The YARN Timeline Service v.2

Overview

Introduction

YARN Timeline Service v.2 is the next major iteration of Timeline Server, following v.1 and v.1.5. V.2 is created to address two major challenges of v.1.

Scalability

V.1 is limited to a single instance of writer/reader and storage, and does not scale well beyond small clusters. V.2 uses a more scalable distributed writer architecture and a scalable backend storage.

YARN Timeline Service v.2 separates the collection (writes) of data from serving (reads) of data. It uses distributed collectors, essentially one collector for each YARN application. The readers are separate instances that are dedicated to serving queries via REST API.

YARN Timeline Service v.2 chooses Apache HBase as the primary backing storage, as Apache HBase scales well to a large size while maintaining good response times for reads and writes.

Usability improvements

In many cases, users are interested in information at the level of "flows" or logical groups of YARN applications. It is much more common to launch a set or series of YARN applications to complete a logic application. Timeline Service v.2 supports the notion of flows explicitly. In addition, it supports aggregating metrics at the flow level.

Also, information such as configuration and metrics is treated and supported as a first-class citizen.

Architecture

YARN Timeline Service v.2 uses a set of collectors (writers) to write data to the backend storage. The collectors are distributed and co-located with the application masters to which they are dedicated. All data that belong to that application are sent to the application level timeline collectors with the exception of the resource manager timeline collector.

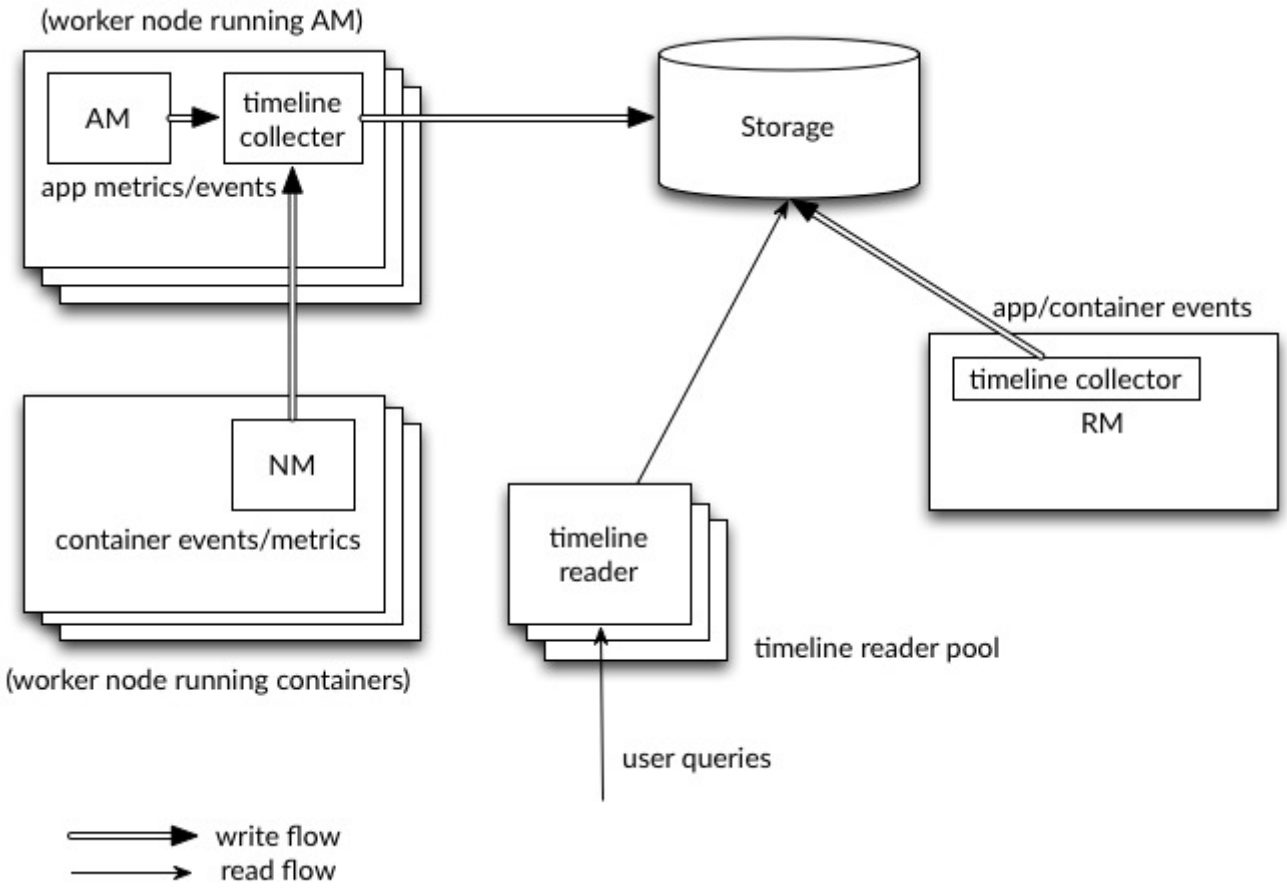
For a given application, the application master can write data for the application to the co-located timeline collectors (which is an NM auxiliary service in this release). In addition, node managers of other nodes that are running the containers for the application also write data to the timeline collector on the node that is running the application master.

