario 3 “an IPv4 network to the IPv6 Internet” **<SF**
Scenario 4 “the IPv6 Internet to an IPv4 network”



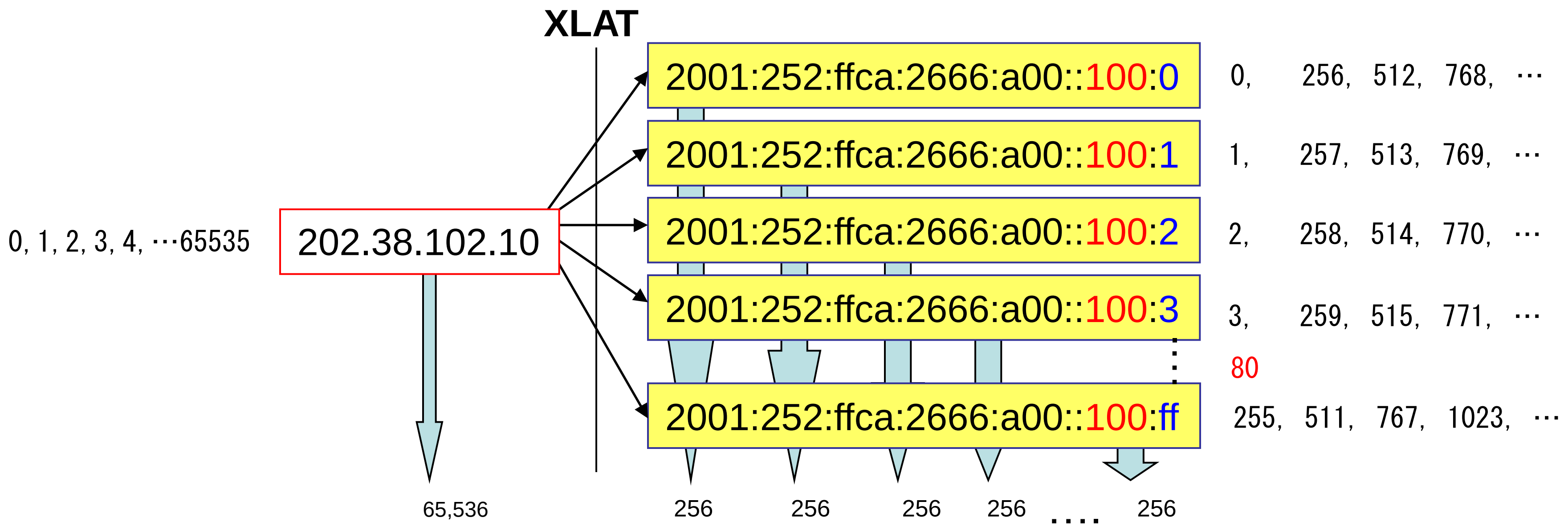
Scenario 7 “the IPv6 Internet to the IPv4 Internet”
Scenario 8 “the IPv4 Internet to the IPv6Internet”

Concept of 1:N translation (1)



- Port range
  - P0∩PK = φ
  - P0∪P1∪…∪PK=I
- If R=256, an IPv4 /24 can support 65,000+ IPv6 hosts

Concept of 1:N translation (2)



