Apache Metron

A Case Study of a Modern Streaming Architecture on Hadoop

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2017

Introduction

Hi, I'm Casey Stella!

Apache Metron: A Cybersecurity Analytics Platform

- Metron provides a scalable, advanced security analytics framework to offer a centralized tool for security monitoring and analysis.
- Metron was initiated at Cisco in 2014 as OpenSOC.
- Metron was submitted to the Apache Incubator in December 2015
- Metron graduated to a top level project in April 2017

Characteristics of Metron

- Metron is built atop the Apache Hadoop ecosystem handle capturing, ingesting, enriching and storing streaming data at scale
    - Kafka provides a unified data bus
    - Storm providing a distributed streaming framework
    - HBase provides a low latency key/value lookup store for enrichments and profiles
    - Zookeeper provides a distributed configuration store
- Ingested network telemetry can be enriched pluggably
    - New enrichments can be done live on running topologies without restart
    - New enrichment capabilities can be added via user defined functions
    - Enrichments can be composed through a domain specific language called **Stellar**
- Data stored in HBase can be the source of enrichments

Characteristics of Metron

- Enriched network telemetry can be indexed into a Security data lake
  - Indexes supported are pluggable and include HDFS, Solr and Elasticsearch
- Advanced analytics can be done on streaming data
  - Probabalistic data structures (e.g. sketches) can sketch streaming data across time and enable approximate distribution, set existence and distinct count queries
  - Models can be deployed using Yarn, autodiscovered via Zookeeper and interrogated via Stellar functions

Stellar

Metron needed the ability to allow users to pluggably and consistently enrich and transform streaming data. Out of this need, we created **Stellar**:

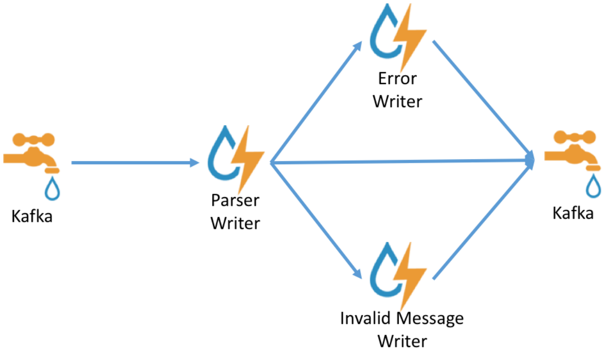
- Interact with the various enabling Hadoop components in a unified manner
- Compose a rich set of built-in functions with user defined functions
- Provide simple primitives around the functions: boolean operations, conditionals, numerical computation.

Think of Stellar as similar to Excel functions that we can run on streaming data.

Data Ingest: Parsers

- Telemetry data comes in a variety of formats and velocities.
- Each telemetry source is ingested into kafka
- A Storm **parser** topology is used to convert the raw telemetry format to a normalized JSON Map
  - Common network-related raw telemetry formats
  - Specifying the parser via Grok
  - Generic formats such as CSV and JSON
  - Creating your own parser in a JVM-based language
- Simple transformations and normalizations can be done post-parse via Stellar statements
- The normalized data across all telemetries is written to an **enrichment** kafka topic

Data Ingest: Parsers



Enrichment

- The enrichment topology takes the various normalized telemetry sources and allows users to enrich the messages with broader context
  - Enriching with reference data ingested into HBase
  - Enriching via arbitrary Stellar expressions
  - Enriching with Geolocation data
- Enrichment is split into two phases
  - Preparatory Enrichment
  - Threat Intelligence Enrichment
- If messages are marked with an **is_alert** field, they can have a triage score computed via Stellar which defines their priority as threats

Enrichment: HBase

A core enrichment source is enriching messages with reference data stored in HBase. Metron provides a loading framework which takes data and

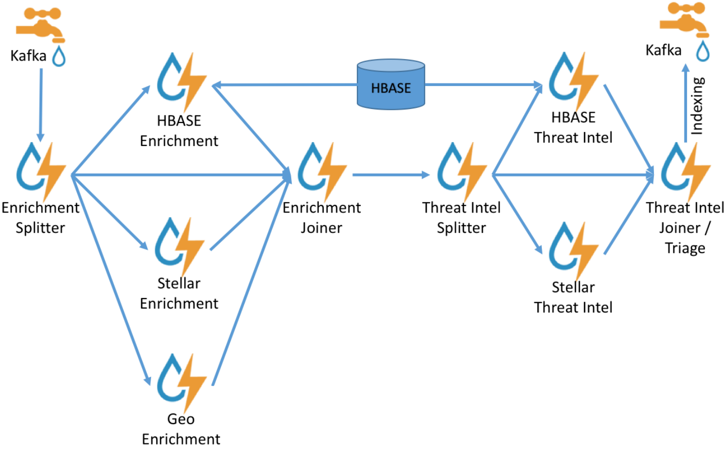
- Defines a logical key for the HBase enrichment via Stellar
- Loads the data into HBase via MapReduce or directly depending on data size
- For reference data which is streamed in, you can write to HBase from a parser and ingest the streaming reference data as any other telemetry