The resource manager also maintains its own timeline collector. It emits only YARN-generic lifecycle events to keep its volume of writes reasonable.

The timeline readers are separate daemons separate from the timeline collectors, and they are dedicated to serving

queries via REST API.

The following diagram illustrates the design at a high level.



Current Status and Future Plans

YARN Timeline Service v.2 is currently in alpha. It is very much work in progress, and many things can and will change rapidly. Users should enable Timeline Service v.2 only on a test or experimental cluster to test the feature.

A complete end-to-end flow of writes and reads should be functional, with Apache HBase as the backend. You should be able to start generating data. When enabled, all YARN-generic events are published as well as YARN system metrics such as CPU and memory. Furthermore, some applications including Distributed Shell and MapReduce write per-framework data to YARN Timeline Service v.2.

The REST API comes with a good number of useful and flexible query patterns (see below for more information).

Although the basic mode of accessing data is via REST, it also comes with a basic web UI based on the proposed new YARN UI framework. Currently there is no support for command line access, however.

The collectors (writers) are currently embedded in the node managers as auxiliary services. The resource manager also has its dedicated in-process collector. The reader is currently a single instance. Currently, it is not possible to write to Timeline Service outside the context of a YARN application (i.e. no off-cluster client).

When YARN Timeline Service v.2 is disabled, one should expect no functional or performance impact on any other existing functionality.

The work to make it production-ready continues. Some key items include

- More robust storage fault tolerance
- Security
- Support for off-cluster clients
- More complete and integrated web UI
- Better support for long-running apps

- Offline (time-based periodic) aggregation for flows, users, and queues for reporting and analysis
- Timeline collectors as separate instances from node managers
- Clustering of the readers
- Migration and compatibility with v.1

Deployment

Configurations

New configuration parameters that are introduced with v.2 are marked bold.

Basic configuration

Configuration Property	Description
`yarn.timeline-service.enabled`	Indicate to clients whether Timeline service is enabled or not. If enabled, the `TimelineClient` library used by applications will post entities and events to the Timeline server. Defaults to `false`.
`yarn.timeline-service.version`	Indicate what is the current version of the running timeline service. For example, if "yarn.timeline-service.version" is 1.5, and "yarn.timeline-service.enabled" is true, it means the cluster will and should bring up the timeline service v.1.5 (and nothing else). On the client side, if the client uses the same version of timeline service, it should succeed. If the client chooses to use a smaller version in spite of this, then depending on how robust the compatibility story is between versions, the results may vary. Defaults to `1.0f`.
`yarn.timeline-service.writer.class`	The class for the backend storage writer. Defaults to a filesystem storage writer, therefore it should be overridden.
`yarn.timeline-service.reader.class`	The class for the backend storage reader. Defaults to a filesystem storage reader, therefore it should be overridden.
`yarn.system-metrics-publisher.enabled`	The setting that controls whether yarn system metrics is published on the Timeline service or not by RM And NM. Defaults to `false`.
`yarn.rm.system-metrics-publisher.emit-container-events`	The setting that controls whether yarn container metrics is published to the timeline server or not by RM. This configuration setting is for ATS V2. Defaults to `false`.

