

IPv6 Multi-homing Solutions and their Pro's and Con's

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1 Introduction:

This document attempts to address all the IPv6 Multi-homing Solutions and their Pro's and Con's, put forward by the Internet Community as a collective. The use of this document is intended for the sole purpose of providing clarification of the IPv6 Multi-homing Solutions and their pro's and con's, in order to assist the Internet Community on deciding what solution are currently available to use Globally as a United Internet Community. The ultimate solution may or may not be as written in this document. However, these are the suggested solutions put forward to date and the ones we have to work with and adjust as needed. Additional suggested solutions and pro's and con's will be added to this document as members in the Internet Community bring them forward.

2 IPv6 Multi-homing Solutions and their Pro's and Con's:

Suggested solutions currently being worked on are provided in this section (2) and **are not listed in any order of preference.**

2.1 CIDR:

As a community we decide on a boundary we think routers can handle now and possibly in the future. This solution would require filters to be opened to the selected CIDR boundary. This would exactly mirror how we do multi-homing with IPv4.

For Example: If the community decides that a /49 is what Prefix we want to use, then filters need to be opened up to allow /49 or less specific Prefix through.

Pro's:

1. Everyone who multi-homes with IPv4 currently can use current knowledge to implement IPv6 with only minimal training.
2. This solution provides the ability for both multi-homing and route engineering.
3. Fast to implementation.
4. This is not an economically demanding solution in the near future.
5. This can provide a multi-home solution for both PA and PI Addresses.

Con's:

1. This solution could cause bloating in the routing tables.
2. This solution could cost money in the future for a different solution to coexist for routing table bloat.
3. This solution could cost money in the future to continue to scale routing CPU, and memory to keep up with route table bloat.
4. Potentially run out of memory on routing platforms.
5. Most large ISP's are unable to make major changes in short periods of time.
6. May further grow the WHOIS/CIDR DB problem.

Questions to answer if choosing this solution:

1. What prefix should we use?
 - a. One that is as least specific as possible in order to prevent routing table bloat.
2. What size prefix will do the best at preventing accidental leaked routes?
 - a. One theory is the /49 because it is not a commonly routed CIDR yet and PI policy has been set for /48's.
3. Will vendors rise to the occasion and make changes that will resolve route bloat?
 - a. None of the vendors are currently shipping have hardware with capabilities to scale the routing table to the five year projected IPv4/IPv6 routing table size. None of the vendors have made a strong commitment to continue to be a few years ahead of the routing table bloat for the foreseeable future without greatly increasing costs.
 - b. Routing table lookups in memory for real replacement for IPv6 space is not a simple fix; it is a limitation of processors and memory (MAX) in routing architectures.

2.1.1 Choosing the CIDR boundary:

It is clear that the CIDR boundary should be between a /48 and a /64. Less specific than a /48 and all but the largest end-sites will not be able to multi-home. More specific than /64 does not make much sense as each LAN is expected to be a /64 due to an architectural

boundary in the protocol to support auto configuration requirements. But where in the /48 - /64 spectrum is the right boundary?

2.1.1.1 CIDR Boundary of /48

CIDR boundary of /48 creates an equivalent solution to accepting only PA or PI aggregates except that the multi-homing capabilities apply equally to end-sites with PA and PI addresses.

Pro's:

1. Every end-site can use their current Pv4 multi-homing knowledge to implement IPv6 with only minimal training.
2. This solution provides end-sites the ability to multi-home and have fail-over capabilities.
3. Fast to implementation.
4. This is not an economically demanding solution in the near future.

Con's:

1. This solution does not allow for fine grained inter-AS traffic engineering as it does not allow a site to advertise more than one route.
2. This solution could cause some bloating in the routing tables, but will be limited to the number of AS's (currently 23,093 potentially 4,294,967,296).
3. This solution could cost money in the future for a different solution to coexist for routing table bloat.
4. This solution could cost money in the future to continue to scale routing CPU, and memory to keep up with route table bloat.

