

Implementation of a BGP Route Flap Damping Algorithm for the Bird Routing Project

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Abstract—Today’s Internet stability strongly relies on the good behaviour of dynamic routing protocols such as BGP (Border Gateway Protocol), which enables routing between Autonomous Systems. Route flapping is a well-known and undesirable phenomenon occurring in both commercial and private networks. In this report, we explain our implementation of the RFC 2439, BGP Route Flap Damping, for one famous Open Source routing software suite, the Bird Routing Project.

We also present results of an experiment where we compared the number of BGP updates sent with and without route damping enabled, in a simplified setup where only one of the bgp router was receiving advertisements for flapping routes.

I. INTRODUCTION

The inter-domain routing protocol BGP is still surviving to the gigantic growth of the Internet that started during the last decade. However, some widely used applications, such as Skype, still suffer from weaknesses in that protocol. The main problems are twofolds: firstly, BGP has a slow convergence rate, meaning that a change at one location can take long before it is propagated to the other ends of the network. Secondly, if a node becomes unstable, for example if its connectivity constantly comes up and down, it will have bad consequences on the network, both in terms of useless processing at BGP routers and unnecessary routing traffic. Routes advertised and withdrawn at regular interval of time are said to be *flapping*.

Many approaches to counter route flapping have been developed in the late 90’s. RFC 2439[1] standardized one such approach : it basically blocks updates from flapping routes, and does so until the routes are deemed stable again. This RFC has been used extensively for many years, in both commercial and open source routers.

Although this standard is not recommended anymore[2] in today’s routers, we wanted to implement it for the Bird Routing Project[3], hoping that it will serve as a good basis for future possible improvements and extensions to this RFC. There exist many variants of the Route Flap Damping algorithm and the community has not lost its interest in finding robust mechanisms that could allow BGP to be more resilient.

II. OVERVIEW

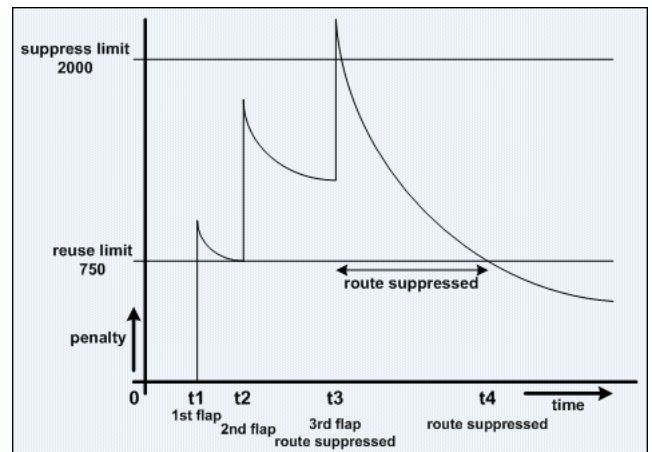
RFC 2349 seeks to limit the impact of route flapping by “damping” (*i.e.* ignoring packets of) misbehaving routes. The solution must be able to distinguish flapping routes from good routes and consume few resources, both in terms of memory usage and process time. The RFC solves these problems by assigning each route a penalty term. Whenever this penalty

term for a given route reaches a certain threshold, further advertisements for that route are ignored. This penalty term varies over time : it is increased when the route becomes unreachable and decays as long as the route stays stable. As soon as the figure of merit goes below a *reuse threshold*, the route can be used again.

The figure of merits decays exponentially over time. Exponential decay has several advantages : it can be implemented very efficiently using precomputed *decay arrays*. Also, with exponential decay, the figure of merit keeps trace of previous instabilities for a fairly long time : old instabilities become less and less important over time, while newer ones have more weight.

Network administrators have lots of freedom in choosing the behavior of the penalty term : they can control the half-life of the penalty term, its maximum value (thus controlling the maximum time a route can be suppressed) and both the reuse and cut thresholds.

Here is an example showing how the figure of merit evolves over time (the illustration comes from [5]). The route flaps three times, exceeding the cut threshold only after the third flap. The route is reused as soon as its penalty term goes below the reuse limit.



