Loggregator Operator Handbook

A guide for operators to scale and manage logging for Cloud Foundry

Introduction

This document provides a guide for operators to plan and measure specific service reliability indicators related to aggregated logging across the Cloud Foundry platform. The guide provides an overview of where loss occurs by analyzing the results of a series of controlled tests performed with specific assumptions. As much as possible, these assumptions are designed to be specific but realistic to typical deployments observed by the Loggregator team.

The guide assumes operators are familiar with BOSH and Cloud Foundry. It is also helpful to be familiar with the language and concepts defined in Google's Site Reliability Engineering book.

Service Level Indicators Overview

Based on ongoing operation of the Loggregator system, feedback from operators and the open source community, the Loggregator team has monitoring for all of the following Service Level Indicators.

Uptime

Ensuring the system is ready to receive messages serves as a foundational requirement of the system. Log message and/or metric delivery reliability cannot exceed the time for which the platform is up and ready to send logs. Unless explicitly noted in release notes, the Loggregator system is designed to remain highly available during a deployment upgrade or other individual service stop. A critical function of uptime for Loggregator is service discovery, which can sometimes operate in a degraded state. Using Loggregator to monitor its own uptime is problematic, so this is actually managed by the BOSH System Metrics component.

Log Message Reliability

Given the system is up and running, the reliability of message delivery is a critical tool for monitoring the health of your Loggregator deployment. High rates of message loss can indicate improperly scaled components, over-crowded Diego Cells, or noisy applications or services that are deployed on your platform. That said, understanding message reliability is a challenging proposition. We'll cover several black-box and white-box tools for monitoring loss as this is the primary SLI for the Loggregator system.

Latency

Loggregator is designed to be a low-latency system with streaming interfaces. However, there are a couple of request-response endpoints that should be monitored for latency as they can cause other failures for the user.

Capacity Planning

As a starting point, it is helpful to use a few heuristic formulas for estimating the scale of the Loggregator components. These formulas are good benchmarks, but you may find that your platform behaves differently as it grows.

Due to encryption and batching of messages, it can be difficult to predict how small differences may affect your platform. However, in our experience, the following best practices provide helpful tools for setting and monitoring Loggregator components.

Doppler Planning

Dopplers are most directly affected by the overall log and metric volume of the platform. The following formula is recommended for determining your number of Dopplers to achieve a loss rate of <1%.

```
Num Dopplers = Logs Per Second / 2,000
```

Our tests measured loss rates of <1% for up to 16,000 envelopes per second. It is difficult to understand the ratio of metrics to logs when you consider the system batches delivery. Therefore, we also recommend monitoring and scaling based on Doppler ingress traffic (see the Scaling Dopplers Based on Ingress *section below).*

Traffic Controller & Nozzle Planning

The number of Traffic Controllers can require scaling with the number of log streams and the Firehose subscriptions but usually is scaled in line with your Dopplers. Therefore, unless you have a special circumstance (e.g., a larger number of Firehose subscriptions), the following formula is recommended for planning for Traffic Controllers.

```
Num Traffic Controllers = Num of Dopplers / 4
```

Each nozzle deployed should be scaled to match the number of Traffic Controller instances.

```
Num Traffic Nozzles = Num of Traffic Controllers
```

Syslog Adapters Planning and Scaling

User-provided syslog drains are managed by an independently scalable component called a Syslog Adapter. This component should be scaled depending on the number of your drain bindings. A drain binding is defined as a syslog destination associated with an application. An application can have multiple bindings, which should be accounted for in your scaling computations. In addition, this count is emitted as the `scheduler.drains` metric and the

number of adapters as the `scheduler.adapters` metric for configuring auto-scaling of these components.

```
Num of Syslog Adapters = Num Drain Bindings / 500
```

Scaling Dopplers Based on Ingress

Monitoring for Doppler ingress requires you to sum two metrics and rate them per second. We recommend planning for max values over a two-week period and following the guidelines for scaling Dopplers.

```
Num Dopplers =  doppler.ingress +
DopplerServer.listeners.receivedEnvelopes / 10,000
```

Black-Box Monitoring Suggestions

Because Loggregator provides an interface for app developers, writing and configuring black-box monitoring tools is easy using the Cloud Foundry CLI. This section conceptually describes black-box tests for monitoring your Loggregator deployment.

Log Stream Message Reliability Tests

Black-box monitoring is one of the best ways to determine message reliability of your Loggregator deployment. It is done by measuring message reliability through the log stream used when running `cf logs`. This reliability test provides a contract with development teams as to how often they can expect to receive intended logs. It also serves as a correlated measurement for Firehose reliability that does not require deploying or scaling nozzles.