Questions to answer if choosing this solution:

1. If each end-site can only advertise a single aggregate how will they accomplish the traffic engineering they are currently using with IPv4?
 - a.
2. Is an IPv6 multi-homing solution that does not support fine-grained traffic engineering that is currently available good enough for now?
 - a.

2.1.1.2 CIDR Boundary More Specific Than /48

A CIDR boundary of longer than a /48 will allow for more fine grained traffic engineering, as end-sites can make different sized announcements to different upstream ISPs. This may result in many more routes in the Internet than the current IPv4 Internet routing table.

Some have suggested that a /49 is the best boundary. This is because it is the least specific mask an end-site would have that is not a /48. Having a shorter mask reduces the possible number of routes each end-site could advertise to the Internet routing table. Many have suggested that a boundary of a /48 should be avoided to alleviate the accidental redistribution of all of an ISP's static /48 customers.

Pro's:

1. Everyone who multi-homes with IPv4 currently can use current knowledge to implement IPv6 with only minimal training.
2. This solution provides the ability for both multi-homing and route engineering.
3. Fast to implementation.
4. This is not an economically demanding solution in the near future.

Con's:

1. This solution could cause bloating in the routing tables.
2. This solution could cost money in the future for a different solution to coexist for routing table bloat.
3. This solution could cost money in the future to continue to scale routing CPU, and memory to keep up with route table bloat.

Questions to answer if choosing this solution:

1. What prefix should we use?
 - a. One that is as least specific as possible in order to prevent routing table bloat.
2. What size prefix will do the best at preventing accidental leaked routes?
 - a. One theory is the /49 because it is not a commonly routed CIDR yet and PI policy has been set for /48's.
3. Will vendors rise to the occasion and make changes that will resolve route bloat?
 - a. None of the vendors are currently shipping hardware with capabilities to scale the routing table to the five year projected IPv4/IPv6 routing table size. None of the vendors have made a strong commitment to continue to be a few years ahead of the routing table bloat for the foreseeable future without greatly increasing costs.

2.1.1.3 Aggregation Slices:

As a community we decide to allow a specific number of Aggregations per AS. With this approach, we determine what CIDR boundary to filter on by considering how many more specific routes each end-site requires, in order to provide the appropriate level of fine grained traffic engineering capabilities, in concert with multi-homing. When approached this way we can work backwards from the default end-site assignment, divide that into the appropriate number of slices, and as a community decide on a CIDR that allows the appropriate number of slices.

For example: on average in IPv4 there is an 8.4:1 route to AS ratio. On average in IPv6 (assuming that all more specifics from non-contiguous blocks go away) there would be a 3.9:1 route to AS ratio.

If you think on average an AS will need 4 discrete slices, and the default assignment to an end site is a /48, then everyone should accept up to and including /50s.

If you want to be conservative and say on average an AS will need 8 discrete slices and the default assignment to an end site is a /48, then everyone should accept up to and including /51s.

End-sites that can justify a need for additional slices may be assigned a larger PI address block. For example if the chosen CIDR boundary is /51, then an end-site with a /48 could only advertise 8 /51 prefixes. If the end-site required 16 prefixes to meet their traffic engineering need, then they could be granted a /47 PI assignment.

If the community has concerns about the accidental redistribution of all of an ISP's static customers as in the previous section (2.1.1.2), then ISPs will need to give static end-sites a prefix that is smaller than the specified prefix used for multi-homing. In the cases above, non-multi-homing sites need to be given a default assignment of /51

Pro's

1. This solution provides a way to help limit routing table bloat.
2. This solution provides the ability for both multi-homing and route engineering.
3. This is not an economically demanding solution in the near term.

