The Path to Six/One
Incentives, Backward-Compatibility and Deployment Flexibility

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Each provider allocates addresses
- Hosts configure “address bunch”
- Routers may rewrite source address
- Hosts recognize rewrites and adapt
  - Address mapping at hosts’ IP layer
  - Address ownership verification via crypto interface ID in address bunch
Recap of Six/One

Each provider allocates addresses
Hosts configure “address bunch”
Routers may rewrite source address
Hosts recognize rewrites and adapt
  - Address mapping at hosts’ IP layer
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Case 1: no rewriting
- Host selects source address
- It thereby suggests provider
- Routers accept host selection
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- Host selects source address
- It thereby suggests provider
- Routers accept host selection

Case 2: rewriting in edge network
- Router rewrites source address
- Hosts learn new address and adapt
- No address change in application
Context establishment when hosts initiate first communication session
Context IDs for subsequent look-up
Six/One: Context Establishment

- Context establishment when hosts initiate first communication session
- Context IDs for subsequent look-up
- Routers do not rewrite IP address prefixes before context established
Transition Path

Incentives for providers
- Smaller global routing table
- Less frequent table updates

Incentives for edge networks
- Packet flow redirection ability if Six/One support on remote side
- Reduced renumbering costs

Advantages for hosts
- Influence on path selection
  - during session establishment
  - upon failure
- Light-weight IPv6 crypto
  - Security without infrastructure
  - No costly public-key math
- Cross-layer optimization

Deployment flexibility
- Rewrite functionality can be located in arbitrary routers

Backward-compatibility
- En- and disable Six/One based on support on remote side

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Deployment flexibility
- Rewrite functionality can be located in arbitrary routers
- Deployment without host upgrades?

Backward-compatibility
- En- and disable Six/One based on support on remote side
- Packet flow redirection even if remote side is legacy-v6/v4?
- Support Six/One hosts connected via v4 Internet?
New Transition Tools

1. Proxies
   - Run Six/One on behalf of host
   - Six/One deployment without host upgrades

2. Translators
   - Replace addresses in packets without reversal
   - Benefits also without Six/One support on remote side

3. v4 Gateways
   - Tunnel packets between Six/One-enabled hosts via v4 Internet

Transition tools composable, depending on need
Proxy in network runs Six/One on behalf of local legacy host
- Perform address mapping
- Recognize address rewrites, adapt

Alternative deployment
- Don’t wait for host upgrades
- For hosts with limited capabilities

Designed for interoperability
- Transparent to local legacy hosts
- Works with local Six/One hosts
- Interoperable with remote Six/One hosts and proxies

Free placement of proxies
- Packet flow redirection between proxies requires synchronization
Proxy Operation in Detail

local legacy-v6 host

to/from

edge network

1

providers

2

rest of Internet

remote Six/One host

to/from

Six/One on host

to/from

IP layer

address bunch of local host

1000:abc:1:1234:5d:clf:fe22:57c1

Proxy Operation in Detail

1. to/from local legacy-v6 host
to/from edge network
map & redirect reverse

2. to/from remote Six/One host
to/from providers
rest of Internet
reverse & adapt map

Six/One on host — Six/One proxy

<table>
<thead>
<tr>
<th>to/from application</th>
<th>IP layer —</th>
<th>to/from application</th>
</tr>
</thead>
<tbody>
<tr>
<td>from 1000:....</td>
<td>—</td>
<td>from 1000:....</td>
</tr>
<tr>
<td>to 1000:....</td>
<td>—</td>
<td>to 1000:....</td>
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<td>from 1000:....</td>
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<td>from 1000:....</td>
</tr>
<tr>
<td>to 1000:....</td>
<td>—</td>
<td>to 1000:....</td>
</tr>
</tbody>
</table>

address bunch of local host
1000:abc:1:1234:5d:ff:fe22:57c1
2000:def:2:1234:5d:ff:fe22:57c1
Address Bunch Configuration with Proxies