Enrichment: Stellar

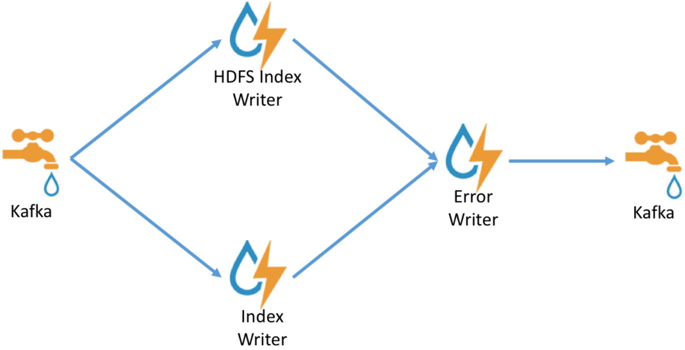
Stellar is the primary method for enrichment in Metron.

- User defined enrichment functions can be enabled through adding a jar implementing the function to HDFS.
- Stellar enrichments can be executed asynchronously across storm workers and their results joined together

Enrichment


Kafka
HBASE Enrichment
HBASE
HBASE Threat Intel
Kafka
Indexing
Enrichment Splitter
Enrichment Joiner
Threat Intel Splitter
Threat Intel Joiner / Triage
Stellar Enrichment
Stellar Threat Intel
Geo Enrichment

Indexing



Profiler: Motivation

- Enrichments and parsers operate within the context of a single message.
- This is insufficient for a number of scenarios
  - Correlating between different sources
  - Making judgments based on past events
  - Both at the same time
- Operating across multiple sources has scalability implications
- Waiting on the data you want from the other stream isn't plausible

Profiler: Solution

- Compromise: Operate on windows in time rather than individual records
- Windows should be able to be specified very flexibly to avoid seasonal aberrations.
- The Profiler is a storm topology that takes the enriched data
    - Capture aggregations of data in a window to HBase
    - Uses Stellar to define how to aggregate data
    - Uses Stellar to define a filter on which messages to consider
- These aggregations can be read anywhere Stellar is used
- This enables things like
    - Temporal outlier detection
    - Limited context from other sources when building threat triage rules

Profiler: Aggregations

- Example aggregations:
  - Distributional statistics: median, mean, percentile
  - Set operations: Contains, Cardinality
  - Simple counts
- Aggregations challenges
  - May be big objects if naively done (e.g. set operations)
  - May not be able to be merged across time (e.g. distributions)
  - Profile reading should be decoupled from writing
- Approach: Use approximate data structures
  - Set operations: Bloom Filters, HyperLogLog approximations
  - Distributional Statistics: t-digests

Demo

- Los Alamos National Lab released an open data set representing 58 consecutive days of de-identified event data collected from five sources within Los Alamos National Laboratory's corporate, internal computer network.
- Among other telemetry sources, authentication logs and a set of well-defined red teaming events that present bad behavior within the 58 days are provided.
- We will look at the authentication logs around a breach and show how we can use Metron to pick out offending user's activity leading up to the event
  - Look for users who are attempting to authenticate to many distinct hosts more than 5 standard deviations from the median across all users.

```
"profile": "distinct_auth_attempts_by_user",
"foreach": "user",
"onlyif": "source.type == 'auth'",
"init" : {
  "total" : "HLLP_INIT(5,6)"
         },
"update": {
  "total" : "HLLP_ADD(total, ip_dst_addr)"
          },
"result" : {
   "profile" : "total",
   "triage" : {
       "total_count" : "HLLP_CARDINALITY(total)"
              }
}
```

```
"profile": "auth_distribution",
"foreach": "'global'",
"onlyif": "source.type == 'profiler' && profile == 'distinct_auth_attempts_by_us
"init" : {
  "s" : "STATS_INIT()"
         },
"update": {
  "s" : "STATS_ADD(s, total_count)"
          },
"result": "s"
```

```
window := PROFILE_WINDOW('...')
profile := PROFILE_GET('distinct_auth_attempts_by_user', user, window)
distinct_auth_attempts := HLLP_CARDINALITY(GET_LAST(profile))
distribution_profile := PROFILE_GET('auth_distribution', 'global', window)
stats := STATS_MERGE(distribution_profile)
distinct_auth_attempts_median := STATS_PERCENTILE(stats, 0.5)
distinct_auth_attempts_stddev := STATS_SD(stats)
```

Questions

Thanks for your attention! Questions?

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