To execute a test of message reliability, start by creating an application that produces a known number of logs. (There is one available in the Tooling and Troubleshooting section of this document.) Next, deploy that application to Cloud Foundry. Finally, tail the logs on the application and pipe the results into a file. Do a word count on the file, and you will have a single sampling of message reliability.

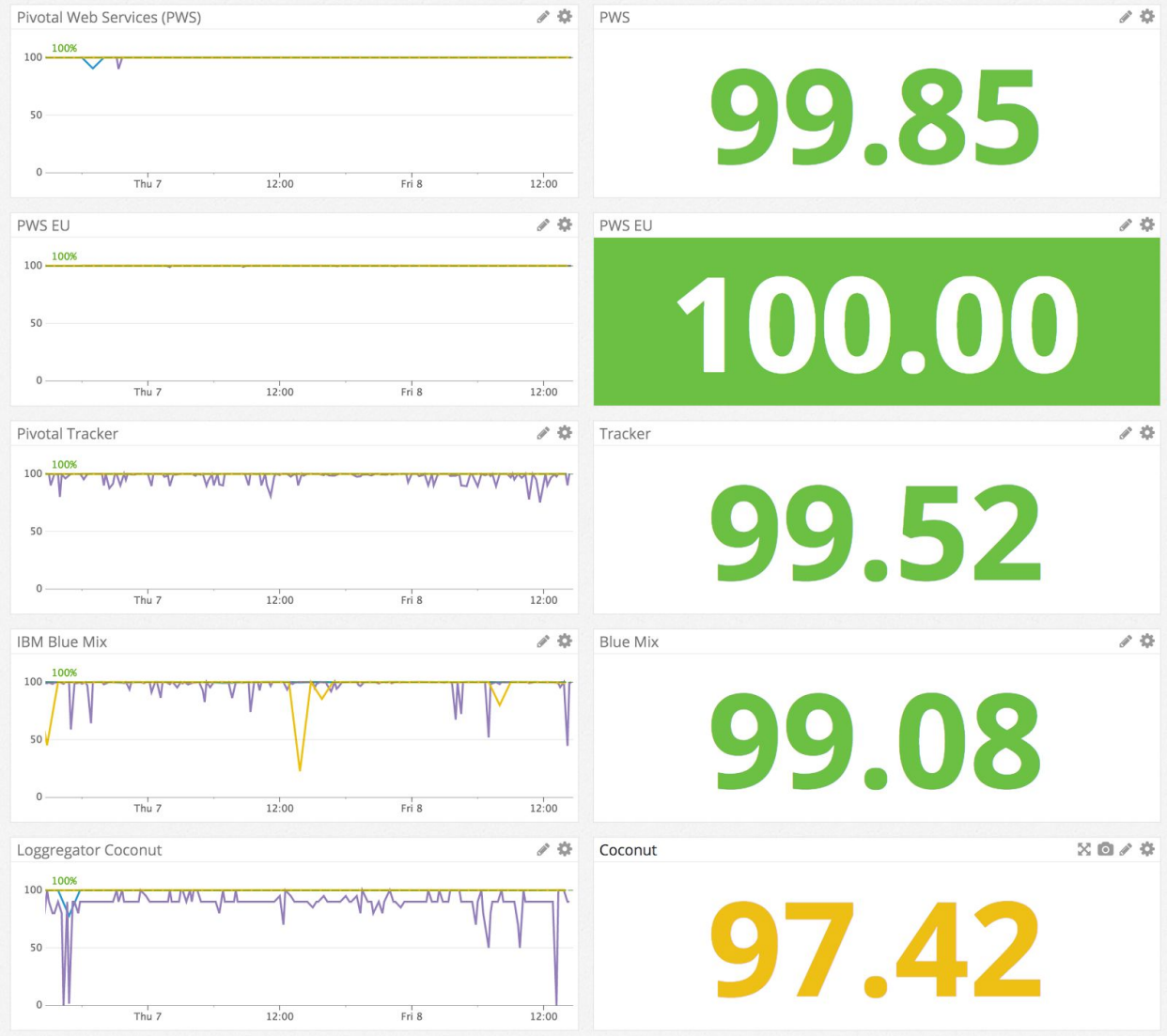
Below is a simple set of commands for doing this using the `logspinner` application described in Tooling and Troubleshooting.

```
cd /loggregator/src/tools/logspinner
cf push logspinner
cf logs logspinner > ./tmp.txt
curl 'logspinner.coconut.cf-app.com?cycles=100&delay=10ms'
grep -wc ./tmp.txt
```

To get an accurate sampling, we recommend running this test repeatedly at multiple log rates representative of your system.