Con's

1. RIR policy will need to be written to support this solution.
2. This solution could cause bloating in the routing tables.
3. This solution could cost money in the future for a different solution to coexist for routing table bloat.
4. This solution could cost money in the future to continue to scale routing CPU, and memory to keep up with route table bloat.
5. Vendors might find the need to implement 4 byte AS sooner since this may drive more businesses to apply for ASN's.
6. There will always be exceptions (content provider anycast for example).
7. RIR's will have to be very vigilant with ASN justification. There is a possibility that companies such as spammers will try to receive additional ASN's to get more space.

Questions to answer if choosing this solution:

1. How many prefix slices should we allow?
 - a.
2. Will this solution be good enough to keep routing table bloat under control?
 - a.

2.2 Metro/Regional:

IP addresses would be assigned to a regional/geographical location as opposed to Large Networks, ISP's, End Users or PI.

For Example: A prefix is assigned to a suitable regional authority, such as a city. The city then chooses a single or list of relevant providers to serve as the interchange. Each

of the providers will advertise the region's prefix to the Internet. Based on a protocol or by a contract, these providers will accept more specific prefixes from subscribers that are within the regional/geographic location, and will then interchange traffic to the other relevant providers appropriately.

To further this Example: Let say the regional authority is the City. They would then operate or contract the operation of a routing interchange point. The router in this chosen interchange point would advertise the full prefix to all relevant providers. The relevant providers would then advertise their more specific routes that are Re-allocations or Re-Assignments from the regional prefix advertised to them to the regional authority or by contract with customers. Traffic that comes to the region that is not delivered directly to a customer is delivered to the interchange router, which in turn passes it to the relevant provider.

This can be achieved through two simultaneous methods. The first method is a Collocation Center; the collocation center would be required to have a large enough interchange point that is able to support the metro regional size. The second method is all the relevant providers would be responsible for setting up direct contracts with each other in order to agree on the exchange of more specific routes.

Pro's

1. This solution can help control routing table bloat.
2. This provides a multi-home solution for everyone.

Con's

1. This solution doesn't allow for Traffic Engineering.
2. This solution would be a complete reorganization and way of routing for the entire Internet community.
3. This solution would be an economical burden for any existing Network Providers and ISPs as they would be required to reconfigure their network to mirror the regional boundaries.
4. This solution would be an economical burden to all who provided Internet access in the region as they would all be required to Peer or buy transit from every Internet provider in the region for local routes.
5. This solution would be an economic burden as a global Internet provider might be compelled to peer in thousands of cities world - wide.
6. RIR policy would have to change.
7. This removes the possibility for portable IP space.
8. This has potential to create security risks.
9. There is a possibility that IX's and many ISP's would have to become non-profit organizations for this to work as desired.

Questions to answer if choosing this solution:

1. How much of an economical burden would this be to do?
 - a.
2. Can the community decide what method would be best to use?

- a.
- 3. If contracts for exchanging routes exists in this method, how would it be decided who pays who and how much? How is exchange of value decided?
 - a.
- 4. If a network moves from one metropolitan area to another, would that network be required to renumber?
 - a.
- 5. How would a large Enterprise Network that spans multiple metro regions be numbered? Would the addresses come out of single block or would they be required to number each of their sites out of it's own metro region space?
 - a.
- 6. Who would define the metropolitan regions?
 - a.

2.3 Community Codes:

A BGP community attribute for tagging prefixes would be used. In order to multi-home with PA space this BGP community attribute would have to be attached to the prefix being used for multi-homing.

For Example: The name of the new community is MULTIHOME and the Internet Assigned Numbers Authority should decide its value. BGP implementations will need to propagate the MULTIHOME community by default, even if they don't propagate other communities by default. Operators will tag prefixes from PA space used for multi-homing with the MULTIHOME community and propagate this community along with the advertisement of these prefixes.

Pro's

1. This solution allows for selective filtering for multi-homing with out opening filters based on a prefix length. Therefore, this would help to control routing table bloat.
2. This solution allows for multi-homing and Traffic Engineering with both PA and PI Addresses.
3. This is not an economically demanding solution.

