

Ryan Heminway
David Tandetnik

Eau2 System Architecture and Design

Introduction

The eau2 system aims to provide key-value storage over a distributed set of nodes acting as the backbone for applications which process large amounts of data. With the requirement of a cluster of compute nodes, users can run the eau2 system to store data across the cluster but interact with it as if it was local. Eau2 only accepts input data formatted based on schema-on-read (SoR) requirements, and that data is read-only once it is stored in the system. For queries, the eau2 system provides the data in the form of a dataframe which allows for easy data aggregation and access.

Architecture

Conceptually, there are three layers of the eau2 system. At the bottom is the key-value storage system. Data is stored across multiple nodes, so this layer also includes a network protocol which allows the key-value stores on each node to interact with each other. Each key consists of a string and a home node while each value is a serialized blob of data. Communication between the stores allows the user to view the key-value storage as a single system holding all the data, without any knowledge of the underlying distribution. The layer above provides abstractions like distributed arrays and distributed dataframes. These utility classes are useful for data aggregation and are easier to work with than the raw data. At the top sits the application layer. This layer provides all the functionality necessary to run the eau2 system and interact with the lower levels. The user builds on top of this layer to leverage the underlying key-value store as the backbone of their program.

Implementation

The bottom layer will be implemented using one main class, for now referenced as Store. This class will have two main components, a Map and a Network. The map is the normal key-value storage structure, mapping Keys to Strings. Keys are a new type which represent a tuple of a String and an integer to denote the home node identifier of the data. Strings are used to hold serialized blobs of data. The Network object on the other hand contains all the necessary logic for registering and communicating with the other nodes in the cluster. Overall, the Store layer will have a simple API supporting methods such as 'get', 'getAndWait', and 'put'.

In the middle layer we have the useful abstraction classes. Specifically, the DistributedDataFrame class and the DistributedArray class. The DistributedDataFrame is a queryable table of data which supports aggregate operations such as 'map' and 'filter'. All data stored in a DistributedDataFrame is stored in columnar format with all data in each column being of a single type. The types supported by a DataFrame are the four SoR types: INT, BOOL,

FLOAT, and STRING. Unlike normal DataFrames, DistributedDataFrames access their data as needed from other nodes across the network under-the-hood. The DistributedArray class has the API of a normal array, however it is implemented such that the values it stores are distributed across the cluster of nodes. This abstraction allows this class to represent much more data than the average array stored in local memory.

For the top layer, we provide a single Application class. This class contains a 'run_' method which must be invoked on all nodes in the cluster to start up the system. This class has the Store as a field, providing the user which extends the Application class with access to all data stored on the system. Additionally, this class will contain any utility methods required for building a program on top of it. One example is the Application API method 'this_node' which returns the index of the current node.

Use Cases

```
// One node saves some data to the store, the other takes the max of the data and saves that to
// the store too.
class Demo : public Application {
Public:
    Key df("data", 0);
    Key max("max", 1);

    Demo(size_t idx): Application(idx) {}

    void run_() {
        switch(this_node()) {
            case 0: producer(); break;
            case 1: maxer();
        }
    }

    void producer() {
        float vals = new float[3];
        vals[0] = 1;
        vals[1] = 10;
        vals[2] = 100;

        DataFrame::fromArray(&df, store, 3, vals);
    }

    void maxer() {
        DataFrame* frame = kv.getAndWait(df);
        int max = frame->get_int(0, 0);
        for (size_t i = 1; i < frame->nrows(); i++) {
```

```
        if (kv->get(0, i) > max) max = store->get(0, i);
    }
    DataFrame::fromScalar(&max, store, max);
}
};
```

Open Questions

- 1) If the user inputs data with a SoR file, what key does it go under by default?
- 2) Are DistributedArrays available to the user to make? Or are they just an implementation details of DistributedDataFrames?
- 3) Who starts the master server? Where does it live?
- 4) In the first assignment, A1, a DataFrame represented an amount of data that may be too much to hold on one node. Is this still the case? Or will every DataFrame be reasonably sized, but data could be scattered over nodes?

Status

At the current time, we have a reasonable understanding of what must be done going forward to implement and design the full eau2 system. The Store class needs to support put/gets across the network. DataFrame needs to be updated to use DistributedArrays as its columns, which will result in a refactor of its serialization methods. Afterwards, we will be able to test loading an input SoR file into the distributed system and being able to query its data from another node. DataFrame also needs to support missing values. There are also a few memory issues with Row that need to be handled, though for the most part our tests are running with clean valgrind results.