To better package this test, we have included an application called cf-logmon that runs these tests and emits metrics through the Firehose.

To establish a Service Level Indicator, we measure logs at three rates: a drip of logs at 2 logs per second, a flood of logs at 2-4 M logs per second (as fast as we can send them), and a steady stream of logs at 1000/sec. We send the results of these tests directly to a monitoring system and use a weighted average of 70% drip, 20% stream, and 10% flood. We have found that size of logs does not affect performance in an expected manner, and we test with a consistent but small log message for our tests.



Dashboard of message reliability and weighted average across multiple deployments.

Firehose Message Reliability Tests

Measuring message loss through the Firehose is more challenging than through the log stream, but it can be done by creating a nozzle. This nozzle needs to look for and count a known number of logs being produced similar to the log stream test. It is important that you scale the nozzle appropriately for the test. Generally, we see a correlation of log stream message reliability to Firehose message reliability. However, Firehose message reliability is consistently lower for application logs. For higher message reliability rates, we recommend using syslog drains or log streams.

Syslog Drain Message Reliability Tests

Syslog drains use a separate set of components and should be measured at the receiving end of the drain, separately from the log stream. To perform this type of black-box testing, you will need to create a syslog drain that receives logs on both the HTTP and syslog protocols. The latter protocol may require routing configuration for your deployment. There is a syslog server application referenced in the Tooling and Troubleshooting section.

The premise for the test is otherwise the same as for the log stream message reliability measurements. Multiple samplings measured over time are used to determine a reliability metric. One important note: this test measures best-case reliability. The application used for the test does not need to write logs to persistent storage, so it likely outperforms most real-world syslog servers. Your real-world message reliability rate will be dependant on the performance of the syslog server it connects to.

Recent Logs Latency Test

The process of returning logs for the `cf logs --recent` request involves collecting logs from all the Dopplers in a deployment and reassembling the results. As your deployment grows and you add more Dopplers, the response time for this call will increase. The latency can be measured with a simple `time` command.

```
time cf logs --recent
```

Historically, the Loggregator team has monitored the upper 95th percentile of latency although the most recent version of Loggregator have added a circuit breaker to return all available logs within 1500 ms.

Container Metrics Latency Test

Container metrics are collected in a similar fashion to recent logs, and they are used during the `cf push` command. This makes container metrics latency a critical indicator for development teams. If the call is slow, developers may experience slowness when pushing their apps. This also now includes a circuit breaker timeout, so monitoring latency of the indicator specifically is not needed. It would be better to monitor latency of the full `cf push` command.

Other Black-Box Monitors

There are other black-box monitoring tests that can be performed, but they are generally less interesting to operators. Some other monitors we have developed but rarely utilize are:

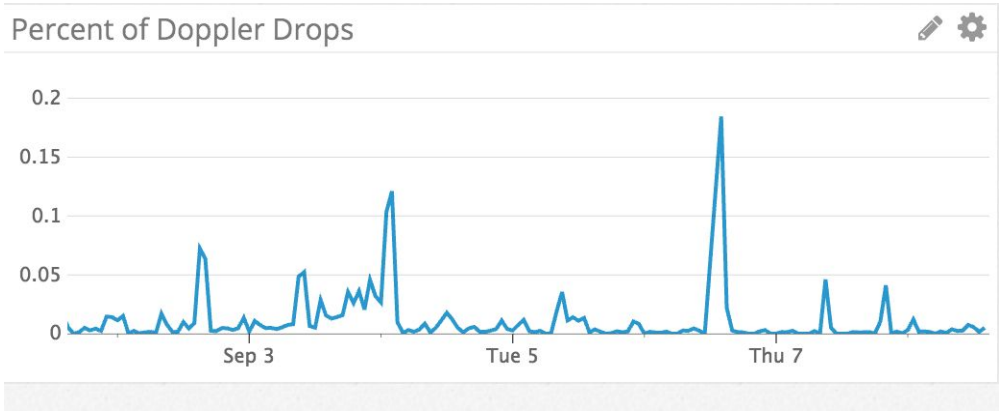
- Firehose message reliability nozzle (this is covered in the capacity planning test)
- Firehose latency

White-Box Monitoring Suggestions

In addition to providing black-box monitoring tooling that works across various versions of the Loggregator system, there has been considerable effort made to standardize and improve the experience of white-box monitoring for operators. All white-box monitoring suggestions are based on monitoring metrics emitted through the Firehose.