Advanced configuration

Configuration Property	Description
`yarn.timeline-service.hostname`	The hostname of the Timeline service web application. Defaults to `0.0.0.0`
`yarn.timeline-service.address`	Address for the Timeline server to start the RPC server. Defaults to `${yarn.timeline-service.hostname}:10200`.
`yarn.timeline-service.webapp.address`	The http address of the Timeline service web application. Defaults to `${yarn.timeline-service.hostname}:8188`.
`yarn.timeline-service.webapp.https.address`	The https address of the Timeline service web application. Defaults to `${yarn.timeline-service.hostname}:8190`.
`yarn.timeline-service.writer.flush-interval-seconds`	The setting that controls how often the timeline collector flushes the timeline writer. Defaults to `60`.
`yarn.timeline-service.app-collector.linger-period.ms`	Time period till which the application collector will be alive in NM, after the application master container finishes. Defaults to `1000` (1 second).
`yarn.timeline-service.timeline-client.number-of-async-entities-to-merge`	Time line V2 client tries to merge these many number of async entities (if available) and then call the REST ATS V2 API to submit. Defaults to `10`.
`yarn.timeline-service.coprocessor.app-final-value-retention-milliseconds`	The setting that controls how long the final value of a metric of a completed app is retained before merging into the flow sum. Defaults to `259200000` (3 days).

Enabling the Timeline Service v.2

Preparing Apache HBase cluster for storage

The first part is to set up or pick an Apache HBase cluster to use as the storage cluster. Once you have an HBase cluster ready to use for this purpose, perform the following steps.

First, add the timeline service jar to the HBase classpath in all HBase machines in the cluster. It is needed for the coprocessor as well as the schema creator. For example,

```
cp hadoop-yarn-server-timelineservice-3.0.0-SNAPSHOT.jar /usr/hbase/lib/
```

Then, enable the coprocessor that handles the aggregation. To enable it, add the following entry in region servers' `hbase-site.xml` file (generally located in the `conf` directory) as follows:

```
<property>
  <name>hbase.coprocessor.region.classes</name>
  <value>org.apache.hadoop.yarn.server.timelineservice.storage.flow.FlowRunCoprocess
</property>
```

Restart the region servers and the master to pick up the timeline service jar as well as the config change. In this version, the coprocessor is loaded statically (i.e. system coprocessor) as opposed to a dynamically (table coprocessor).

Finally, run the schema creator tool to create the necessary tables:

```
bin/hbase org.apache.hadoop.yarn.server.timelineservice.storage.TimelineSchemaCreato
```

The `TimelineSchemaCreator` tool supports a few options that may come handy especially when you are testing. For example, you can use `-skipExistingTable` (`-s` for short) to skip existing tables and continue to create other tables rather than failing the schema creation.

Enabling Timeline Service v.2

Following are the basic configurations to start Timeline service v.2:

```
<property>
  <name>yarn.timeline-service.version</name>
  <value>2.0f</value>
</property>

<property>
  <name>yarn.timeline-service.enabled</name>
  <value>true</value>
</property>
```

```
<property>
  <name>yarn.timeline-service.writer.class</name>
  <value>org.apache.hadoop.yarn.server.timelineservice.storage.HBaseTimelineWriterIm
</property>

<property>
  <name>yarn.timeline-service.reader.class</name>
  <value>org.apache.hadoop.yarn.server.timelineservice.storage.HBaseTimelineReaderIm
</property>

<property>
  <name>yarn.nodemanager.aux-services</name>
  <value>mapreduce_shuffle,timeline_collector</value>
</property>

<property>
  <name>yarn.nodemanager.aux-services.timeline_collector.class</name>
  <value>org.apache.hadoop.yarn.server.timelineservice.collector.PerNodeTimelineColl
</property>

<property>
  <description>The setting that controls whether yarn system metrics is
  published on the Timeline service or not by RM And NM.</description>
  <name>yarn.system-metrics-publisher.enabled</name>
  <value>true</value>
</property>

<property>
  <description>The setting that controls whether yarn container events are
  published to the timeline service or not by RM. This configuration setting
  is for ATS V2.</description>
  <name>yarn.rm.system-metrics-publisher.emit-container-events</name>
  <value>true</value>
</property>
```