Penalty terms are re-computed at regular time intervals using timers. Also, every time an update for a route is received, the penalty term for that route is re-computed.

The RFC proposes several optimizations to decrease processing time, at the cost of a slightly bigger memory footprint. *E.g.* *reuse lists* are used to not have to recompute the figure of merit of all routes : damped routes with similar penalty terms are grouped together in a same reuse list. Penalty terms of the routes in a given reuse list are then re-computed only when necessary.

III. IMPLEMENTATION

Our implementation contains most of the data structure definitions and functions needed for the route damping algorithm (RFC 2439). As the RFC leaves little freedom regarding the implementation and the design of the data structures, our implementation closely matches the RFC. The code, along with the list of commits, is publicly available on <https://github.com/alexchap/Albatros-Project>.

Several parts of BIRD had to be modified for the implementation of route damping. The configuration file parser had to be modified in order to correctly handle the parameters required by the RFC. Also, we had to make similar modifications to the command line parser so that suppressed routes could be listed. Last but not least, we had to add hooks to BIRD's BGP implementation : whenever a route is added or withdrawn, our code is executed. Route damping is enabled at configure time by adding the `--enable-route-damping` switch.

A. Data structures

The data structures used by the implementation are very close to those described in the RFC (§4.4, *Run Time Data Structures*). The most important of which are certainly `damping_config` and `damping_info`. Their definitions can be found in `damping.h`.

`damping_config` groups all configurations parameters for a BGP peer. This allows network administrators to have different sets of parameters for different routes. *I.e.* `damping_configs` have a one-to-one relation to BIRD's `bgp_proto`. This structure contains all the parameters controlling the behaviour of the damping algorithm : `reuse_threshold`, `cut_threshold`, `ceiling`, `tmax_hold` and `half_time`. Additionally, it contains some informations used to speedup the algorithm (at the cost of a more important memory consumption) : both the decay arrays and the reuse lists are contained here. The former speeds up the computation of new figure of merits by pre-computing a predefined set of (costly) exponentials and using them when figures of merit needs to be updated. The latter limitates the time of computation at every timer tick by grouping damped routes according to their penalty term. Instead of being updated at every tick, a group of routes is updated once every n ticks, where n is the number of reuse lists. Reuse lists are implemented using `slists`, a doubly linked list implementation provided by BIRD.

BIRD's timer are used to regularly update the penalty terms of routes : every `bgp_proto` structure contains a `reuse_list_timer`. These timers are set up to call `damping_reuse_timer_handler` at every tick. This function is responsible for updating the penalty terms of damped routes and re-inserting damped routes into the routing table if their penalty term is low enough.

The core of the damping algorithm lies with the `damping_info` structure. The penalty term is stored in that structure, along with a timestamp indicating when the last update of the penalty term was. Other informations, such as the IP prefix of the route, reuse list pointers and route attributes (BIRD specific) are also included in `damping_info`. One

such structure is allocated once a route starts to flap, and is de-allocated whenever the penalty term becomes "small enough". There is a one-to-one mapping between routes (`rte` in BIRD) and `damping_info`. This mapping was made possible by FIBs, an hash table implementation provided by BIRD's API. FIBs basically map IP prefixes to any other data structure, `damping_infos` in our case.

Last but not least, the fact that BIRD uses only one thread made our job much simpler as we didn't have to worry about concurrency.

B. Configuration parameters

Our extended version of BIRD gives network administrators a set of four parameters to control the behaviour of route damping. In particular, `cut_threshold`, `reuse_threshold`, `tmax_hold` and `half_time` are all modifiable from the configuration file. Both `tmax_hold` and `half_time` are expressed in seconds. Here is an example of configuration :

```
protocol bgp bgp_config {
    description "BGP daemon";
    debug all;

    # Specific config for BGP
    local as 65011;
    source address 10.10.10.11;
    multihop;
    next hop self;
    path metric 1;

    # Route damping configuration
    route damping;
    cut_threshold 2500;
    reuse_threshold 1000;
    tmax_hold 3000;
    half_time 900;
}
```

The route damping parameters can be used to enable/disable route damping for a particular neighbour. All the other parameters used by the RFC (*e.g.* decay arrays, scaling factor, ...) are derived from those four values.