Monitoring Drops

Monitoring drops for each component is an important consideration for operators. This metric shows the number of dropped “envelopes” that could contain either a metric or a log. This helps inform where the platform is constrained and where to add more resources in the form of horizontal scaling. It is also worth noting that drops as an individual metric are not of much value; we recommend monitoring percentage of drops based on the total ingress into the component. This should be monitored for Metron Agents, Dopplers, Reverse Log Proxies, and Adapters.



Example Datadog JSON:

```
{
 "viz": "timeseries",
 "requests": [
   {
     "q": "( per_second(sum:datadog.nozzle.loggregator.doppler.dropped{*}) /
per_second(sum:datadog.nozzle.loggregator.doppler.ingress{*}) ) * 100",
     "conditional_formats": [],
     "type": "line",
     "aggregator": "avg"
   }
 ],
 "autoscale": true,
 "status": "done"
}
```

This behavior tends to be spiky in nature. However, in combination with black-box tests, these are helpful tools for monitoring and alerting.

IaaS Metrics

Monitoring IaaS metrics is a standard practice for most operators and can be an effective predictive indicator for Loggregator as well. As a general rule, most components are bound by CPU constraints, and it can be helpful to compare network traffic across instances to better understand load balancing efficiency. Additionally, Traffic Controller in particular can be CPU bound as your deployment and team scale in ways these guidelines do not anticipate well.

Defining and Monitoring Service Level Objectives

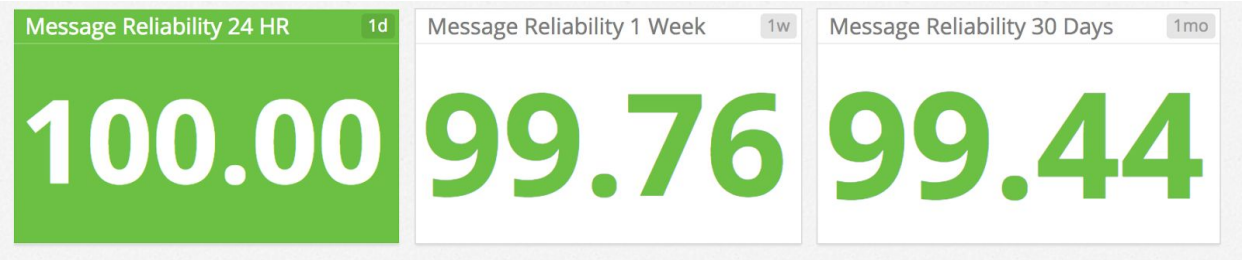
Defining Service Level Objectives (SLOs) for Loggregator can be a nuanced and challenging problem for operators to take on when first working with Cloud Foundry. While this document describes several ways for monitoring Loggregator, focusing on message reliability should be the main concern for most operators (since monitoring message reliability also serves as a valuable proxy for uptime). The Pivotal Web Services (PWS) SRE Team uses a black-box monitor described above for monitoring the single SLO for Loggregator over a 24-hour, 1-week, and 1-month duration.

Message Reliability

It can be challenging to balance the expected loss rates of logs under peak load conditions with the overall needs during low volume periods. While logs are essential for debugging and monitoring, the impact of loss for these functions is hard to quantify. That said, a percentile-based approach is a model for thinking about message reliability. Below is an example of log rate distributions for a hypothetical deployment.

Percentile	Logs Per Second Rate	Num of Dopplers for <1% Loss
95	50,000	25
90	**40,000**	**20**
85	32,000	16
80	25,600	13
75	20,480	10

While it can be tempting to plan for less than 1% at your 95th percentile of traffic, it is twice the infrastructure cost to do so than planning for the 80th percentile of traffic. Without considering autoscaling capabilities, we currently base our scaling around the 90th percentile of traffic at a 1% loss rate for the log stream. We use a black-box monitor described below for monitoring the SLO over a 24-hour, 1-week, and 1-month duration.



Capacity Planning Tests

To better understand the limitations of each of our components, the Loggregator team maintains a set of automated tests that can be deployed to test the Loggregator system at scale and monitor message reliability of both logs and metrics.

This test is similar to our black-box monitoring technique for log stream, and it is performed at scale for both logs and metrics. The test works by allowing for the configuration of a baseline request per second, which is then used to produce one log and one metric. After configuring the test to run at a declared rate, a pipeline is used to deploy Cloud Foundry with a set of applications that produce logs and a BOSH deployment of metric emitters. The assumptions of the deployment are described below. These applications produce logs that are counted in both log streams using the CLI and through a Firehose nozzle. These counts and the metrics emitted by Loggregator during the test are captured in a monitoring tool.

