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

Status of this Memo

Abstract

   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 is expected to adopt when BGP becomes obsolete; see [IDRP]).
   It should be noted that the IDRP equivalent of an AS is the RDI, or
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1. Introduction

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   Protocol, now at historical status; see [EGP]), BGP (Border Gateway
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   [BGP-4]), and IDRP (The OSI Inter-Domain Routing Protocol, which the
   Internet is expected to adopt when BGP becomes obsolete; see [IDRP]).
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   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 one or more IP prefixes 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
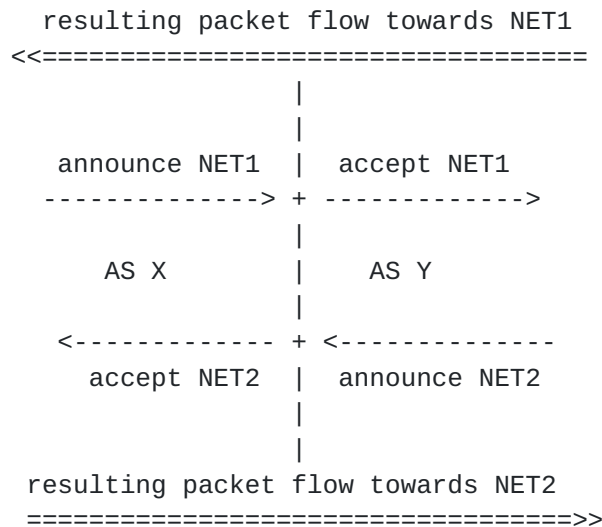   of two ASes, X and Y exchanging routing information:

                  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:

```
                        resulting packet flow towards NET1
                  <<=================================
                                  |
                                  |
                     announce NET1  |  accept NET1
                   --------------> + ------------->
                                  |
                       AS X       |      AS Y
                                  |
                     <------------ + <--------------
                       accept NET2  |  announce NET2
                                  |
                                  |
                   resulting packet flow towards NET2
                   =================================>>
```

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

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 and only when necessary. However,
assymetric routing may be a requirement for mobile hosts and
inherently asymmetric siutation, such a satelite download and a modem
upload connection.

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 longer prefixes, 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 cur-
        rent 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

     An 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 rout-
     ing policy as the other customers of the site's service
     provider, and there is no need to make any distinction in rout-
     ing information.

     This idea may at first seem slightly alien to some, but it high-
     lights 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 sepa-
     rate AS must be created for the affected prefixes. This situa-
     tion 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 repre-
     sentation 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

*   Topology

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 be used as a reference from
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 a prefix
may 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 from the private use range is also
acceptable (see "Reserved AS Numbers"). 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 5,100 ASes have been
allocated and a little under 600 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. Reserved AS Numbers

The Internet Assigned Numbers Authority (IANA) has reserved the
following block of AS numbers for private use (not to be advertised
on the global Internet):

                        64512 through 65535

11. 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.

12. 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].

13. References

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