Network Working Group
INTERNET-DRAFT
Category: Informational
<draft-ietf-idr-autosys-guide-02.txt>

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February 1995

Guidelines for creation, selection, and registration of an Autonomous System (AS)

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Abstract

This draft discusses when it is appropriate to register and utilize an Autonomous System (AS), and lists criteria for such. ASes are the unit of routing policy in the modern world of exterior routing, and are specifically applicable to protocols like EGP (Exterior Gateway Protocol, now at historical status; see [EGP]), BGP (Border Gateway Protocol, the current de facto standard for inter-AS routing; see [BGP-4]), and IDRP (The OSI Inter-Domain Routing Protocol, which the Internet will eventually adopt when BGP becomes obsolete; see [IDRP]). It should be noted that the IDRP equivalent of an AS is the RDI, or Routing Domain Identifier.

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1. Introduction

This memo discusses when it is appropriate to register and utilize an Autonomous System (AS), and lists criteria for such. ASes are the unit of routing policy in the modern world of exterior routing, and are specifically applicable to protocols like EGP (Exterior Gateway Protocol, now at historical status; see [EGP]), BGP (Border Gateway Protocol, the current de facto standard for inter-AS routing; see [BGP-4]), and IDRP (The OSI Inter-Domain Routing Protocol, which the Internet will eventually adopt when BGP becomes obsolete; see [IDRP]). It should be noted that the IDRP equivalent of an AS is the RDI, or Routing Domain Identifier.

2. Motivation

This memo is aimed at network operators and service providers who need to understand under what circumstances they should make use of an AS. It is expected that the reader is familiar with routing protocols and will be someone who configures and operates Internet networks. Unfortunately, there is a great deal of confusion in how ASes should be used today; this memo attempts to clear up some of this confusion, as well as acting as a simple guide to today's exterior routing.

3. Definitions

This document refers to the term ``prefix'' throughout. In the current classless Internet (see [CIDR]), a block of class A, B, or C networks may be referred to by merely a prefix and a mask, so long as such a block of networks begins and ends on a power-of-two boundary. For example, the networks:

192.168.0.0/24
192.168.1.0/24
192.168.2.0/24
192.168.3.0/24

can be simply referred to as:

192.168.0.0/22

The term ``prefix'' as it is used here is equivalent to ``CIDR block'', and in simple terms may be thought of as a group of one or more networks. We use the term ``network'' to mean classful network, or ``A, B, C network''.

The definition of AS has been unclear and ambiguous for some time. [BGP-4] states:

> The classic definition of an Autonomous System is a set of routers under a single technical administration, using an interior gateway protocol and common metrics to route packets within the AS, and using an exterior gateway protocol to route packets to other ASes. Since this classic definition was developed, it has become common for a single AS to use several interior gateway protocols and sometimes several sets of metrics within an AS. The use of the term Autonomous System here stresses the fact that, even when multiple IGPs and metrics are used, the administration of an AS appears to other ASes to have a single

> coherent interior routing plan and presents a consistent picture of what networks are reachable through it.

To rephrase succinctly:

> An AS is a connected group of IP networks run by one or more network operators which has a SINGLE and CLEARLY DEFINED routing policy.

Routing policy here is defined as how routing decisions are made in the Internet today. It is the exchange of routing information between ASes that is subject to routing policies. Consider the case of two ASes, X and Y exchanging routing information:

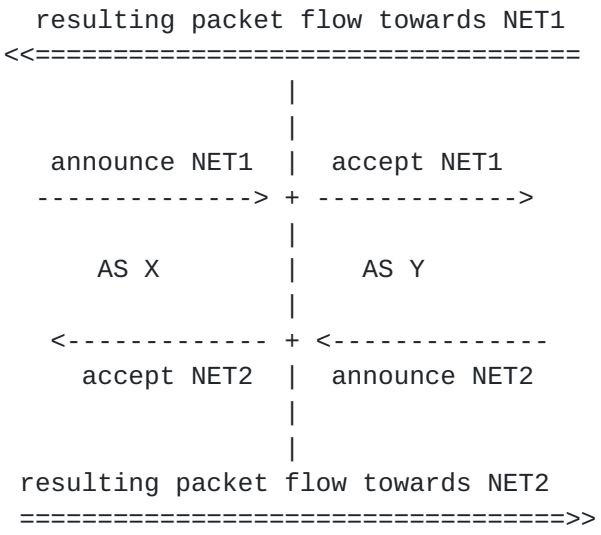
```
NET1 ......  ASX  <--->  ASY  ....... NET2
```

ASX knows how to reach a prefix called NET1. It does not matter whether NET1 belongs to ASX or to some other AS which exchanges routing information with ASX, either directly or indirectly; we just assume that ASX knows how to direct packets towards NET1. Likewise ASY knows how to reach NET2.