Test Assumptions

We have made several assumptions for our test. Where possible we have tried to make these assumptions as simple as possible to allow operators to consider what unique characteristics of their own deployment may influence how the assumptions impact the results. The assumptions are held fixed throughout our tests to allow us to isolate the performance and scaling needs for each component individually.

Log and Metrics Distribution

For simplicity, the test assumes an equal amount of logs and metrics.

Deployment Assumptions

The test runs using cf-deployment and some basic best practices for scaling apps and Diego Cells. These applications produce logs at the same rate. Additionally, there is a BOSH deployment of an application with a collocated Metron. Other components on the platform are generally kept quiet during the test so that the majority of the traffic on Loggregator can be accounted for from our controlled deployments. While this may produce an unrealistically consistent flow of logs and metrics, these assumptions are designed to properly scale Metron and allow us to apply load to Doppler linearly for the tests.

All tests are executed with 2 Firehose subscriptions and a single app stream per application. This is generally in line with most deployments we have seen. These assumptions can have impact on the scaling recommendations for Traffic Controllers, but those effects are not directly measured in these tests.

All tests are executed for at least an hour and use the new go-loggregator client inbound into Metron for logs and UDP inbound into Metron for metrics.

Tests were run multiple times against a scale of Requests Per Second (RPS) and Log Sizes, and data collected for each test is referenced in the following spreadsheet.

Infrastructure Assumptions

All of the tests were executed on Google Cloud Platform (GCP) with the following size assumptions.

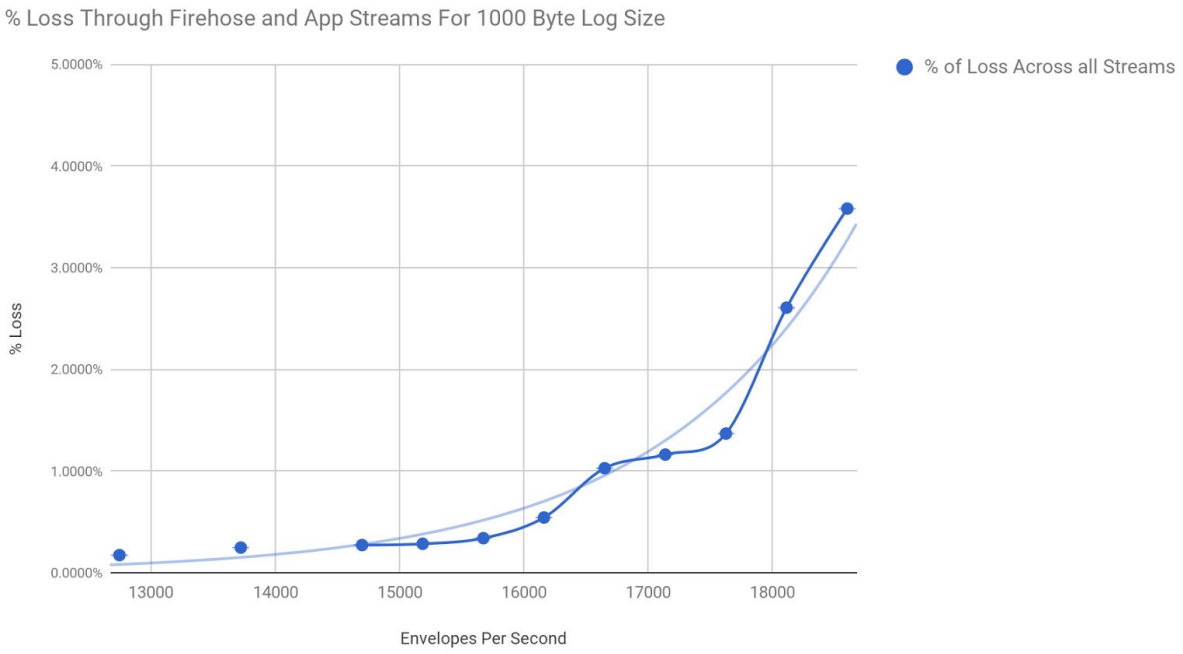
Component Name	BOSH VM Size	GCP VM Size
Doppler	m3.medium	n1-standard-1 (1 vCPU, 3.75 GB memory)
Traffic Controller	c3.large	n1-highcpu-2 (2 vCPUs, 1.8 GB memory)
Reliability Nozzle	default	n1-standard-1 (1 vCPU, 3.75 GB memory)
Datadog Nozzle	default	n1-standard-1 (1 vCPU, 3.75 GB memory)

Capacity Test Results

We executed these tests by ramping up log volume for for a single doppler (micro), and two doppler (small) deployment. The results below highlight loss rates between 0 and 5%.