Con's

1. If someone fails to propagate the MULTIHOME community, then routes will be either not received or dropped.
2. If the MULTIHOME tag is forgotten on a prefix then there is no way of identifying that it is a multi-home prefix, therefore failure to multi-home.
3. Training and education would need to be done in order to make this successful.
4. Any network that might accidentally redistribute extra prefixes from non-multi-homed end-sites would likely already be advertising mutli-homed prefixes with the correct community. A mis-configuration that would result in advertising extra routes would likely also add the MULTIHOME community.

5. This solution is very prone to human error.
6. Any ISP could decide to tag a route with MULTIHOMING or there is the possibility we end up with an authority to decide.
7. This could be used as an easy way to hijack IP space.

Questions to answer if choosing this solution:

1. How much training would need to be done for this?
 - a.
2. Who would do the training for this and would there be a cost?
 - a.

2.4 Published List:

A list of approved prefixes for multi-homing would be published and filters would be opened to this approved list.

For Example: If RIR's decided that the first /41 of a PA /32 allocation is to be utilized for multi-homing, then all filters should be opened up for these approved multi-homing prefixes. This can be accomplished with the RIR's producing a list of approved multi-homing blocks and then publishing it on their public Data Base as a loadable list. This list would be updated daily by the RIR's. This list would include both PA and PI blocks that are approved for multi-homing.

Pro's

1. This solution would enable both multi-homing and Traffic Engineering.
2. This solution would help control routing table bloat.
3. This is not an economically demanding solution.
4. This solution would allow multi-homing for both PA and PI Addresses.
5. This solution may solve several other issues such as hijacking, reduction of spam, reduction of viruses, and create some basic security.

Con's

1. This would require more work from the RIR's.
2. The requirement to open filters to this list may only be possible as a strong suggestion and not as a mandate. This would be something the Community needs to decide.
3. This list of approved blocks might become excessively long.
4. In order to make this work, all the RIR's would need to add assignment and allocation policy. This policy would have to require all users to subscribe to the DB list and do updates with the list, and if they don't membership would go inactive until they comply.
5. Frequency of updates may become an issue.
6. The Internet could encounter a catastrophic failure if someone were to hack the DB.

Questions to answer if choosing this solution:

1. Can the RIR's take on this extra workload?
 - a.
2. Can we make opening of the filters to this list a mandate?
 - a.

2.5 Policy:

This would be a policy written to “work around” the PA multi-homing problem.

For Example: RIR’s would write a policy that allows providers to request PI space. The PI space would be allocated to the Upstream Requestor, who then would Re-Assign the PI space to their customer.

Pro’s

1. In theory providers would be able to offer multi-homing to their customers without requiring their customers to get PI space.

Con’s

1. This does not provide a solution for Traffic Engineering.

Questions to ask if choosing this solution:

1. Should the Upstream provider be required to port the IP’s to the down stream provider if the downstream leaves the upstream network?
 - a.
2. Should the Upstream be allowed to keep this allocation and use it for another customer in the future?
 - a.

2.6 Maximum Prefix:

Rather than setting a specific CIDR to open filters, each origin AS can be limited to a certain number of prefixes. This can be implemented if every upstream AS set a maximum-prefix limit on each eBGP neighbor.

For Example: If each upstream ISP set a maximum prefix limit of 5 on each eBGP customer, the result would be an Internet routing table that contains a maximum of 5 times larger the number of AS’s.

The size of the Internet routing table is dependant on each ISP applying the maximum prefix limit on all of their eBGP customers.

Additional filtering capabilities can be added to routers to drop the most specific routes of a given origin if the origin exceeds the configured limit. This way the number of routes

admitted into the routing table would not depend on each upstream AS from the origin setting max-prefix correctly.