BIRD uses Bison to parse the configuration files and we had to extend it to support the new set of keywords. Those parameters are passed to the `damping_config_new` function, which allocates and initializes a new `damping_config` and computes the other parameters.

C. Detecting BGP Flapping

Our implementation sticks to the RFC regarding route flapping detection. Hooks were added in the BGP module of BIRD for that purpose. Those hooks ensure that the `damping_add_route` and `damping_remove_route` functions get called as routes are advertised/withdrawn respectively.

As those functions are similar to their equivalent in the RFC, only the relevant implementation details are covered here. Please refer to the RFC for additional details.

Figure 1. Topology used for our simulation

Figure 2. Evolution of dampened paths for Simulation 3

When a route is removed for the first time, a new `damping_info` is allocated in a `damping_info_fib`, and its penalty term is set to a default value. The penalty term of this route is updated as the route is re-advertised and removed again. The penalty term is represented by a scaled integer, so that only the right level of precision is kept during execution. The main idea is that floating point operations are used when the figure of merit needs to be updated, but the result is stored as an integer (thus saving memory space). This usually results in an accidental loss of precision, except that in our case, the decrease in precision is controlled so as not to crash the application. Penalty terms are all implicitly multiplied by 1000, implying that only three digits after the dot are kept.

`damping_info` are de-allocated when the penalty gets smaller than `reuse_threshold` divided by two. The rationale being that when the penalty term gets much smaller than the `reuse_threshold` index, keeping the `damping_info` structure with a small figure of merit is equivalent to de-allocating it (in the worst —very unlikely— case, it will only add the cost of re-allocating a new `damping_info` structure).

IV. EVALUATION

A. Overview

We used a topology of 27 routers in the NSL cluster in order to evaluate our implementation. This topology consists of 10 Autonomous systems. Router number 3 with network prefix 10.0.0.3/24 was the one that fed the whole network 10.0.0.0/24 with updates coming from one MRT dump archive (updates.20100401.1729), that we got from the Route Views project[6]. This archive corresponds to 15 minutes of real BGP traffic that were sent by 11 BGP routers. The topology used is represented in figure x.

We ran 3 simulations and recorded every 10 seconds the total number of updates and withdrawals received from all neighbors for all routers. When route damping was enabled, we also recorded the number of route dampened at any given time.

- 1) The first simulation was made without route damping and with the official bird daemon....
- 2) The second was made with our bird implementation and default damping parameters....
- 3) The third was the same as the second, except for the `cut_threshold` parameters that was set to 1000 instead of 1500....

B. Evolution of dampened paths

it represent time vs. the actual number of dampened routes in AS2 (actually, router 3)

also note that we aggregated results for each AS (for better readability)

Figure 3. Difference of import updates between simulations 1 and 3

C. Number of route updates

it's the difference between graph sim1 and graph sim3 -> i.e we have less updates in SIM3 ! :-)

maybe we can also display one graph with the evolution -> show that the number is quite huge !! and that's why we show the difference rather than the two graph on top of each other !

D. Number of withdrawals

works for sim3, not for sim2 !

V. CONCLUSION

show importance of stability

VI. FUTURE WORK

possible extensions
real scale tests

VII. ACKNOWLEDGEMENT

REFERENCES

- [1] The RFC 2439, BGP Route Flap Damping, <http://www.ietf.org/rfc/rfc2439.txt>
- [2] RIPE Recommendations On Route-flap Damping, <http://www.ripe.net/ripe/docs/ripe-378>
- [3] Bird Routing Project, <http://bird.network.cz>
- [4] Our publicly available repository, <https://github.com/alexchap/Albatros-Project>
- [5] itcertnotes, <http://www.itcertnotes.com>
- [6] <http://routeviews.org>