Micro Test for RPS Rates

The micro-scale test is designed to understand what deployment size will overwhelm a single Doppler. However, it is important to note that we recommend deploying at least two Dopplers. This test gives us a reference for scaling up to a small deployment with two Dopplers.

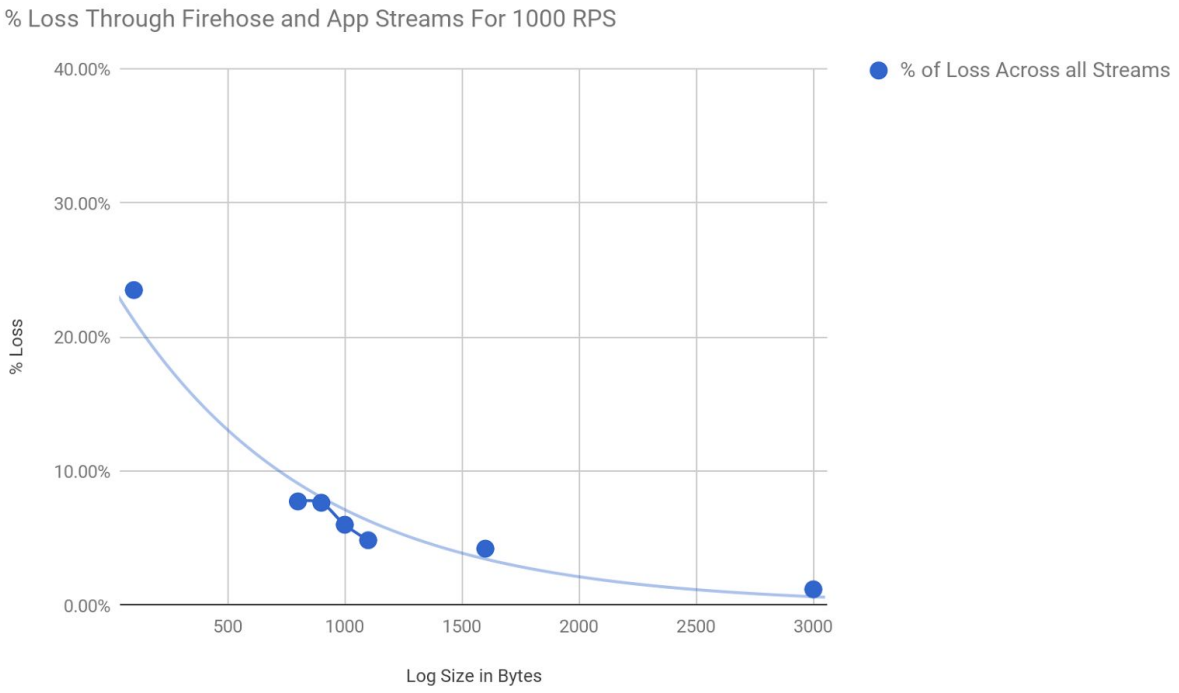


Log loss rates for a single Doppler hold below 1% up to approximately 16,000 logs per second and increase exponentially for all streams after that threshold is exceeded.

Logs and Metrics Per Second	Envelopes Per Second	% of Log Loss in Firehose	% Loss in Log Stream	% of Metric Loss in Firehose	% of Loss Across all Streams	Number of Dopplers
7349	14,698	0.2566%	0.2750%	0.2847%	0.2721%	1
7593	15,186	0.2689%	0.2873%	0.2970%	0.2844%	1
7837	15,674	0.3200%	0.3200%	0.3800%	0.3400%	1
8081	16,162	0.5800%	0.2800%	0.7690%	0.5430%	1
8325	16,650	1.0700%	0.2130%	1.8000%	1.0277%	1
8569	17,138	1.0700%	0.7700%	1.6450%	1.1617%	1
8813	17,626	1.1400%	1.3500%	1.6150%	1.3683%	1
9057	18,114	2.0000%	2.8900%	2.9300%	2.6067%	1
9301	18,602	3.0400%	3.1830%	4.5200%	3.5810%	1

Micro Test for Log Sizes

The request per second tests were executed at a consistent log size of 1000 bytes. Another micro test was executed with a single Doppler across a variety of log sizes at 1000 requests per second for all tests.

