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Considerations for Benchmarking Link-State IGP Data Plane Route Convergence

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ABSTRACT

This document discusses considerations for benchmarking Interior Gateway Protocol (IGP) Route Convergence for any link-state IGP, such as Intermediate System-Intermediate System (ISIS) and Open-Shorted Path first (OSPF). A companion methodology document is to be used for benchmarking IGP convergence time through externally observable (black box) data plane measurements. A companion terminology document is to be referenced to support the benchmarking.

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1. Introduction

Convergence Time is a critical performance parameter. Customers of Service Providers use convergence packet loss [Po07t] due to Interior Gateway Protocol (IGP) convergence as a key metric of their network service quality. Service Providers use IGP Convergence time as a key metric of router design and architecture for any IGP such as Intermediate System - Intermediate System (ISIS) [Ca90] and Open-Shorted Path first (OSPF) [Mo98]. Fast network convergence can be optimally achieved through deployment of fast converging routers. The fundamental basis by which network users and operators benchmark convergence is packet loss, which is an externally observable event having direct impact on their application performance.

IGP Route Convergence is a Direct Measure of Quality (DMOQ) when benchmarking the data plane. For this reason it is important to develop a standard router benchmarking methodology and terminology for measuring IGP convergence that uses the data plane as described in [Po07m] and [Po07t]. This document describes all of the factors that influence a convergence measurement and how a purely black box test can be designed to account for all of these factors. This enables accurate benchmarking and evaluation for route convergence time.

2. Existing definitions

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 BCP 14, RFC 2119 [Br97]. RFC 2119 defines the use of these key words to help make the intent of standards track documents as clear as possible. While this document uses these keywords, this document is not a standards track document.

3. Factors for IGP Route Convergence Time

There are four major categories of factors contributing to the measured Router IGP Convergence Time. As discussed in [Vi02],

[Ka02], [Fi02], [Al02] and [Al00], these categories are Event Detection, Shortest Path First (SPF) Processing, IGP Advertisement, and Forwarding Information Base (FIB) Update. These have numerous components that influence the convergence time, as listed below:

-Event Detection-
Physical Layer failure/recovery indication time
Layer 2 failure/recovery indication time
IGP Hello Dead Interval

-SPF Processing-
SPF Delay Time
SPF Hold time
SPF Execution time

-IGP Advertisement-
LSA/LSP Flood Packet Pacing
LSA/LSP Retransmission Packet Pacing
LSA/LSP Generation time

-FIB Update-
Tree Build time
Hardware Update time

-Increased Forwarding Delay due to Queueing

The contribution of each of these factors listed above will vary with each router vendors' architecture and IGP implementation. Routers may have a centralized forwarding architecture, in which one route table is calculated and referenced for all arriving packets, or a distributed forwarding architecture, in which the central route table is calculated and distributed to the interfaces for local look-up as packets arrive. The distributed route tables are typically maintained in hardware.

It is therefore necessary to design a convergence test that considers all of these components contributing to convergence time and is independent of the Device Under Test (DUT) architecture, The benefit of designing a test for these considerations is that it enables black-box testing in which knowledge of the routers' internal implementations is not required. It is then possible to make valid use of the convergence benchmarking metrics when comparing routers from different vendors.

4. Network Events that Cause Convergence

There are different types of network events that can cause IGP convergence. These network events are as follow:

* administrative link removal
* unplanned link failure
* line card failure
* route changes such as withdrawal, flap, next-hop change, and cost change.
* session loss due to loss of peer or adjacency

* link recovery
* link insertion

When benchmarking a router it is important to measure convergence time for local and remote occurrence of these network events. The convergence time measured will vary whether the network event occurred locally or remotely due to varying combinations of factors listed in the previous sections. This behavior makes it possible to design purely black-box tests that isolate measurements for each of the components of convergence time.

5. Use of Data Plane for IGP Route Convergence Benchmarking

Customers of service providers use packet loss as the metric to calculate convergence time. Packet loss is an externally observable event having direct impact on customers' application performance. For this reason it is important to develop a standard router benchmarking methodology and terminology that is a Direct Measure of Quality (DMOQ) for measuring IGP convergence. Such a methodology uses the data plane as described in [Po07m] using the terminology provided in [Po07t].

An additional benefit of using packet loss for calculation of IGP Route Convergence time is that it enables black-box tests to be designed. Data traffic can be offered to the device under test (DUT), an emulated network event can be forced to occur, and packet loss can be externally measured to calculate the convergence time. Knowledge of the DUT architecture and IGP implementation is not required. There is no need to rely on the DUT to produce the test results. There is no need to build intrusive test harnesses for the DUT.

Use of data traffic and measurement of packet loss on the data plane also enables Route Convergence methodology test cases that consider the time for the Route Controller to update the FIB on the forwarding engine of the hardware. A router is not fully converged until all components are updated and traffic is rerouted to the correct egress interface. As long as there is packet loss, routes have not converged. It is possible to send diverse traffic flows to destinations matching every route in the FIB so that the time it takes for the router to converge an entire route table can be benchmarked.

6. IANA Considerations

This document requires no IANA considerations.

7. Security Considerations

Documents of this type do not directly effect the security of the Internet or of corporate networks as long as benchmarking is not performed on devices or systems connected to production networks.

8. Acknowledgements

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9. References

9.1 Normative References

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