For Example: Assume there is one irresponsible ISP, which does not apply a maximum prefix limit on any of its eBGP customers. This irresponsible ISP may pass an excessive amount of prefixes for each down stream eBGP customer. With the new functionality described in the paragraph above, a Peer of the irresponsible ISP could limit the number of routes they receive by filtering down the routes to a certain number (say five) per Originating AS. If the irresponsible ISP advertises more than 5 routes for a given origin AS, then the upstream Peer would discard all but five routes for the given origin AS. The upstream Peer would keep the 5 least specific non-overlapping prefixes for a given origin.

Pro's

1. This solution provides a way to help limit routing table bloat.
2. This solution provides the ability for both multi-homing and route engineering.
3. This is not an economically demanding solution in the near term.

Con's

1. This solution could cause bloating in the routing tables.
2. This solution could cost money in the future for a different solution to coexist for routing table bloat.
3. This solution could cost money in the future to continue to scale routing CPU, and memory to keep up with route table bloat.

Questions to answer if choosing this solution:

3. How many prefix slices should we allow?
 - a.
4. Will this solution be good enough to keep routing table bloat under control?
 - a.

2.7 Shim6:

This is a protocol and both provider ends would have to run SHIM 6 protocol.

For Example: Shim6 provides a way to look at routing and starts communicating by both ends running Shim6. A Shim6 handshake occurs, and then the shake informs what addresses are ok for talking for engineering layer 3. Shim inserts alternate id in source and destination upper layer so the path can be monitored and rerouted while in session if a failure is identified. It changes the original source and destination address if failure in middle of session occurs.

Pro's

1. This solution would help control routing table bloat.
2. This is not a large economically demanding solution.

Con's

1. This solution doesn't provide for Route Engineering to choose the most economical path.
2. All traffic-engineering decisions are made by the source of session.
3. Does not allow for traffic engineering at the site level.
4. Does not allow for traffic engineering by transit AS's.
5. Creates a lot of state on servers with many concurrent sessions.
6. A round robin failure could occur with this solution.
7. A lot of training and education needs to be done for this solution to be a possibility.
8. This is an economically demanding solution.
9. There is a possibility that router code would need to be modified everywhere.

Questions to ask if choosing this solution:

1. Who will do the training and education needed for this solution to work?
 - a.
2. Can Shim6 be worked on to resolve the Traffic Engineering problem in question?
 - a.

2.8 8+8 / GSE:

This is a protocol solution that functions through identification manipulation.

For Example: 8+8 and GSE are protocol based solutions that attempt to completely separate the identifier, which uniquely identifies an end host, from the locator (routing goop), which locates the end host behind one or more ISPs. GSE is an extension to 8+8 that separates the address into the routing goop (Locator), local site sub-netting, and the end system identifier. All pseudo header checksums should only reference the end system identifier so that the routing goop (locator) can be modified.

Pro's

1. This solution would help control routing table bloat.
2. This is not an economically demanding solution.
3. This solution could support traffic engineering.
4. This solution introduces another level of routing hierarchy to allow for better scaling characteristics.
5. This solution would allow both PI and PA to multi-home.

Con's

1. Security issues in only mapping authorized routing goop to a particular end site will have to be solved.
2. Traffic engineering details will need to be worked out.
3. It will take some time for the protocol standards to be developed, implemented by vendors, and deployed in the Internet.
4. May end up creating as much state as de-aggregating.

5. A lot of training and education needs to be done for this solution to be a possibility.

Questions to ask if choosing this solution:

1. How much standards work is required for this type of a solution?
 - a.
2. Can this solution resolve the security problem in question?
 - a.

2.9 PI Only:

*This is included in this document only because it provides a means to multi-home to a select few, otherwise this solution would be omitted due to it not providing a solution for PA Multi-homing.

RIR's would allocate both IPv6 PA and PI addresses. In both types of allocations, only the direct allocation aggregate would be announced.

