A Study on IPv6 Transition Architecture through Comparison and Analysis of IPv6 Transition Mechanisms

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요 약

1. 서론
2. IPv6 전환 메커니즘의 비교 분석

본 장에서는 IETF ngrtrans WG에 제안된 IPv6 전환 메커니즘의 특성과 장단점, 구현하기 위해서 필요한 요구사항, 적용하기에 적합한 환경과 전환 시기 등을 비교, 분석한다.

### 1) 두일 스타크 (Dual stack)

<table>
<thead>
<tr>
<th>Transition Type</th>
<th>IPv6-to-IPv4, IPv4-to-IPv6</th>
</tr>
</thead>
<tbody>
<tr>
<td>Applicability Scope</td>
<td>Host</td>
</tr>
<tr>
<td>Routing Information</td>
<td>All IPv4 enable routers must maintain both IPv4 and IPv6 routes and IPv4, IPv6 enable nodes</td>
</tr>
<tr>
<td>IPv4 Addr Requirement</td>
<td>One per host and many per router</td>
</tr>
<tr>
<td>IPv6 Addr Requirement</td>
<td>One IPv4-comparable IPv6 address per host and many per router</td>
</tr>
<tr>
<td>Host Requirement</td>
<td>Dual stack</td>
</tr>
<tr>
<td>Router Requirement</td>
<td>Dual stack - IPv4-to-IPv6 over IPv4 tunneling - IPv6 routing protocols</td>
</tr>
<tr>
<td>Server Requirement</td>
<td>DNS server must be capable of handling both A and AAAA records</td>
</tr>
<tr>
<td>Transition Layer</td>
<td>Network layer</td>
</tr>
<tr>
<td>Applicable Deployment Environment</td>
<td>Unmanaged, Managed, ISP networks</td>
</tr>
<tr>
<td>Applicable Deployment Time</td>
<td>Beginning period (IPv4, IPv6-Islands)</td>
</tr>
</tbody>
</table>

### 2) Configured 터널

<table>
<thead>
<tr>
<th>Transition Type</th>
<th>IPv6-to-IPv4 over IPv4, IPv4-to-IPv6 over IPv6</th>
</tr>
</thead>
<tbody>
<tr>
<td>Applicability Scope</td>
<td>Site</td>
</tr>
<tr>
<td>Routing Information</td>
<td>Need configured information to tunnel end-point</td>
</tr>
<tr>
<td>IPv4 Addr Requirement</td>
<td>One per site</td>
</tr>
<tr>
<td>IPv4 Addr Requirement</td>
<td>One per host and many per router</td>
</tr>
<tr>
<td>Host Requirement</td>
<td>IPv6 stack</td>
</tr>
<tr>
<td>Router Requirement</td>
<td>IPv6-to-IPv4, IPv4-to-IPv6 over IPv4 tunneling - IPv6 routing protocols - Connection to IPv6 site</td>
</tr>
<tr>
<td>NAT Impact</td>
<td>Will not work if the tunnel has cross NAT</td>
</tr>
<tr>
<td>Applicable Deployment Environment</td>
<td>Managed, ISP networks</td>
</tr>
<tr>
<td>Applicable Deployment Time</td>
<td>Beginning period (IPv4, IPv6-Islands), Middle period (Mixed), Last period (IPv6, IPv6-Islands)</td>
</tr>
</tbody>
</table>

### 3) 터널 브로커 (Tunnel Broker)

<table>
<thead>
<tr>
<th>Transition Type</th>
<th>IPv6-to-IPv4 over IPv4</th>
</tr>
</thead>
<tbody>
<tr>
<td>Applicability Scope</td>
<td>Site</td>
</tr>
<tr>
<td>IPv4 Addr Requirement</td>
<td>One per site</td>
</tr>
<tr>
<td>Host Requirement</td>
<td>IPv6 router - IPv6 routing protocols - Connection to IPv6 site</td>
</tr>
<tr>
<td>NAT Impact</td>
<td>Will not work if the tunnel has cross NAT</td>
</tr>
<tr>
<td>Applicable Deployment Environment</td>
<td>Managed, ISP networks</td>
</tr>
<tr>
<td>Applicable Deployment Time</td>
<td>Beginning period (IPv4, IPv6-Islands), Middle period (Mixed)</td>
</tr>
</tbody>
</table>

