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SPF Back-off algorithm for link state IGPs
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Abstract

   This document defines a standard algorithm to back-off link-state IGP
   SPF computations.

   Having one standard algorithm improves interoperability by reducing
   the probability and/or duration of transient forwarding loops during
   the IGP convergence when the IGP reacts to multiple proximate IGP
   events.

Requirements Language

   The key words "MUST", "MUST NOT", "REQUIRED", "SHALL", "SHALL NOT",
   "SHOULD", "SHOULD NOT", "RECOMMENDED", "MAY", and "OPTIONAL" in this
   document are to be interpreted as described in [RFC2119].

Status of This Memo

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1. Introduction

   Link state IGPs, such as IS-IS [ISO10589-Second-Edition] and OSPF
   [RFC2328], perform distributed route computation on all routers of
   the area/level. In order to have consistent routing tables across
   the network, such distributed computation requires that all routers
   have the same version of the network topology (Link State DataBase
   (LSDB)) and perform their computation at the same time.

   In general, when the network is stable, there is a desire to compute
   the new SPF as soon as the failure is detected in order to quickly
   route around the failure. However, when the network is experiencing
   multiple proximate failures over a short period of time, there is a
   conflicting desire to limit the frequency of SPF computations.
   Indeed, this allows a reduction in control plane resources used by
   IGPs and all protocols/subsystem reacting on the attendant route

change, such as LDP, RSVP-TE, BGP, Fast ReRoute computations, FIB
updates... This will reduce the churn on routers and in the network
and, in particular, reduce the side effects such as micro-loops that
ensue during IGP convergence.

To allow for this, IGPs implement a SPF back-off algorithm.
Different implementations choose different algorithms. Hence, in a
multi-vendor network, it's not possible to ensure that all routers
trigger their SPF computation after the same delay. This situation
increases the average differential delay between routers completing
their SPF computation. It also increases the probability that
different routers compute their FIBs based on a different LSDB
versions. Both factors increase the probability and/or duration of
micro-loops.

To allow multi-vendor networks to have all routers delay their SPF
computations for the same duration, this document specifies a
standard algorithm. Optionally, implementations may offer
alternative algorithms.

[2](). **High level goals**

The high level goals of this algorithm are the following:

o Very fast convergence for a single event (e.g., link failure).

o Slightly paced fast convergence for multiple proximate IGP events
   while IGP stability is considered acceptable.

o Delayed convergence when the IGP stability is problematic. This
   will allow the IGP and related processes to conserve resources
   during the period of instability.

o Always try to avoid different SPF_DELAY timers values across
   different routers in the area/level. Even though not all routers
   will receive IGP messages at the same time (due to differences
   both in the distance from the originator of the IGP event and in
   flooding implementations).

[3](). **Definitions and parameters**

IGP events: An IGP LSDB change requiring a new routing table
computation. Examples are a topology change, a prefix change, a
metric change on link or prefix...

Routing table computation: computation of the routing table, by the
IGP, using the IGP LSDB. No distinction is made between the type of
computation performed. e.g., full SPF, incremental SPF, Partial Route

Computation (PRC). The type of computation is a local consideration.
This document may indifferently use the terms routing table
computation or SPF computation.

The SPF_DELAY is the delay introduced between the IGP event and the
start of the routing table computation. It can take the following
values:

 INITIAL_WAIT: a very small delay to quickly handle link failure,
 e.g., 0 milliseconds.

 FAST_WAIT: a small delay to have a fast convergence in case of
 single component failure (node, SRLG..), e.g., 50-100 milliseconds.
 Note: we want to be fast, but as this failure results in multiple
 IGP events, being too fast increases the probability to receive
 additional network events immediately after the SPF computation.

 LONG_WAIT: a long delay when the IGP is unstable, e.g., 2 seconds.
 Note: Allow the IGP network to stabilize.

The TIME_TO_LEARN timer is the maximum duration typically needed to
learn all the IGP events related to a single component failure (e.g.,
router failure, SRLG failure), e.g., 1 second. It's mostly dependent
on variation of failure detection times between all routers that are
adjacent to the failure. Additionally, it may depend on the
different flooding implementations for routers in the network.

The HOLD_DOWN timer is the time needed with no received IGP events
before considering the IGP to be stable again, allowing the SPF_DELAY
to be restored to INITIAL_WAIT. e.g., 3 seconds.

[4](#). Principles of SPF delay algorithm

For this first IGP event, we assume that there has been a single
simple change in the network which can be taken into account using a
single routing computation (e.g., link failure, prefix (metric)
change) and we optimize for very fast convergence, delaying the
routing computation by INITIAL_WAIT. Under this assumption, there is
no benefit in delaying the routing computation. In a typical
network, this is the most common type of IGP event. Hence, it makes
sense to optimize this case.