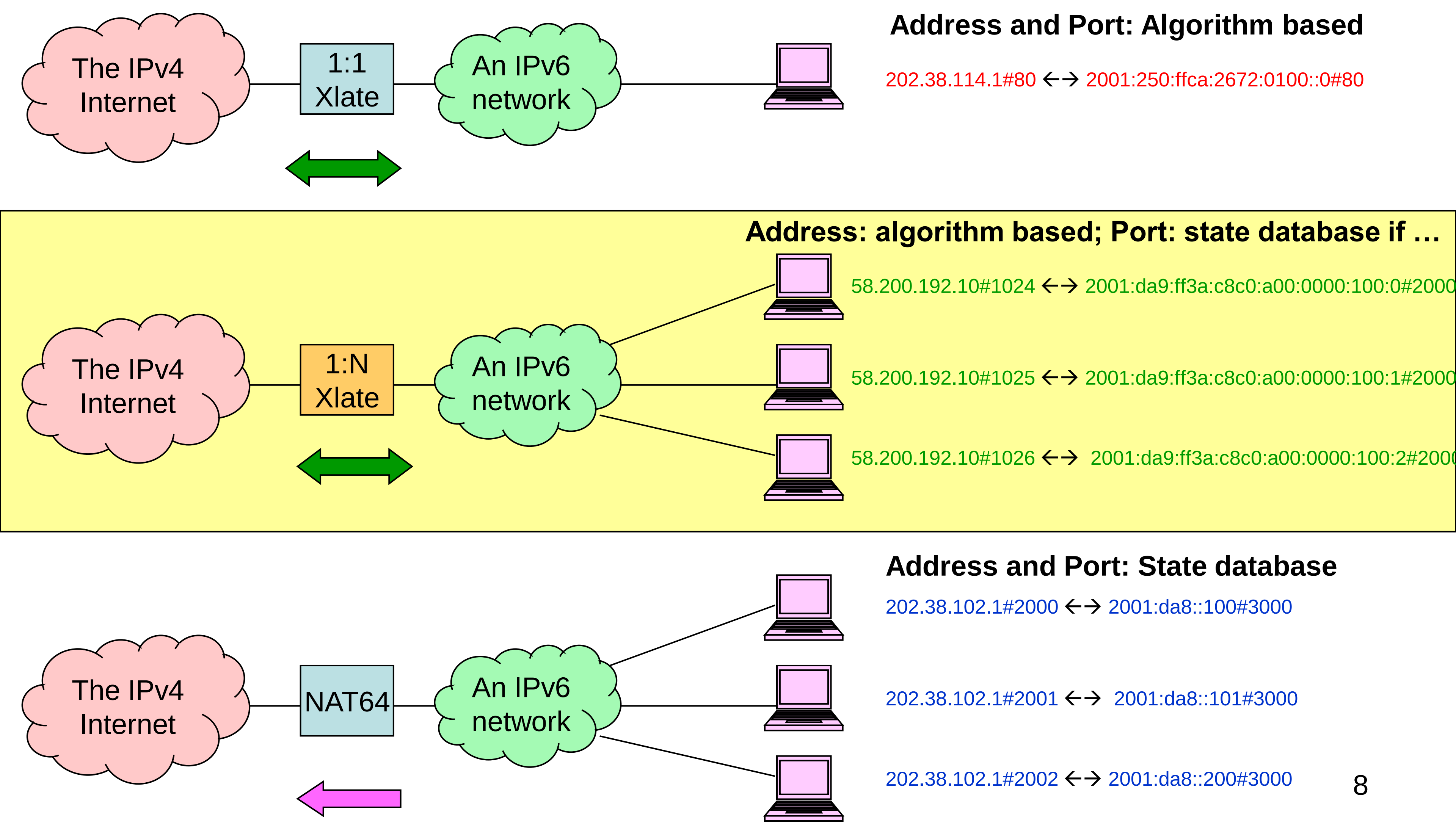
- Algorithm
  - For host K, the allowed port number (P) are P=j*N + K (j=0, 1, ..., N-1)
  - For the destination port number (P), the packets will be sent to host K=(P%N) (% is the Modulus Operator)
- Server port considerations
  - For example, relaying HTTP from IPv4 to IPv6 can be used [draft-wing-behave-http-46-relay-02]

Comparisons (1)

- NAT64
  - Stateful
  - Only supports IPv6 initiated communication
  - Public IPv4 addresses can be shared dynamically by several IPv6 hosts
  - Use any IPv6 address

- 1:N Xlate
  - Stateless/partial-state
  - Supports both IPv4 and IPv6 initiated communications
  - Public IPv4 addresses can be shared by several predefined IPv6 hosts (less efficiency)
  - Use extended IPv4-translatable address

Comparisons (2)



