IVI - IPv4/IPv6
Coexistence and Transition

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Unexpected situation
Why Is This Happening?

- No transition plan
- Declared victory before the hard part started
- No real long term plan
- No realistic estimation of costs
- No support for the folk on the front lines
- Victory will be next month
Why Is This Happening?

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This Describes:
  a - The invasion of Iraq
  b - IPv6
  c - DNSSec
  d - All of the above
Transition

- IPv4 and IPv6 is NOT compatible
- There is NO flag day
- Transition is REALLY difficult
IPv6 Road Map
Transition methods

• Dual-stack
• Tunneling
• Translation
The IP infrastructure at crossroad

IPv4/NAT

IPv6 only

Something new coming along?

IP4-6 coexistence
Crossroad

IPv6 Workshop, Sigcomm 2007
Background

CERNET (IPv4)
2,000 universities connected
20M users

CNGI-CERNET2 (IPv6)
100 universities connected
400K users

IPv4-accessible servers
The lessons learned

• The only viable option for future Internet is IPv6
  – The transitions can only starts when the part of it is pure IPv6
• The scenarios of building new IPv6 network for the unwired population
  – The cost-effective way for building a new infrastructure
• The natural transition
  – Construction and operation single stack costs less than dual-stack
  – Construction and operation simple (stateless) network costs less than complex (stateful) network
• The resources should be shared via inter-communication
  – The IPv6 servers should be IPv4 accessible
  – The IPv4 servers should be IPv6 accessible
IPv6 promotion
- Dual stack
- IPv6 single stack + IPv4 accessible

IPv6 S Curve

Many IPv6 Servers Few IPv4 Servers

Many IPv4 Servers Few IPv6 Servers
The IVI model
IVI address format

<table>
<thead>
<tr>
<th>0</th>
<th>32</th>
<th>40</th>
<th>64</th>
<th>72</th>
<th>96</th>
<th>127</th>
</tr>
</thead>
<tbody>
<tr>
<td>LIR Prefix</td>
<td>IPv4 addr</td>
<td>Entirely 0</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Prefix part Host part

For example
LIR consists of ISP prefix (usually /32) and IVI flag
CERNET/CNGI-CERNET2’s selection
- LIR = 2001:da8:ff00::/40
- ISP’s IVI service IPv4 address mapping
  • 202.38.108.0/24 → 2001:250:ffca:266c:0000::/64
- ISP’s non-IVI service IPv4 address mapping
  • 202.38.96.0/20 → 2001:250:ffca:2660:0000::/60
- Other ISP’s IPv4 address mapping
  • 0.0.0.0 → 2001:da8:ff00::/40
  • 18.181.0.31/32 → 2001:250:ff12:b500:1f00::/72
Address Mapping (1)
Address Mapping (2)
Conceptual example
IVI routing

Longest prefix match
IVI DNS service

- Normal DNS
  - Algorithm based

- DNS translation
  - Algorithm based

![Diagram of DNS service](image)

**Figure 4: Normal DNS Service**

**Figure 5: DNS Record Translation Service**
Stateless (1:1) operation

• Stateless
  – SIIT extension
    • Based on ISP’s prefix
    • The mapping between IPv4 and IPv6IPv6 is based on algorithm
    • Support both IPv6 initiated and IPv4 initiated communications
Stateful (1:N) operation

• Stateful
  – NAT-PT (NAPT-PT) improvement
    • IPv4 address multiplexing
    • Based on ISP’s prefix
    • Support IPv6 initiated communication
IVI Reachability

- $4\text{Host1} \rightarrow \text{IVI1}$ (stateless)
- $\text{IVI1} \rightarrow 4\text{Host1}$ (stateless)
- $4\text{Host1} \rightarrow 6\text{Host1}$
- $6\text{Host1} \rightarrow 4\text{Host1}$ (stateful)
- $4\text{Host1} \rightarrow 4\text{Host2}$
- $4\text{Host2} \rightarrow 4\text{Host1}$
- $6\text{Host1} \rightarrow \text{IVI1}$
- $\text{IVI1} \rightarrow 6\text{Host1}$
- $6\text{Host1} \rightarrow 6\text{Host2}$
- $6\text{Host2} \rightarrow 6\text{Host1}$
- $\text{IVI1} \rightarrow \text{IVI2}$
- $\text{IVI2} \rightarrow \text{IVI1}$

Route Advertisements:
- R1: its IPv4 LAN
- R2: its IPv4 LAN
- R3: its IPv6 LAN
- XLATE: IPv4 IVI prefix
- possible IPv4 overlay
- prefix
- XLATE: IVI /40

Figure 3: IVI Reachability example
IPv4 initiated communication (1:1)