If subsequent IGP events are received in a short period of time
(TIME_TO_LEARN), we then assume that a single component failed, but
that this failure requires the knowledge of multiple IGP events in
order for the IGP routing to converge. Under this assumption, we
want fast convergence since this is a normal network situation.
However, there is a benefit in waiting for all IGP events related to

this single component failure so that the IGP can compute the post-
failure routing table in a single route computation. In this
situation, we delay the routing computation by FAST_WAIT.

If IGP events are still received after TIME_TO_LEARN seconds from the
initial IGP event, then the network is presumably experiencing
multiple independent failures and while waiting for network
stability, the computations are delayed for a longer time represented
by LONG_WAIT. This SPF_delay is kept until no IGP events are
received for HOLD_DOWN seconds.

Note: previous SPF delay algorithms used to count the number of SPF
computations. However, as all routers may receive the IGP events at
different times, we cannot assume that all routers will perform the
same number of SPF computations or that they will schedule them at
the same time. For example, assuming that the SPF delay is 50 ms,
router R1 may receive 3 IGP events (E1, E2, E3) in those 50 ms and
hence will perform a single routing computation. While another
router R2 may only receive 2 events (E1, E2) in those 50 ms and hence
will schedule another routing computation when receiving E3. That's
why this document defines a time (TIME_TO_LEARN) from the initial
event detection/reception as opposed to defining the number of SPF
computations to determine when the IGP is unstable.

[5](#). Specification of the SPF delay algorithm

When no IGP events have occurred during the HOLD_DOWN interval:

o The IGP is set to the QUIET state.

When the IGP is in the QUIET state and an IGP event is received:

o The time of this first IGP event is stored in FIRST_EVENT_TIME.

o The next routing table computation is scheduled at: this IGP event
   received time + INITIAL_WAIT.

o The IGP is set to the FAST_WAIT state.

When the IGP is in the FAST_WAIT state and an IGP event is received:

o If more than the TIME_TO_LEARN interval has passed since
   FIRST_EVENT_TIME, then the IGP is set to the HOLD_DOWN state.

o If a routing table computation is not already scheduled, one is
   scheduled at: this IGP event received time + FAST_WAIT.

When the IGP is in the HOLD_DOWN state and an IGP event is received:

   o If a routing table computation is not already scheduled, one is
      scheduled at: this IGP event received time + LONG_WAIT.

6. Parameters

   All the parameters MUST be configurable. All the delays
   (INITIAL_WAIT, FAST_WAIT, LONG_WAIT, TIME_TO_LEARN, HOLD_DOWN) SHOULD
   be configurable at the millisecond granularity. They MUST be
   configurable at least at the tenth of second granularity. The
   configurable range for all the parameters SHOULD be at least from 0
   milliseconds to 60 seconds.

   This document does not propose default values for the parameters
   because these values are expected to be context dependent.
   Implementations are free to propose their own default values.

   When setting the (default) values, one SHOULD consider the customer's
   or their applications' requirements, the computational power of the
   routers, the size of the network, and, in particular, the number of
   IP prefixes advertised in the IGP, the frequency and number of IGP
   events, the number of protocols reactions/computations triggered by
   IGP SPF (e.g., BGP, PCEP, Traffic Engineering CSPF, Fast ReRoute
   computations).

   Note that some or all of these factors may change over the life of
   the network. In case of doubt, it's RECOMMENDED to play it safe and
   start with safe, i.e., longer timers.

   For the standard algorithm to be effective in mitigating micro-loops,
   it is RECOMMENDED that all routers in the IGP domain, or at least all
   the routers in the same area/level, have exactly the same configured
   values.

7. Impact on micro-loops

   Micro-loops during IGP convergence are due to a non-synchronized or
   non-ordered update of the forwarding information tables (FIB)
   [RFC5715] [RFC6976] [I-D.ietf-rtgwg-spf-uloop-pb-statement]. FIBs
   are installed after multiple steps such as SPF wait time, SPF
   computation, FIB distribution, and FIB update. This document only
   addresses the first contribution. This standardized procedure
   reduces the probability and/or duration of micro-loops when the IGP
   experience multiple proximate events. It does not prevent all micro-
   loops. However, it is beneficial and its cost seems limited compared
   to full solutions such as [RFC5715] or [RFC6976].

8. IANA Considerations

   No IANA actions required.

9. Security considerations

   This algorithm presented in this document does not in any way
   compromise the security of the IGP. In fact, the HOLD_DOWN state may
   mitigate the effects of Denial-of-Service (DOS) attacks generating
   many IGP events.

10. Acknowledgements

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   Shand for the discussions and comments related to this document.

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11.1. Normative References

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