Why call it partial state

- Stateless translation
  - 1:1 address translation
  - 1:N address translation with modified IPv6 end systems
- Partial-state translation
  - The address mapping is fully algorithm based. The states are used for port number mapping only.
  - No session table created if the source port number from IPv6 to IPv4 is in the range defined by the extended IPv4-translatable address. If application has port restrictions (e.g P, P+1), the state of port mapping remains.
  - For the destination port number of the packet from the IPv4 to IPv6, no session table is created
- Full-state translation (stateful)
  - End system can use any IPv6 addresses

Implementation (1)

Address format

PLEN	0-7	8-15	16-23	24-31	32-39	40-47	48-55	56-63	64-71	72-79	80-87	88-95	96-103	104-111	112-119	120-127
/32	prefix				IPv4(32)				u/g	suffix						
/40	prefix					IPv4(24)			u/g	IPv4(8)	suffix					
/48	prefix						IPv4(16)		u/g	IPv4(16)		suffix				
/56	prefix							IPv4(8)	u/g	IPv4(24)			suffix			
/64	prefix								u/g	IPv4(32)				suffix		
/96	prefix												IPv4(32)			

IPv4-converted address

PLEN	0-7	8-15	16-23	24-31	32-39	40-47	48-55	56-63	64-71	72-79	80-87	88-95	96-103	104-111	112-119	120-127
/32	prefix				IPv4(32)				u/g	Port Coding (16)		suffix				
/40	prefix					IPv4(24)			u/g	IPv4(8)	Port Coding (16)		suffix			
/48	prefix						IPv4(16)		u/g	IPv4(16)		Port Coding (16)		suffix		
/56	prefix							IPv4(8)	u/g	IPv4(24)			Port Coding (16)		suffix	
/64	prefix								u/g	IPv4(32)				Port Coding (16)		suffix
/96	prefix												IPv4(32)			

IPv4-translatable address

- [I-D.ietf-behave-v6v4-address-format] extensions

Implementation (2)

Port coding

(4 bits)	Index Range(12 bits)	Multx ratio	# of Ports
0	000-000	1	65,536
1	000-001	2	32,768
2	000-003	4	16,384
3	000-007	8	8,192
4	000-00f	16	4,096
5	000-01f	32	2,048
6	000-03f	64	1,024
7	000-07f	128	512
8	000-0ff	256	256
9	000-1ff	512	128
A	000-3ff	1,024	64
B	000-7ff	2,048	32
C	000-fff	4,096	16

- Use 16 bits to encode the port number range
  - 4 bits: multiplexing ratio
  - 12 bits: the host index

Implementation (3)

	Source port		Destination port	
	In defined range	No in defined range	Entry exists	Entry does not exists
From IPv6 to IPv4	Copy the port number.	If the entry exists, use it to map the port number. If the entry does not exist, create the entry (time out for UDP or state machine for TCP) and use it to map the port number.	Copy the port number.	Copy the port number.
From IPv4 to IPv6	Copy the port number.	Copy the port number.	Use it to map the port number.	Copy the port number.

Deployment Considerations

- Using Modified IPv6 Hosts in an IPv6 Network
  - Stateless 1:N XLATE
- Using Unmodified IPv6 Hosts in an IPv6 Network
  - Partial-state 1:N XLATE
- Using mixed unmodified and modified IPv6 Hosts
  - Partial-state 1:N XLATE

```
                                            -----------
                                         .-|Host0 (mdf)| A1/(P%N)+0
               ------                   /   -----------
  ------      |State-|      -----      |
 /  The   \   |less  |    /  An    \   |    -----------
|  IPv4    |--|1:N   |---|  IPv6    |------|Host1 (mdf)| A1/(P%N)+1
 \Internet/   |XLATE |    \Network/    |    -----------
  ------       ------       -----      |
                                       |\   -----------
                                       |  -|Host2 (mdf)| A1/(P%N)+2
                                       |    -----------
                                       |
                                        \   -----------
                                          -|HostK (mdf)| A1/(P%N)+K
                                            -----------
```