### 4) 6to4

<table>
<thead>
<tr>
<th>Transition Type</th>
<th>IPv6-to-IPv4 over IPv4</th>
</tr>
</thead>
<tbody>
<tr>
<td>Applicability Scope</td>
<td>Site</td>
</tr>
<tr>
<td>IPv4 Addr Requirement</td>
<td>One per site</td>
</tr>
<tr>
<td>IPv4 Addr Requirement</td>
<td>6to4 prefix per site</td>
</tr>
<tr>
<td>Host Requirement</td>
<td>IPv6 router - Source address selection</td>
</tr>
<tr>
<td>Router Requirement</td>
<td>6to4 router - Dual stack - Special forwarding and decapsulation rules - IPv4-to-IPv6 over IPv4 tunneling - IPv4 IPv6 routing protocols - Connection to IPv4 site</td>
</tr>
<tr>
<td>NAT Impact</td>
<td>Will not work if the tunnel has cross NAT</td>
</tr>
<tr>
<td>Applicable Deployment Environment</td>
<td>Unmanaged, Managed networks</td>
</tr>
<tr>
<td>Applicable Deployment Time</td>
<td>Beginning period (IPv4, IPv6-Islands), Middle period (Mixed)</td>
</tr>
</tbody>
</table>

터널 브로커는 터널을 수동으로 설정하는 부담을 줄이기 위하여 제안된 터널링 메커니즘으로, 터널 브로커와 터널 서버를 통해 IPv6 망에 존재하는 두일 스타크 호스트에게 IPv6 인터넷으로의 연결을 제공한다. IPv6 망으로 연결하고자 하는 경우에 두일 스타크 호스트는 터널 브로커에게 연결을 요청한다. 요청을 받은 터널 브로커는 두일 스타크 호스트에게 동적으로 글로벌 IPv6 주소를 할당하고, 두일 스타크 호스트와 터널 서버 사이에 터널을 설정해 준다. 터널 브로커는 IPv6 망보다는 호스트에 적용하기에 적합하다.

5) ISATAP (Intra-Site Automatic Tunnel Addressing Protocol) [6]

<table>
<thead>
<tr>
<th>Transition Type</th>
<th>IPv6-4 to IPv4</th>
<th>IPv4 to IPv6</th>
</tr>
</thead>
<tbody>
<tr>
<td>Applicability Scope</td>
<td>Site</td>
<td>Site</td>
</tr>
<tr>
<td>IPv4 Addr Requirement</td>
<td>One per host and many per router</td>
<td>Can only be private address</td>
</tr>
<tr>
<td>IPv6 Addr Requirement</td>
<td>One prefix out of native IPv6 address</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Host Requirement</th>
<th>Dual stack</th>
<th>ISATAP interface</th>
</tr>
</thead>
<tbody>
<tr>
<td>IPv6-4 to IPv4 tunneling</td>
<td>Potential router list management</td>
<td>Need to modify neighbor discovery mechanism</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Router Requirement</th>
<th>Dual stack</th>
<th>ISATAP interface</th>
</tr>
</thead>
<tbody>
<tr>
<td>IPv6-4 to IPv4 tunneling</td>
<td>IPv4, IPv6 routing protocols</td>
<td>Need to modify neighbor discovery mechanism</td>
</tr>
<tr>
<td>IPv4-4 to IPv6 packet translation</td>
<td>IPv4, IPv6 routing protocols</td>
<td>Connection to IPv6 site</td>
</tr>
</tbody>
</table>

Server requirement: DNS server

Network layer: Network layer

NAT Impact: Not allowed the virtual ISATAP link to span NAT

Other Requirement: IANA adopt the interface identifier construction (ISATAP interface identifier) for the existing IANA (IEEE 04) registration (09-03-5E). Need that the name "ISATAP" be reserved in the IANA "Protocol and Service Name" assigned numbers document.