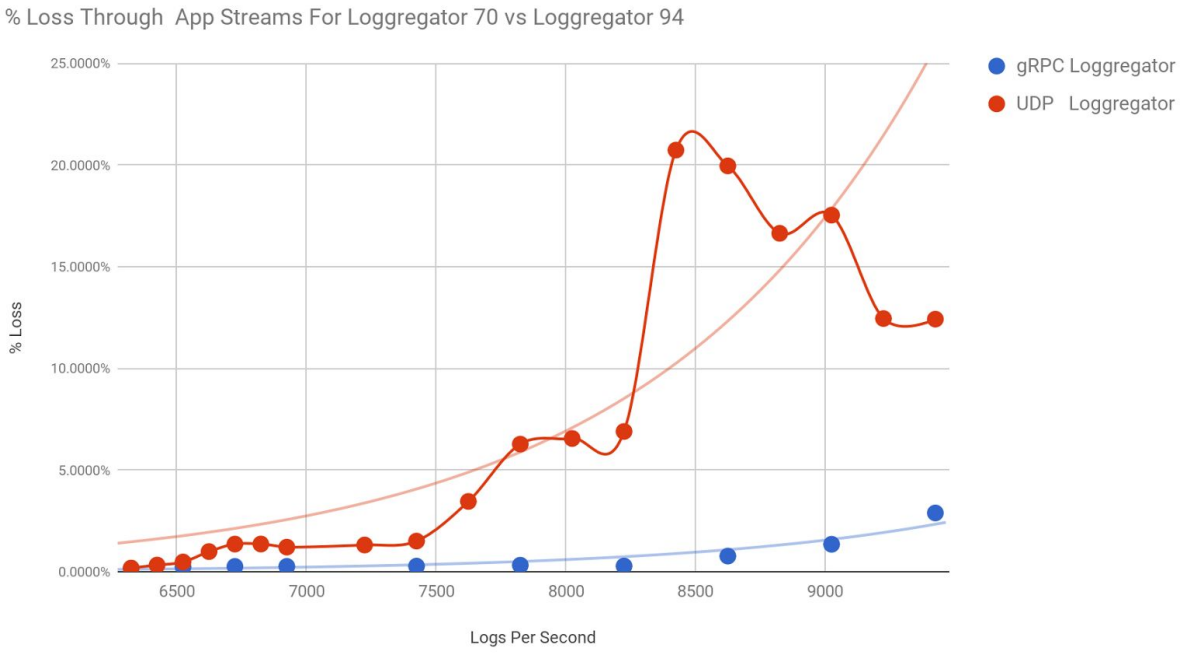


The results of the log size test are surprising and somewhat counterintuitive. That is, smaller logs are more likely to produce drops in Doppler than larger logs. This trend follows an exponential pattern, with 1000-byte log sizes producing surprisingly high loss rates at 1000 logs per second.

Log Size in Bytes	% of Log Loss in Firehose	% Loss in Log Stream	% of Metric Loss in Firehose	% of Loss Across all Streams	Number of Dopplers
100	37.41%	32.85%	0.25%	23.50%	1
800	12.48%	10.62%	0.10%	7.73%	1
900	12.52%	10.28%	0.10%	7.63%	1
1000	9.54%	8.35%	0.09%	5.99%	1
1100	7.77%	6.63%	0.11%	4.84%	1
1600	6.46%	5.12%	1.04%	4.21%	1
3000	2.60%	0.64%	0.28%	1.17%	1