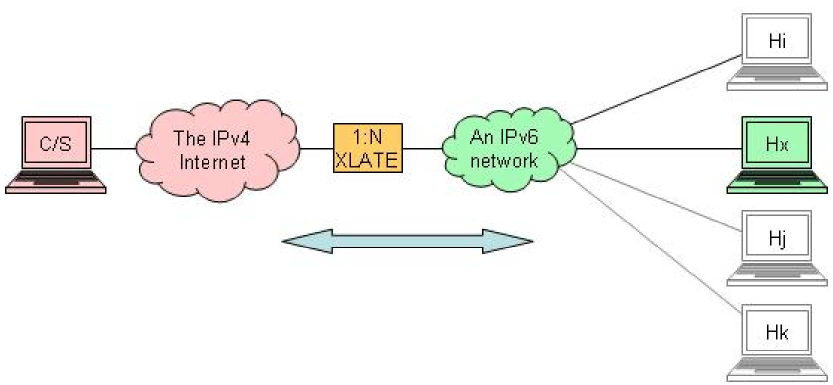
```
                                            -----------
                                         .-|   Host0   | A1/(P%N)+0
               ------                   /   -----------
  ------      |Partia|      -----      |
 /  The   \   |-state|    /  An    \   |    -----------
|  IPv4    |--|1:N   |---|  IPv6    |------|   Host1   | A1/(P%N)+1
 \Internet/   |XLATE |    \Network/    |    -----------
  ------       ------       -----      |
                                       |\   -----------
                                       |  -|   Host2   | A1/(P%N)+2
                                       |    -----------
                                       |
                                        \   -----------
                                          -|   HostK   | A1/(P%N)+K
                                            -----------
```

Examples

Sateless/Partial-state 1:N Xlate demo

H0 as a server http://58.200.192.10:4096/cgi-bin/nph-ivi-server2
H1 as a server http://58.200.192.10:4097/cgi-bin/nph-ivi-server2
H3 as a server http://58.200.192.10:4099/cgi-bin/nph-ivi-server2

H0 as a client http://58.200.192.10:4096/cgi-bin/nph-ivi-client2
H1 as a client http://58.200.192.10:4097/cgi-bin/nph-ivi-client2
H3 as a client http://58.200.192.10:4099/cgi-bin/nph-ivi-client2



- Use old address format
  - 2001:da8:ff00::/40 as prefix
  - No U-octet
  - Port coding is in last 32 bits ratio:index

IPv4-converted address format

Extended IPv4-translatable address format

http://www.ivi2.org/demo2.html

Example (server)

- Host C1 (125.34.46.137) in the IPv4 Internet initiates communication with IPv6 end system Host0.
  - On the IPv4 Internet
  - Src#p= 125.34.46.137:1856 (random port)
  - Dst#p= 58.200.192.10:4096 (server port)

  - On trnaslator
  - Src#p= [2001:DA9:FF7d:222e:8900::]:1856 (random port)
  - Dst#p= [2001:DA9:FF**3A:C8C0:A**00:0:**100:0**]:4096 (server port)

  - On an IPv6 network
  - Src#p= [2001:DA9:FF7d:222e:8900::]:1856 (random port)
  - Dst#p= [2001:DA9:FF**3A:C8C0:A**00:0:**100:0**]:4096 (server port)

Example (client)

- AnIPv6 end system Host0 initiates communication with Host S2 (http://202.38.105.1:80) in the IPv4 Internet
  - On an IPv6 network
  - Src#p= [2001:DA9:FF**3A:C8C0:A**00:0:**100:0**]:10327 (random port)
  - Src#p= [2001:252:ffca:2669:100::]:80 (server port)
  - On translator
  - Src#p= [2001:DA9:FF**3A:C8C0:A**00:0:**100:0**]:8192 (mapped port)
  - Src#p= [2001:252:ffca:2669:100::]:80 (server port)
  - On the IPv4 Internet
  - Src#p= 58.200.192.10:8192 (mapped port)
  - Dst#p= 202.38.105.1:80 (server port)

Remarks

- Stateless/partial-state 1:N Xlate is a natural extension of stateless 1:1 Xlate
- It is an alternative approach of stateful Xlate
- When partial-state Xlate is used, the modification of IPv6 end system is NOT required. However, if this kind of modification is allowed, the translation may reduce to stateless.
- Stateless 1:N translation is one of key technologies for Double IVI [draft-xli-behave-divi]