IPv4 client \(\rightarrow\) IPv4 \(\rightarrow\) IPv4 to IPv6 translation

\[\text{src}=59.66.24.42, \text{dst}=202.38.114.1\]

\[\text{src}=2001:250:ff3b:4218:2a00::, \text{dst}=2001:250:ffca:2672:0100::0\]

IPv6 to IPv4 translation

\[\text{src}=2001:250:ffca:2672:0100::0, \text{dst}=202.38.114.1\]

\[\text{src}=59.66.24.42, \text{dst}=2001:250:ff3b:4218:2a00::\]
IPv6 initiated communication (1:1)

- Ask for AAAA record or A record
- Ask for AAAA record
- Stateless

IPv6 to IPv4 translation:
- src=202.38.108.5 src=2001:da8:ffca:266c:0500::
- dst=18.7.22.83 dst=2001:da8:ff12:0716:5300::

IPv4 to IPv6 translation:
- src=18.7.22.83 src=2001:da8:ff12:0716:5300::
- dst=202.38.108.5 dst=2001:da8:ffca:266c:0500::

Global DNS -> IVI DNS -> IPv4 server

IVI DNS -> IPv6 client

IPv4

www.mit.edu
IPv6 initiated communication (1:N)

IPv4

Global DNS

Ask for AAAA record or A record

IVI DNS

IPv4 pool 202.38.102.0/24

stateful

IPv4

www.mit.edu

Ask for AAAA record

IPv6

IPv6 non-IVI client

IPv6 to IPv4 translation

src=202.38.102.1#2000

dst=18.7.22.83#80

dst=2001:da8::100#3000

IPv4 to IPv6 translation

src=2001:da8::100#3000

dst=2001:da8:ff12:0716:5300::#80

src=18.7.22.83#80

dst=202.38.108.5#2000

state

state
IVI ICMP extension

- Operation
  - IPv4 → IPv6
  - IPv6 → IPv4
Stateless 1:N operation

IPv4 address: 202.38.108.5

IPv6 addresses:
- 2001:da8:ffca:266c:0500::4:0 (port 84)
- 2001:da8:ffca:266c:0500::4:1 (port 85)
- 2001:da8:ffca:266c:0500::4:2 (port 86)
- 2001:da8:ffca:266c:0500::4:3 (port 87)

Port number keep the same
The multiplexing ratio

- If the multiplexing ratio is 256.
- One IPv4 /8 can support 4.3 billion IPv6 hosts, same as the size of the global IPv4 space.
IVI multicast

- IVI supports PIM SSM
  - Group address mapping
  - RPF → mapped IPv6 address
  - PIM Spare-mode ALG

IVI Multicast Group Address Mapping

<table>
<thead>
<tr>
<th>IPv4 Group Address</th>
<th>IPv6 Group Address</th>
</tr>
</thead>
<tbody>
<tr>
<td>232.0.0.0/8</td>
<td>ff3e:0:0:0:0:ff00:0000/96</td>
</tr>
<tr>
<td>232.255.255.255/8</td>
<td>ff3e:0:0:0:0:ff0f:ffff/96</td>
</tr>
</tbody>
</table>
Transition mechanisms

• When IPv4 addresses are running out
  – IPv4 + NAT
    • Short term solution
  – Pure IPv6
    • Cannot reach the global IPv4, unacceptable
  – Dual stack
    • The cost increases, ISPs want others to deploy dual stack
  – IVI IPv6
    • The cost is the same as the single stack, but the IPv6 host can be reached by global IPv4
Dual stack

- Global IPv4
- Direct access network
- IPv6 enterprise network

- Global IPv6
- Direct access network
- IPv6 enterprise network

- IPv4+IPv6
- Access network
- Enterprise network

- Not easy
• Encourage transition
Transition

IPv4 area
- Support IPv4
- V4 only Network

IPv6 area
- Support IPv6 (IVI)
- Support IPv6 (non-IVI)
- V6 only Network

Service
- Transition IPv4 IPv6

Network
- Support IPv4
- Support IPv6 (IVI)
- Support IPv6 (non-IVI)

User
http://www.ivi2.org/IVI/

IVI source code download

The IVI IPv4/IPv6 packet translation implementation as a Linux kernel patch is available below.
- IVI v0.5 kernel patch for Linux kernel 2.6.17
- IVI v0.5 kernel patch for Linux kernel 2.6.18

The IVI A/AAAA DNS proxy implementation is available below.
- IVIDNS v0.1 C code

For installing and configuration, please follow the instructions in the source code packages.

IVI test servers

- Access IPv4 server (202.38.114.129) across single-stack IPv6 network

IVI references

- IETF drafts:
  - Prefix-specific and Stateless Address Mapping (IVI) for IPv4/IPv6 Coexistence and Transition
  - IVI Update to SIIT and NAT-PT

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