Previous Version Comparison

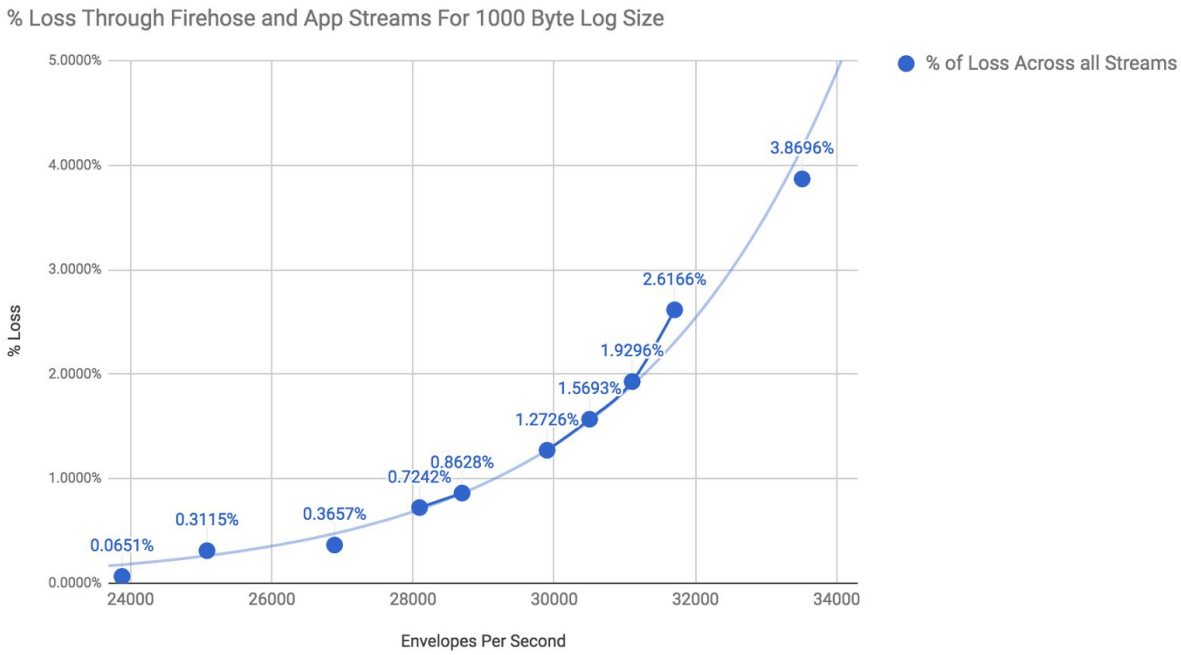
In order to best understand the impact that the switch to gRPC has had on the recent Loggregator versions, these same tests were run against an older version of Loggregator that still relied on the UDP protocol.



Critically, these tests showed a dramatic improvement in reliability with gRPC and a drastically more unpredictable increase in loss for UDP.

Small Test

To better understand how Doppler throughput scales, we repeated the test with 2 Dopplers. In this test, we saw similar loss rates patterns starting at about 30,000 envelopes per second, or 15,000 envelopes per second per Doppler.



Tooling and Troubleshooting

The following are a set of tools and applications that the Loggregator team has found useful. These tools are included in the [Loggregator tools repo](#).

Health Endpoints

All Loggregator components have a health endpoint available. These health endpoints can be used for debugging through BOSH. A summary of information provided by each endpoint is listed below:

- Metron - `localhost:14824/health`
  - Number of connections to Dopplers
  - Number of v1 gRPC streams to Dopplers
  - Number of v2 gRPC streams to Dopplers
- Doppler - `localhost:14825/health`
  - Number of container metrics caches
  - Number of open ingress streams
  - Number of recent log caches
  - Number of open subscriptions
- Traffic Controller - `localhost:14825/health`
  - Number of open app streams
  - Number of open Firehose streams
- Reverse Log Proxy - `localhost:33333/health`
  - Number of subscriptions
- Syslog Scheduler - `localhost:8080/health`
  - Number of adapters
  - Number of blacklisted or invalid URLs
  - Number of drains
- Syslog Adapter - `localhost:8080/health`
  - Drain count

Log and Metric Emitters

It can be helpful to emit logs and metrics at known rates. We have a variety of tools for performing both. The two most relevant are:

- **`logspinner`** is intended to be pushed via `cf push` and allows you to specify cycles, delay, and text as query parameters. This is helpful for creating tests that require deploying an application that can emit a known number of metrics in a given time frame.

- **`cf-logmon`** provides a self contained black-box monitor, which runs continuously to monitor message reliability of your platform.

Syslog Drain Counters

The following applications can be used together to implement a black-box monitor for syslog drains.

- **`https-drain`** can be deployed using `cf push` and details about the counter location. Its route can then be created and bound as a syslog drain with the results being recorded in counter and outputted to the logs.
- **`syslog-drain`** can be deployed using `cf push`.You need to enable TCP routing to access this application as a drain.
- **`counter`** records results for both the `sylog_drain` and `http_drain` applications.

Capacity Planning Pipelines

The capacity planning results outlined in this document were generated using an automated process. If you are using Concourse on Google Cloud Platform, these tests could easily be used to measure the capacity of your deployment. The tests allow you to specify a start RPS, an ending RPS, and a number of steps.

Message Reliability Nozzle

The reliability nozzle is a scalable nozzle for counting log throughput through the Firehose. This nozzle uses tags for each scaled index of the nozzle and reports the results to a monitoring tool.

Contributing and Collaborating

Loggregator is an open-source project within the Cloud Foundry Foundation. We welcome your feedback in Slack and GitHub.