For Example: A provider such as a large ISP would announce their PA aggregate, and the aggregate of any smaller ISP down stream of their network that has a direct allocation of PA address and any End-User down stream of their network that has PI addresses.

Filters would need to limit route announcements from Peers, at best, only to PA aggregates allocated to ISPs and PI aggregates allocated to end-sites, or at worst to the minimum PA allocation size and the minimum PI allocation size.

Pro's:

1. Every end-site who has IPv6 PI address can use their current Pv4 multi-homing knowledge to implement IPv6 with only minimal training.
2. This solution enables end-sites with an IPv6 PI address to multi-home and has fail-over capabilities.
3. Fast to implementation.
4. This is not an economically demanding solution in the near future.

Con's:

1. This solution only provides multi-homing to PI.
2. This solution does not allow for fine grained inter-AS traffic engineering as it does not allow a site to advertise more than one route.
3. This solution could cause some bloating in the routing tables, but will be limited to the number of AS's (currently 23,093 potentially 4,294,967,296).
4. This solution does not allow Upstream providers to offer multi-homing. The End-User or small ISP customers who choose to use their Upstream Providers PA addresses will be unable to multi-home.
5. This solution could cost money in the future for a different solution to coexist for routing table bloat.
6. This solution could cost money in the future to continue to scale routing CPU, and memory to keep up with route table bloat.

Questions to answer if choosing this solution:

1. How do you justify only allowing PI addresses to take up one slot in the Internet routing table, but that it is not ok for end-sites using PA addresses to also multi-home and take up one slot in the Internet routing table?
 - a. Aggregating routes is the most important aspect of IPv6 stewardship. PA more specifics can easily be aggregated to the PA aggregate allocated to an LIR / ISP. PI aggregates can easily be aggregated to the PI aggregate assigned to an end-site.
2. If each end-site can only advertise a single aggregate how will they accomplish the traffic engineering they are currently using with IPv4?
 - a.
3. Is an IPv6 multi-homing solution that does not support fine-grained traffic engineering that is currently available good enough for now?
 - a.
4. Will vendors rise to the occasion and make changes that will resolve route bloat?
 - a.

3 Acknowledgements:

This document is a working compilation of the Global Internet Community. Special regards and appreciation for the time put into thinking out possible solutions go to Jason Schiller, Aaron Hughes, Iljitsch van Beijnum, and Fred Baker.

4 Applicable References with detail:

4.1 RFC-1887 [Rekhter, Y. and T. Li, "An Architecture for IPv6 Unicast Address Allocation," RFC 1887, December 1995.](#)

RFC-1887 sets the groundwork for the RIRs to assign large amounts of IPv6 space to ISPs and transit providers (network service providers), and for all down stream end-sites (network service subscribers) to use a more specific route of a provider aggregate.

Topics covered in RFC-1887 include:

“- Benefits of encoding some topological information in IPv6 addresses to significantly reduce routing protocol overhead;

The anticipated need for additional levels of hierarchy in Internet addressing to support network growth;

The recommended mapping between Internet topological entities (i.e., service providers, and service subscribers) and IPv6 addressing and routing components;”

4.2 [RFC 1187](#) - Bulk Table Retrieval with the SNMP by M. Rose, K. McCloghrie, J. Davin

RFC-1187 points out the technical impact of an IPv6 routing system that lacks routing data abstraction and summarization on router cpu, router memory, and transmission bandwidth to carry routing information. “The result would be flat inter-domain routing; all routing domains would need explicit knowledge of all other routing domains that they route to. This can work well in either a small or medium sized network. However, this does not scale to very large networks. For example, we expect IPv6 to grow to hundreds of thousands of routing domains in North America alone. This requires a greater degree of the reach ability information abstraction beyond that which can be achieved at the ‘routing domain’ level.”