In addition, you may want to set the YARN cluster name to a reasonably unique name in case you are using multiple clusters to store data in the same Apache HBase storage:

```
<property>
  <name>yarn.resourcemanager.cluster-id</name>
  <value>my_research_test_cluster</value>
</property>
```

Also, add the `hbase-site.xml` configuration file to the client Hadoop cluster configuration so that it can write data to the Apache HBase cluster you are using.

Running Timeline Service v.2

Restart the resource manager as well as the node managers to pick up the new configuration. The collectors start within the resource manager and the node managers in an embedded manner.

The Timeline Service reader is a separate YARN daemon, and it can be started using the following syntax:

```
$ yarn-daemon.sh start timelinereader
```

Enabling MapReduce to write to Timeline Service v.2

To write MapReduce framework data to Timeline Service v.2, enable the following configuration in `mapred-site.xml`:

```
<property>
  <name>mapreduce.job.emit-timeline-data</name>
  <value>true</value>
</property>
```

Publishing application specific data

This section is for YARN application developers that want to integrate with Timeline Service v.2.

Developers can continue to use the `TimelineClient` API to publish per-framework data to the Timeline Service v.2. You only need to instantiate the right type of the client to write to v.2. On the other hand, the entity/object API for v.2 is different than v.1 as the object model is significantly changed. The v.2 timeline entity class is `org.apache.hadoop.yarn.api.records.timelineservice.TimelineEntity` whereas the v.1 class is `org.apache.hadoop.yarn.api.records.timeline.TimelineEntity`. The methods on `TimelineClient` suitable for writing to the Timeline Service v.2 are clearly delineated, and they use the v.2 types as arguments.

Timeline Service v.2 `putEntities` methods come in 2 varieties: `putEntities` and `putEntitiesAsync`. The former is a blocking operation which should be used for writing more critical data (e.g. lifecycle events). The latter is a non-blocking operation. Note that neither has a return value.

Creating a `TimelineClient` for v.2 involves passing in the application id to the factory method.

For example:

```
// Create and start the Timeline client v.2
TimelineClient client = TimelineClient.createTimelineClient(appId);
client.init(conf);
client.start();

try {
  TimelineEntity myEntity = new TimelineEntity();
  myEntity.setEntityType("MY_APPLICATION");
  myEntity.setEntityId("MyApp1")
  // Compose other entity info

  // Blocking write
  client.putEntities(entity);

  TimelineEntity myEntity2 = new TimelineEntity();
  // Compose other info

  // Non-blocking write
  timelineClient.putEntitiesAsync(entity);

} catch (IOException e) {
```

```
  // Handle the exception
} catch (RuntimeException e) {
  // In Hadoop 2.6, if attempts submit information to the Timeline Server fail more t
  // a RuntimeException will be raised. This may change in future releases, being
  // replaced with a IOException that is (or wraps) that which triggered retry failu
} catch (YarnException e) {
  // Handle the exception
} finally {
  // Stop the Timeline client
  client.stop();
}
```

As evidenced above, you need to specify the YARN application id to be able to write to the Timeline Service v.2. Note that currently you need to be on the cluster to be able to write to the Timeline Service. For example, an application master or code in the container can write to the Timeline Service, while an off-cluster MapReduce job submitter cannot.

You can create and publish your own entities, events, and metrics as with previous versions.