In order for traffic from NET2 to NET1 to flow between ASX and ASY, ASX has to announce NET1 to ASY using an exterior routing protocol; this means that ASX is willing to accept traffic directed to NET1 from ASY. Policy comes into play when ASX decides to announce NET1 to ASY.

For traffic to flow, ASY has to accept this routing information and use it. It is ASY's privilege to either use or disregard the information that it receives from ASX about NET1's reachability. ASY might decide not to use this information if it does not want to send traffic to NET1 at all or if it considers another route more appropriate to reach NET1.

In order for traffic in the direction of NET1 to flow between ASX and ASY, ASX must announce that route to ASY and ASY must accept it from ASX:



Ideally, and seldom practically, the announcement and acceptance policies of ASX and ASY are identical.

In order for traffic towards NET2 to flow, announcement and acceptance of NET2 must be in place (mirror image of NET1). For almost all applications connectivity in just one direction is not useful at all.

It should be noted that, in more complex topologies than this example, traffic from NET1 to NET2 may not necessarily take the same path as traffic from NET2 to NET1; this is called asymmetrical routing. Asymmetrical routing is not inherently bad, but can often cause performance problems for higher level protocols, such as TCP, and should be used with caution.

It is important to realise that with current destination based forwarding technology routing policies must eventually be expressed in these terms.

Policies are not configured for each prefix separately but for groups of prefixes. These groups of prefixes are ASes.

An AS has a globally unique number (sometimes referred to as an ASN, or Autonomous System Number) associated with it; this number is used in both the exchange of exterior routing information (between neighboring ASes), and as an identifier of the AS itself.

In routing terms, an AS will normally use one or more interior gateway protocols (IGPs) when exchanging reachability information within its own AS. See ``IGP Issues''.

4. Common errors in allocating ASes

The term AS is often confused or even misused as a convenient way of grouping together a set of prefixes which belong under the same administrative umbrella, even if within that group of prefixes there are various different routing policies. Without exception, an AS must have only one routing policy.

It is essential that careful consideration and coordination be applied during the creation of an AS. Using an AS merely for the sake of having an AS is to be avoided, as is the worst-case scenario of one AS per classful network (the IDEAL situation is to have one prefix, containing many networks, per AS). This may mean that some re-engineering may be required in order to apply the criteria and guidelines for creation and allocation of an AS that we list below; nevertheless, doing so is probably the only way to implement the desired routing policy.

If you are currently engineering an AS, careful thought should be taken to register appropriately sized CIDR blocks with your registration authority in order to minimize the number of advertised prefixes from your AS. In the perfect world that number can , and should, be as low as one.

Some router implementations use an AS number as a form of tagging to identify interior as well as exterior routing processes. This tag does not need to be unique unless routing information is indeed exchanged with other ASes. See ``IGP Issues''.

5. Criteria for the decision -- do I need an AS?

* Exchange of external routing information

  An AS must be used for exchanging external routing information with other ASes through an exterior routing protocol. The current recommended exterior routing protocol is BGP, the Border Gateway Protocol. However, the exchange of external routing information alone does not constitute the need for an AS. See ``Sample Cases'' below.

* Many prefixes, one AS

  As a general rule, one should try to place as many prefixes as possible within a given AS, provided all of them conform to the same routing policy.

* Unique routing policy

  As AS is only needed when you have a routing policy which is different from that of your border gateway peers. Here routing policy refers to how the rest of the Internet makes routing decisions based on information from your AS. See ``Sample Cases'' below to see exactly when this criteria will apply.

5.1 Sample Cases

* Single-homed site, single prefix

  A separate AS is not needed; the prefix should be placed in an AS of the provider. The site's prefix has exactly the same routing policy as the other customers of the site's service provider, and there is no need to make any distinction in routing information.

  This idea may at first seem slightly alien to some, but it highlights the clear distinction in the use of the AS number as a representation of routing policy as opposed to some form of administrative use.