Applicable Deployment Environment: Managed networks

Applicable Deployment Time: Beginning period (IPv4-6, IPv6-64) Middle period (IPv6-64)

[6 - ISATAP]


6) SIIT (Stateless IP/ICMP Transition Algorithm) [3]


7) NAT-PT (Network Address Translation – Protocol Transition) [2]

<table>
<thead>
<tr>
<th>Transition Type</th>
<th>IPv4-6 to IPv4</th>
<th>IPv4-6 to IPv6</th>
</tr>
</thead>
<tbody>
<tr>
<td>Applicability Scope</td>
<td>Site</td>
<td>Site</td>
</tr>
<tr>
<td>IPv4 Addr Requirement</td>
<td>One per host per IPv4</td>
<td>One per host per IPv4</td>
</tr>
<tr>
<td>IPv6 Addr Requirement</td>
<td>One prefix out of native IPv6 address</td>
<td></td>
</tr>
</tbody>
</table>

Host Requirement: IPv6 stack

Router Requirement: SIIT translator - Dual stack - IPv4 address pool management - IPv4-6 packet translation - IPv4-6 routing protocols - Connection to IPv4 site

Transition Layer: Network layer

Impact on Upper Layer: Fields related to IP address such as TCP, UDP and ICMP header checksums are translated Applications that carry the IP address in payload will not work

Other Requirement: ALG

Applicable Deployment Environment: Unmanaged network

Applicable Deployment Time: Beginning period (IPv4-6, IPv6-64)

[2 - NAT-PT]
8) DSTM (Dual Stack Transition Mechanism)\(^7\)

<table>
<thead>
<tr>
<th>Transition Type</th>
<th>IPv4-to-IPv6</th>
</tr>
</thead>
<tbody>
<tr>
<td>Applicability Scope</td>
<td>Site</td>
</tr>
<tr>
<td>IPv4 Addr. Requirement</td>
<td>One temporary per host</td>
</tr>
<tr>
<td>IPv6 Addr. Requirement</td>
<td>One per host and many per router</td>
</tr>
<tr>
<td>Host Requirement</td>
<td>DSTM client</td>
</tr>
<tr>
<td>Router Requirement</td>
<td>Dual stack</td>
</tr>
<tr>
<td>Server Requirement</td>
<td>DSTM server</td>
</tr>
<tr>
<td>Other Requirement</td>
<td>Network layer</td>
</tr>
<tr>
<td>Applicable Deployment Environment</td>
<td>Managed networks</td>
</tr>
<tr>
<td>Applicable Deployment Time</td>
<td>Beginning period (IPv6-Ocean, IPv6-Islands)</td>
</tr>
</tbody>
</table>

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9) BIA (Dual Stack Hosts using the “Bump-In-the-AP”\(^3\))

BIA는 튜nel 스택 호스트에 존재하는 기존의 IPv4 응용을 새로운 호스트가 상호 호스트의 주소를 사용하여 호스트 사이의 튜nel 호스트로 통신을 초기화 하는 경우에만 전환을 지원하기 때문에, 앞으로 IPv4 호스트에서 튜nel 스택 호스트로 통신을 초기화 하는 경우에만 전환을 지원할 수 있도록 하는 것이 필요하다.

3. 결론

IPv4 망과 IPv6 망이 존재할 경우 두 망간의 통신은 자연스럽게 이루어질 수 있도록 하기 위하여 IETF ngntrns WG을 중심으로 많은 IPv6 전환 메커니즘이 제안되었다. 이러한 IPv6 전환 메커니즘들은 단순한 통신만을 지원하는 것이며, 제안된 메커니즘이 망의 특성에 따라 차계로 동작할 수 있는지에 대한 연구가 지금까지 진행되지 못했다.

본 논문에서는 IETF ngntrns WG에 제안된 IPv6 전환 메커니즘의 특성과 상호 호스트가 요구하는 요구 사항에 따라 적합한 방법을 전환 시기 등에 대하여 분석하였다. IPv6 전환 메커니즘을 비교 분석한 결과, 제안된 메커니즘은 전환 메커니즘의 장점과 단점을 고려하여 적합한 전환과 시기 및 특성에 따라 적합한 전환메커니즘을 선택할 수 있는지에 대한 연구가 지속적으로 진행되어져야할 것이다.

참고문헌