Application frameworks should set the "flow context" whenever possible in order to take advantage of the flow support Timeline Service v.2 provides. The flow context consists of the following:

- Flow name: a string that identifies the high-level flow (e.g. "distributed grep" or any identifiable name that can uniquely represent the app)
- Flow run id: a monotonically-increasing sequence of numbers that distinguish different runs of the same flow
- (optional) Flow version: a string identifier that denotes a version of the flow

If the flow context is not specified, defaults are supplied for these attributes:

- Flow name: the YARN application name (or the application id if the name is not set)
- Flow run id: the application start time in Unix time (milliseconds)
- Flow version: "1"

You can provide the flow context via YARN application tags:

```
ApplicationSubmissionContext appContext = app.getApplicationSubmissionContext();

// set the flow context as YARN application tags
Set<String> tags = new HashSet<>();
tags.add(TimelineUtils.generateFlowNameTag("distributed grep"));
tags.add(Timelineutils.generateFlowVersionTag("3df8b0d6100530080d2e0decf9e528e57c42a
tags.add(TimelineUtils.generateFlowRunIdTag(System.currentTimeMillis()));

appContext.setApplicationTags(tags);
```

Timeline Service v.2 REST API

Querying the Timeline Service v.2 is currently only supported via REST API; there is no API client implemented in the YARN libraries.

The v.2 REST API is implemented at under the path, `/ws/v2/timeline/` on the Timeline Service web service.

Here is an informal description of the API.

Root path

```
GET /ws/v2/timeline/
```

Returns a JSON object describing the service instance and version information.


```
{
  "About":"Timeline Reader API",
  "timeline-service-version":"3.0.0-SNAPSHOT",
  "timeline-service-build-version":"3.0.0-SNAPSHOT from fb0acd08e6f0b030d82eeb7cbfa54
  "timeline-service-version-built-on":"2016-04-11T23:15Z",
  "hadoop-version":"3.0.0-SNAPSHOT",
  "hadoop-build-version":"3.0.0-SNAPSHOT from fb0acd08e6f0b030d82eeb7cbfa5404376313e
  "hadoop-version-built-on":"2016-04-11T23:14Z"
}
```


Request Examples

The following shows some of the supported queries on the REST API. For example, to get the most recent flow activities,

HTTP request:

```
GET /ws/v2/timeline/clusters/{cluster name}/flows/
```

Response:


```
[
  {
    "metrics": [],
    "events": [],
    "id": "test-cluster/1460419200000/sjlee@ds-date",
    "type": "YARN_FLOW_ACTIVITY",
    "createdtime": 0,
    "flowruns": [
      {
        "metrics": [],
        "events": [],
        "id": "sjlee@ds-date/1460420305659",
        "type": "YARN_FLOW_RUN",
        "createdtime": 0,
        "info": {
          "SYSTEM_INFO_FLOW_VERSION": "1",
          "SYSTEM_INFO_FLOW_RUN_ID": 1460420305659,
          "SYSTEM_INFO_FLOW_NAME": "ds-date",
          "SYSTEM_INFO_USER": "sjlee"
        },
        "isrelatedto": {},
        "relatesto": {}
```

```
      },
      {
        "metrics": [],
        "events": [],
        "id": "sjlee@ds-date/1460420587974",
        "type": "YARN_FLOW_RUN",
        "createdtime": 0,
        "info": {
          "SYSTEM_INFO_FLOW_VERSION": "1",
          "SYSTEM_INFO_FLOW_RUN_ID": 1460420587974,
          "SYSTEM_INFO_FLOW_NAME": "ds-date",
          "SYSTEM_INFO_USER": "sjlee"
        },
        "isrelatedto": {},
        "relatesto": {}
      }
    ],
    "info": {
      "SYSTEM_INFO_CLUSTER": "test-cluster",
      "UID": "test-cluster!sjlee!ds-date",
      "SYSTEM_INFO_FLOW_NAME": "ds-date",
      "SYSTEM_INFO_DATE": 1460419200000,
      "SYSTEM_INFO_USER": "sjlee"
    },
    "isrelatedto": {},
    "relatesto": {}
  }
]
```

It returns the flows that had runs (specific instances of the flows) most recently.