  In some situations, a single site, or piece of a site, may find it necessary to have a policy different from that of its provider, or the rest of the site. In such an instance, a separate AS must be created for the affected prefixes. This situation is rare and should almost never happen. Very few stub sites require different routing policies than their parents. Because the AS is the unit of policy, however, this sometimes occurs.

* Single-homed site, multiple prefixes

  Again, a separate AS is not needed; the prefixes should be placed in an AS of the site's provider.

* Multi-homed site

  Here multi-homed is taken to mean a prefix or group of prefixes which connects to more than one service provider (i.e. more than one AS with its own routing policy). It does not mean a network multi-homed running an IGP for the purposes of resilience.

  An AS is required; the site's prefixes should be part of a

single AS, distinct from the ASes of its service providers. This allows the customer the ability to have a different representation of policy and preference among the different service providers.

This is ALMOST THE ONLY case where a network operator should create its own AS number. In this case, the site should ensure that it has the necessary facilities to run appropriate routing protocols, such as BGP4.

5.2 Other factors

* Topolgy

  Routing policy decisions such as geography, AUP (Acceptable Use Policy) compliance and network topology can influence decisions of AS creation. However, all too often these are done without consideration of whether or not an AS is needed in terms of adding additional information for routing policy decisions by the rest of the Internet. Careful consideration should be taken when basing AS creation on these type of criteria.

* Transition / ``future-proofing''

  Often a site will be connected to a single service provider but has plans to connect to another at some point in the future. This is not enough of a reason to create an AS before you really need it. The AS number space is finite and the limited amount of re-engineering needed when you connect to another service provider should be considered as a natural step in transition.

* History

  AS number application forms have historically made no reference to routing policy. All too often ASes have been created purely because it was seen as ``part of the process'' of connecting to the Internet. The document should act as reference to future application forms to show clearly when an AS is needed.

6. Speculation

1) If provider A and provider B have a large presence in a

geographical area (or other routing domain), and many customers are multi-homed between them, it makes sense for all of those customers to be placed within the same AS. However, it is noted that case should only be looked at if practical to do so and fully coordinated between customers and service providers involved.

2) Sites should not be forced to place themselves in a separate AS just so that someone else (externally) can make AS-based policy decisions. Nevertheless, it may occasionally be necessary to split up an AS or a prefix into two ASes for policy reasons. Those making external policy may request the network operators make such AS changes, but the final decision is up to those network operators who manage the prefixes in question, as well as the ASes containing them. This is, of course, a trade off -- it will not always be possible to implement all desired routing policies.

7. One prefix, one origin AS

Generally, a prefix can should belong to only one AS. This is a direct consequence of the fact that at each point in the Internet there can be exactly one routing policy for traffic destined to each prefix. In the case of an prefix which is used in neighbor peering between two ASes, a conscious decision should be made as to which AS this prefix actually resides in.

With the introduction of aggregation it should be noted that an AS can occasionally be represented as residing in more than one AS, however, this is very much the exception rather than the rule. This happens when aggregating using the AS_SET attribute in BGP, wherein the concept of origin is lost. In some cases the origin AS is lost altogether if there is a less specific aggregate announcement setting the ATOMIC_AGGREGATE attribute.

8. IGP Issues

As stated above, many router vendors require an identifier for tagging their IGP processes. However, this tag does not need to be globally unique. In practice this information is never seen by exterior routing protocols. If already running an exterior routing protocol, it is perfectly reasonable to use your AS number as an IGP tag; if you do not, choosing a random value is acceptable. Merely running an IGP is not grounds for registration of an AS number.

With the advent of BGP4 it becomes necessary to use an IGP that can carry classless routes. Examples include OSPF [OSPF] and ISIS [ISIS].

9. AS Space exhaustion

The AS number space is a finite amount of address space. It is currently defined as a 16 bit integer and hence limited to 65535 unique AS numbers. At the time of writing some 3,700 ASes have been allocated and a little under 400 ASes are actively routed in the global Internet. It is clear that this growth needs to be continually monitored. However, if the criteria applied above are adhered to, then there is no immediate danger of AS space exhaustion. It is expected that IDRP will be deployed before this becomes an issue. IDRP does not have a fixed limit on the size of an RDI.

10. Security Considerations

There are few security concerns regarding the selection of ASes.

AS number to owner mappings are public knowledge (in WHOIS), and attempting to change that would serve only to confuse those people attempting to route IP traffic on the Internet.

11. Acknowledgments

This document is largely based on [RIPE-109], and is intended to have a wider scope than purely the RIPE community; this document would not exist without [RIPE-109].

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