Domino: An Incremental Computing Framework in Cloud with Eventual Synchronization

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Outline

• Motivation
• Domino Model
• Design and Implementation
• Evaluations
• Q & A
Motivation

- Continuous data streams are more and more important today.
- To process these streaming data, event-driven models have emerged, including Percolator, Oolong, etc.
- Event-Driven tasks are distributed into multiple servers and run in parallel.

- How to synchronize them becomes a big challenge
Motivation - Cont.

- Multi-iteration trigger-based applications requires synchronization between iterations

- We show two typical strategies to synchronize

  - Fig.(a): Sync needs to wait all triggers to finish. In streaming case, this is not possible as we do not know when previous triggers will finish.

  - Fig.(b): Each sync waits for a time window to start. This may introduce lots of unnecessary syncs.

- Our goal:

  - **trigger-based programming model with flexible sync mechanism for streaming data to avoid these limitations**
Domino Model

• Sparse table
  • Data streams are viewed as *insert* or *update* on table
  • Similar with Bigtable with multi-columns in different column families
  • Each data cell stores multi-version data

• Programming model
  • **Event**: Generated from the data modifications; Applications need to declare which columns, column-families, or table they are monitoring to detect the events.
  
  • **Condition**: Filter events to control the execution of triggers. It is user-defined function that returns true or false to denote whether current event should be processed or not.
  
  • **Action**: The real logic of application. It consumes the events and write the results back into sparse table persistently. Actions always run locally.

  • **Event + Condition + Action** $\Rightarrow$ **A Trigger**
Trigger Types

• **Plain trigger**
  - The simplest case. It responds to new data streams and executes independently in different servers in parallel.

• **Async accumulator trigger**
  - Accumulate partial results from other triggers in an async way.
  - Partial results arrive and activate the execution of accumulator triggers without any coordination.

• **Sync accumulator trigger**
  - Similar with Async accumulator trigger
  - Provide a self-managed eventual synchronization mechanism between partial results.
  - Avoid global blocking and make progress all the time.
Accumulator, Sync

- **Accumulator trigger**
  - For each accumulator trigger, Domino implicitly creates a table.
  - The *partial-results* is automatically monitored by accumulator trigger.
  - Previous results will be written into this table under the same column-family and trigger actions.
  - For the sync accumulator, Domino will use version management to guarantee the right results.

- **Version Management**
  - The sparse table stores multi-version data in each cell, which allows us to trace the execution status of each data.
  - We introduce two ids to trace the data: one represents the iteration round; one indicates the external data version.
  - The actions also have version information inherited from those two ids.
  - Whenever an action is triggered, it only can access the data with lower version number comparing the version number of itself.
PageRank Example

- Sparse table WebRepo stores the web repository.

- Application has two triggers:
  
  - **Plain trigger.**
    
    - Monitor the Meta column-family (Event);
    
    - If the changes are large enough (Condition);
    
    - Calculate all the out-edges’ weights (Action);
    
    - Write the out-edges’ weights to accumulator trigger (Key=edge.dst, Value=weights)
  
  - **Sync accumulator trigger.**
    
    - Monitor the implicit table, which stores the urls and the incoming edges’ weights (Event);
    
    - Accumulate all weights for each url to form a new page rank value (Action)
    
    - Write new page rank value to Meta:Rank column to activate next round.
Implementation

• Current tightly integrated with HBase,
  • Can work on any storage layers that support spare table and multi-version persistent storage.

• Event detector
  • Detects the updates on spare table
  • Intercept the core execution path of WAL (write-ahead-log) appending in HBase.

• Gathered I/O
  • Encapsulates all the data accesses in action function into a delegate to accelerate I/O operations.
Evaluations

- 12-node local cluster and 64-node EC2
- Word-count and PageRank
- Compare with MapReduce, Mimic Percolator, Oolong.

**Figure 3:** WordCount under different sizes.

**Figure 4:** PageRank under different changing sets.
Thanks! Q & A