- DHCP server generates address bunch
  - Crypto parameters made by DHCP server
  - Proxy retrieves crypto parameters from DHCP server

- Flexible support for Six/One-upgraded hosts
  - Disable by mandating standard DHCP
  - Permit by allowing Six/One hosts to autonomously configure address bunches in Router Advertisements
  - Permit by communicating crypto parameters to hosts, e.g., via new DHCP option
Translators

- Enable packet flow redirection without remote Six/One support
- Like a NAT: Replace addresses in packets without reversal
- Translator on host or on proxy

- Immediate redirection – no need to check remote support first
- No address ownership verification necessary
- Facilitates backward-compatibility for remote legacy-v4 hosts

Six/One host

Local

Address translation at IP layer

Remote legacy-v6/v4 host

Border routers

Edge network

Access router

Immediate redirection
Translator Operation in Detail

- **local Six/One host**
  - to/from application
  - Six/One on host
  - no remote support, translate
  - from 1000:....
  - to 1000:....

- **remote legacy-v6 host**
  - to/from application
  - IP layer
  - from 2000:....
  - to 2000:....

**Edge Network Providers**
- rest of Internet
- router

**Rewrite**
- 1000:....
- 2000:....

**Address bunch of local host**
- 1000:abc:1:1234:5d:ff:fe22:57c1
Translator Operation in Detail

local Six/One host

to/from application

to/from application

Six/One on host

to/from

to/from

edge network

1

2

providers

rest of Internet

remote legacy-v6 host

to/from application

to/from

— router

— IP layer

from 1000::....

to 1000::....

from 1000::....

to 1000::....

no remote support, translate

translate

rewrite

1000::....

2000::....

address bunch of local host

1000:abc:1:1234:5d:cff:fe22:57c1

Combined Proxy and Translator for v4 Support

Local legacy-v6 host

to/from application 
IP layer

Edge network

 Providers

Rest of Internet

Remote legacy-v4 host

60.50.40.30

to/from application

IP layer

Six/One proxy

Redirect, map & translate
(addresses and ports)

Address bunch of local host

1000:abc:1:1234:5d:caff:fe22:57c1
Combined Proxy and Translator for v4 Support

local legacy-v6 host

edge network providers rest of Internet

— Six/One proxy

remote legacy-v4 host 60.50.40.30

to/from

edge network

1

2
to/from

— IP layer

from 1000:... to ::3c32:281e

from 1000:... to ::3c32:281e

from 23.45.67.89 to 60.50.40.30

redirect, map & translate (addresses and ports)

reverse

address bunch of local host
1000:abc:1:1234:5d:ccff:fe22:57c1

to/from

to/from

Translation may again also happen on host directly (without proxy)
v4 Gateways

- Connect Six/One hosts via v4 Internet
- Automated tunneling: Packet extensions with gateway addresses
- Redirection: Gateway addresses are bound to address bunches
  - Local gateways in Router Advertisement
  - Remote gateway in DNS
v4 Gateway Operation in Detail

local Six/One host

Six/One on host

edge network

providers

rest of Internet

remote Six/One host

12.34.56.78

v4 gateways

60.50.40.30

retrieve remote v4 gateway address from DNS

from 1000:... to 6000:...

to/from application

from 1000:... to 6000:...
ext to 60.50.40.30

outer from 12.34.56.78

inner from 1000:...
ext to 6000:...

to/from application

outer to 60.50.40.30

inner to 6000:...
ext from 12.34.56.78
Conclusions

- Improve existing transition path to Six/One
  - Higher deployment flexibility
  - Benefits also with legacy hosts
  - Backward-compatibility with v4

- Flexible, arbitrary composition, depending on need
  - Local legacy-v6/v4 hosts via proxies
  - Remote legacy-v6/v4 host via translators
  - Legacy-v4 Internet via v4 gateways

- Not more complex than other network-based techniques

- Reusable for v4-to-v6 transition