RFC-1887 recommendations are:

“We anticipate that the current exponential growth of the Internet will continue or accelerate for the foreseeable future. In addition, we anticipate a rapid internationalization of the Internet. The ability of routing to scale is dependent upon the use of data abstraction based on hierarchical IPv6 addresses. It is therefore essential to choose a hierarchical structure for IPv6 addresses with great care. ...

It is in the best interests of the internetworking community that the cost of operations be kept to a minimum where possible. In the case of IPv6 address allocation, this again means that routing data abstraction must be encouraged.

In order for data abstraction to be possible, the assignment of IPv6 addresses must be accomplished in a manner which is consistent with the actual physical topology of the Internet. For example, in those cases where organizational and administrative boundaries are not”

In summary, current reference materials can appear contradictory in what direction we should take for a solution. Currently references being utilized have lead the internet community to believe that only single aggregates should be advertised to the Internet routing table. This has left IPv6 with no globally accepted means for a multi-homing solution. This is why we are working on a solution today as a Global Community.

5 Informative References (no detail)

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- 5.2 Internet Draft in Progress: Filtering IPv6 Prefixes for Multi-homing by Fred Baker
- 5.3 RFC4177 Huston, G., “[Architectural Approaches to Multi-homing for IPv6,](#)” ---
-- RFC 4177, September 2005.
- 5.4 Metro- Deering, S., “[Metro-Based Addressing,](#)” July 1995.
- 5.5 RFC1517 [Hinden, R., “Applicability Statement for the Implementation of Classless Inter-Domain Routing \(CIDR\),”](#) RFC 1517, September 1993.
- 5.6 RFC1518 [Rekhter, Y. and T. Li, “An Architecture for IP Address Allocation with CIDR,”](#) RFC 1518, September 1993.
- 5.7 RFC1519 [Fuller, V., Li, T., Yu, J., and K. Varadhan, “Classless Inter-Domain Routing \(CIDR\): an Address Assignment and Aggregation Strategy,”](#) RFC 1519, September 1993.

- 5.8 RFC1787 [Rekhter, Y.](#), “[Routing in a Multi-provider Internet](#),” RFC 1787, April 1995.
- 5.9 RFC3178 Hagino, J. and H. Snyder, “[IPv6 Multihoming Support at Site Exit Routers](#),” - RFC 3178, October 2001.
- 5.10 RFC3704 Baker, F. and P. Savola, “[Ingress Filtering for Multihomed Networks](#),” --
- BCP 84, RFC 3704, March 2004.
- 5.11 RFC4218 Nordmark, E. and T. Li, “[Threats Relating to IPv6 Multihoming ----- Solutions](#),” RFC 4218, October 2005.
- 5.12 RFC4291 Hinden, R. and S. Deering, “[IP Version 6 Addressing Architecture](#),” --- --
- RFC 4291, February 2006.
- 5.13 [Applicability Statement for the Level 3 Multihoming Shim Protocol \(Shim6\)](#) by J. -
-- Abley and M. Bagnulo
- 5.14 [Level 3 multi-homing shim protocol](#) by E. Nordmark and M. Bagnulo
- 5.15 [Default Locator-pair selection algorithm for the SHIM6 protocol](#) by M. Bagnulo
- 5.16 [draft-odell-8+8-00.txt](#) 8+8 - An Alternate Addressing Architecture for IPv6 by
Mike - O’Dell
- 5.17 [draft-ietf-ipngwg-gseaddr-00.txt](#) GSE - An Alternate Addressing Architecture for --
- IPv6 by Mike O’Dell
- 5.18 [draft-ietf-ipngwg-esd-analysis-05.txt](#) Separating Identifiers and Locators in -----
- Addresses: An Analysis of the GSE Proposal for IPv6 by Matt Crawford, Allison
- Mankin, Thomas Narten, John W. Stewart, Lixia Zhang
- 5.19 Rebuttal by Bellovin [bellovin.esd-secure.txt](#)