You can drill further down to get the runs (specific instances) of a given flow.

HTTP request:

```
GET /ws/v2/timeline/users/{user name}/flows/{flow name}/runs/
```

Response:

```
[
  {
    "metrics": [],
    "events": [],
    "id": "sjlee@ds-date/1460420587974",
    "type": "YARN_FLOW_RUN",
    "createdtime": 1460420587974,
    "info": {
      "UID": "test-cluster!sjlee!ds-date!1460420587974",
      "SYSTEM_INFO_FLOW_RUN_ID": 1460420587974,
      "SYSTEM_INFO_FLOW_NAME": "ds-date",
      "SYSTEM_INFO_FLOW_RUN_END_TIME": 1460420595198,
      "SYSTEM_INFO_USER": "sjlee"
    },
    "isrelatedto": {},
    "relatesto": {}
```

```
  },
  {
    "metrics": [],
    "events": [],
    "id": "sjlee@ds-date/1460420305659",
    "type": "YARN_FLOW_RUN",
    "createdtime": 1460420305659,
    "info": {
      "UID": "test-cluster!sjlee!ds-date!1460420305659",
      "SYSTEM_INFO_FLOW_RUN_ID": 1460420305659,
      "SYSTEM_INFO_FLOW_NAME": "ds-date",
      "SYSTEM_INFO_FLOW_RUN_END_TIME": 1460420311966,
      "SYSTEM_INFO_USER": "sjlee"
    },
    "isrelatedto": {},
    "relatesto": {}
  }
]
```

This returns the most recent runs that belong to the given flow.

You can provide a `limit` query parameter to limit the number of entries that returned in a query. If you want to limit the number of flow runs in the above query, you can do the following:

HTTP request:

```
GET /ws/v2/timeline/users/{user name}/flows/{flow name}/runs?limit=1
```

Response:

```
[
  {
    "metrics": [],
    "events": [],
    "id": "sjlee@ds-date/1460420587974",
    "type": "YARN_FLOW_RUN",
    "createdtime": 1460420587974,
    "info": {
      "UID": "test-cluster!sjlee!ds-date!1460420587974",
      "SYSTEM_INFO_FLOW_RUN_ID": 1460420587974,
      "SYSTEM_INFO_FLOW_NAME": "ds-date",
      "SYSTEM_INFO_FLOW_RUN_END_TIME": 1460420595198,
      "SYSTEM_INFO_USER": "sjlee"
    },
    "isrelatedto": {},
    "relatesto": {}
  }
]
```

Most queries in the v.2 REST API support the following query parameters:

- `limit`
- `createdtimestart`

- createdtimeend
- relatesto
- isrelatedto
- infofilters
- conffilters
- metricfilters
- eventfilters
- fields

Given a flow run, you can query all the YARN applications that are part of that flow run:

HTTP request:

```
GET /ws/v2/timeline/users/{user name}/flows/{flow name}/runs/{run id}/apps/
```

Response:


```
[
  {
    "metrics": [],
    "events": [],
    "id": "application_1460419579913_0002",
    "type": "YARN_APPLICATION",
    "createdtime": 0,
    "info": {
      "UID": "test-cluster!sjlee!ds-date!1460420587974!application_1460419579913_000
    },
    "configs": {},
    "isrelatedto": {},
    "relatesto": {}
  }
]
```


You can also provide per-framework entity type to query for them. For example,

HTTP request:

```
GET /ws/v2/timeline/clusters/{cluster name}/apps/{app id}/entities/DS_APP_ATTEMPT
```

Response:


```
[
  {
    "metrics": [],
    "events": [],
    "id": "appattempt_1460419579913_0002_000001",
    "type": "DS_APP_ATTEMPT",
    "createdtime": 0,
```

```
    "info": {
      "UID": "test-cluster!application_1460419579913_0002!DS_APP_ATTEMPT!appattempt_1
    },
    "configs": {},
    "isrelatedto": {},
    "relatesto": {}
  }
]
```