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        Underlay Path Calculation Algorithm and Constraints for Bit Index
                     Explicit Replication (BIER)

Abstract

   This document specifies general rules for the interaction between the
   BIER Algorithm (BAR) and the IGP Algorithm (IPA) used for underlay
   path calculation within the Bit Index Explicit Replication (BIER)
   architecture. The semantics defined in this document update RFC 8401
   and RFC 8444. This document also updates the "BIER Algorithm"
   registry established in RFC 8401.

Table of Contents

1. Introduction

    In the Bit Index Explicit Replication (BIER) architecture [RFC8279],
    packets with a BIER encapsulation header are forwarded to the
    neighbors on the underlay paths towards Bit-Forwarding Egress Routers
    (BFERs) that are represented by bits set in the BIER header's
    BitString. The paths are calculated in the underlay topology for
    each sub-domain following a calculation algorithm specific to the
    sub-domain. The topology or algorithm may or may not be congruent
    with unicast. The algorithm could be a BIER-specific algorithm or
    could be a generic IGP one, e.g., Shortest Path First (SPF).

    In [RFC8401] and [RFC8444], an 8-bit BAR (BIER Algorithm) field and
    8-bit IPA (IGP Algorithm) field are defined to signal the BIER-
    specific algorithm and generic IGP Algorithm, respectively, and only
    value 0 is allowed for both fields in those two documents.

    This document specifies general rules for the interaction between the
    BIER Algorithm (BAR) and the IGP Algorithm (IPA) used for underlay
    path calculation when other BAR and/or IPA values are used. The
    semantics defined in this document update [RFC8401] and [RFC8444].
    This document also updates the "BIER Algorithm" registry defined in
    [RFC8401] by renaming the "Experimental Use" range to "Private or
    Experimental Use".

1.1. Requirements Language

    The key words "MUST", "MUST NOT", "REQUIRED", "SHALL", "SHALL NOT",
    "SHOULD", "SHOULD NOT", "RECOMMENDED", "NOT RECOMMENDED", "MAY", and
    "OPTIONAL" in this document are to be interpreted as described in
    BCP 14 [RFC2119] [RFC8174] when, and only when, they appear in all
    capitals, as shown here.

2. Updated Definitions for IPA and BAR Fields

    The definitions for the IPA and BAR fields in Section 6.1 of
    [RFC8401] and Section 2.1 of [RFC8444] are updated as follows.

    IPA: IGP Algorithm. Specifies a generic Routing Algorithm and
       related Routing Constraints to calculate underlay paths to reach
       other Bit-Forwarding Routers (BFRs). Values are from the "IGP
       Algorithm Types" registry. One octet.

    BAR: BIER Algorithm. Specifies a BIER-specific Algorithm and BIER-
       specific Constraints used to either modify, enhance, or replace
       the calculation of underlay paths to reach other BFRs as defined
       by the IPA value. Values are allocated from the "BIER Algorithm"
       registry. One octet.

       When a BAR value is defined, the corresponding BIER-specific
       Algorithm (BA) and BIER-specific Constraint (BC) semantics SHOULD
       be specified. For an IGP Algorithm to be used as a BIER IPA, its
       Routing Algorithm (RA) and Routing Constraint (RC) semantics
       SHOULD be specified. If any of these semantics is not specified,
       it MUST be interpreted as the "NULL" algorithm or constraint. For
       example, the IGP Algorithm 0 defined in [RFC8665] is treated as
       having a NULL RC, i.e., no constraints (see Section 3).

       If a specification is not available for a specific BAR value, its
       value MUST be from the Private or Experimental Use range of the
       registry.

3. General Rules for the BAR and IPA Interaction

    For a particular sub-domain, all BFRs MUST be provisioned with and
    signal the same BAR and IPA values. If a BFR discovers another BFR
    advertising a different BAR or IPA value for a sub-domain, it MUST
    treat the advertising router as incapable of supporting BIER for that

sub-domain. (One way of handling incapable routers is documented in
Section 6.9 of [RFC8279], and additional methods may be defined in
the future.)

For a particular topology X that a sub-domain is associated with, a
router MUST calculate the underlay paths according to its BAR and IPA
values in the following way:

1. Apply the BIER constraints, resulting in BC(X). If BC is NULL,
    then BC(X) is X itself.

2. Apply the routing constraints, resulting in RC(BC(X)). If RC is
    NULL, then RC(BC(X)) is BC(X).

3. Select the algorithm AG as follows:

    a. If BA is NULL, AG is set to RA.

    b. If BA is not NULL, AG is set to BA.

4. Run AG on RC(BC(X)).

It's possible that the resulting AG is not applicable to BIER. In
that case, no BIER paths will be calculated, and this is a network
design issue that an operator needs to avoid when choosing the BAR or
IPA.

3.1. When BAR Is Not Used

BAR value 0 is defined as "No BIER-specific algorithm is used"
[RFC8401]. This value indicates NULL BA and BC. Following the rules
defined above, the IPA value alone identifies the calculation
algorithm and constraints to be used for a particular sub-domain.

3.2. Exceptions or Extensions to the General Rules

Exceptions or extensions to the above general rules may be specified
in the future for specific BAR and/or IPA values. When that happens,
compatibility with defined BAR and/or IPA values and semantics need
to be specified.

4. Examples

As an example, one may define a new BAR with a BIER-specific
constraint of "excluding BIER-incapable routers". No BIER-specific
algorithm is specified, and the BIER-specific constraint can go with
any IPA, i.e., any RC defined by the IPA is augmented with "excluding
BIER-incapable routers". (Routers that do not support BIER are not
considered when applying the IGP Algorithm.)

If the BC and RC happen to conflict and lead to an empty topology,
then no BIER forwarding path will be found. For example, the BC
could be "exclude BIER-incapable routers", and the RC could be
"include green links only". If all the green links are associated
with BIER-incapable routers, it results in an empty topology. This
is a network design issue that an operator needs to avoid when
choosing the BAR or IPA.

In another example, a BAR value can be specified to use the Steiner
tree algorithm and used together with IPA 0 (which uses an SPF
algorithm). According to the general rules, the BIER-specific
algorithm takes precedence so SPF is not used.

5. IANA Considerations

The "BIER Algorithm" registry has been updated as follows:

1. The "Experimental Use" range has been renamed "Private or
    Experimental Use".

2. This document has been added as a reference both for the registry

itself and for values 240-254 in the registry.

6. Security Considerations

    This document specifies general rules for the interaction between the
    BIER Algorithm (BAR) and the IGP Algorithm (IPA) used for underlay
    path calculation. It does not change the security aspects as
    discussed in [RFC8279], [RFC8401], and [RFC8444].

7. Normative References

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