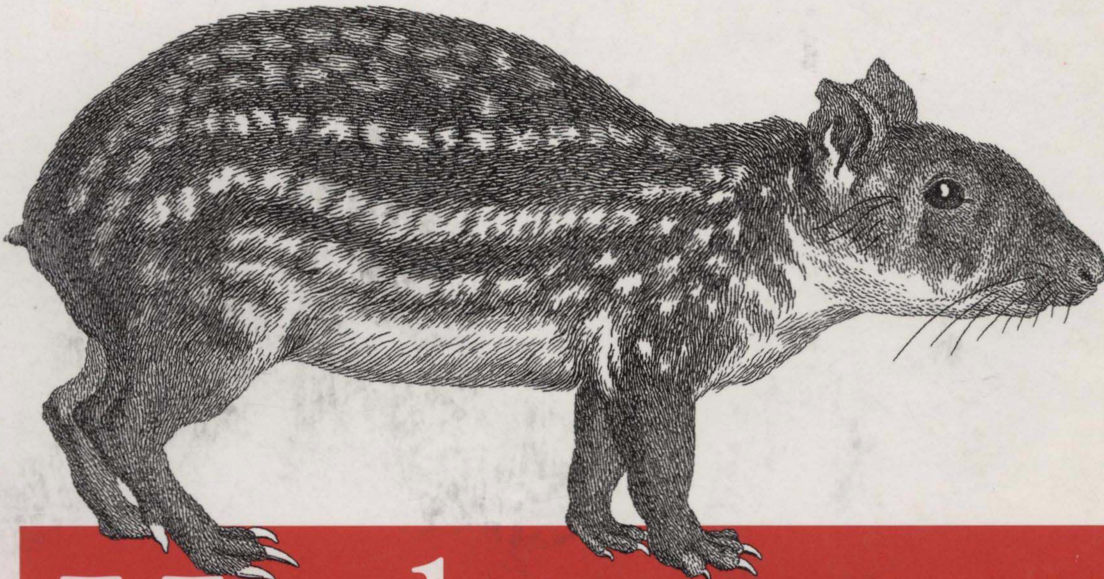
Hadoop操作手册（影印版）



Hadoop Operations

O'REILLY®

東南大學出版社

Eric Sammer 著

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For Aida.

Preface

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The following typographical conventions are used in this book:

Italic
: Indicates new terms, URLs, email addresses, filenames, and file extensions.

`Constant width`
: Used for program listings, as well as within paragraphs to refer to program elements such as variable or function names, databases, data types, environment variables, statements, and keywords.

`Constant width bold`
: Shows commands or other text that should be typed literally by the user.

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: Shows text that should be replaced with user-supplied values or by values determined by context.

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CHAPTER 1
Introduction

Over the past few years, there has been a fundamental shift in data storage, management, and processing. Companies are storing more data from more sources in more formats than ever before. This isn't just about being a "data packrat" but rather building products, features, and intelligence predicated on knowing more about the world (where the world can be users, searches, machine logs, or whatever is relevant to an organization). Organizations are finding new ways to use data that was previously believed to be of little value, or far too expensive to retain, to better serve their constituents. Sourcing and storing data is one half of the equation. Processing that data to produce *information* is fundamental to the daily operations of every modern business.

Data storage and processing isn't a new problem, though. Fraud detection in commerce and finance, anomaly detection in operational systems, demographic analysis in advertising, and many other applications have had to deal with these issues for decades. What has happened is that the volume, velocity, and variety of this data has changed, and in some cases, rather dramatically. This makes sense, as many algorithms benefit from access to more data. Take, for instance, the problem of recommending products to a visitor of an ecommerce website. You could simply show each visitor a rotating list of products they could buy, hoping that one would appeal to them. It's not exactly an informed decision, but it's a start. The question is what do you need to improve the chance of showing the right person the right product? Maybe it makes sense to show them what you think they like, based on what they've previously looked at. For some products, it's useful to know what they already own. Customers who already bought a specific brand of laptop computer from you may be interested in compatible accessories and upgrades.[1] One of the most common techniques is to cluster users by similar behavior (such as purchase patterns) and recommend products purchased by "similar" users. No matter the solution, all of the algorithms behind these options require data

1. I once worked on a data-driven marketing project for a company that sold beauty products. Using purchase transactions of all customers over a long period of time, the company was able to predict when a customer would run out of a given product after purchasing it. As it turned out, simply offering them the same thing about a week before they ran out resulted in a (very) noticeable lift in sales.

and generally improve in quality with more of it. Knowing more about a problem space generally leads to better decisions (or algorithm efficacy), which in turn leads to happier users, more money, reduced fraud, healthier people, safer conditions, or whatever the desired result might be.

Apache Hadoop is a platform that provides pragmatic, cost-effective, scalable infrastructure for building many of the types of applications described earlier. Made up of a distributed filesystem called the Hadoop Distributed Filesystem (HDFS) and a computation layer that implements a processing paradigm called MapReduce, Hadoop is an open source, batch data processing system for enormous amounts of data. We live in a flawed world, and Hadoop is designed to survive in it by not only tolerating hardware and software failures, but also treating them as first-class conditions that happen regularly. Hadoop uses a cluster of plain old commodity servers with no specialized hardware or network infrastructure to form a single, logical, storage and compute platform, or *cluster*, that can be shared by multiple individuals or groups. Computation in Hadoop MapReduce is performed in parallel, automatically, with a simple abstraction for developers that obviates complex synchronization and network programming. Unlike many other distributed data processing systems, Hadoop runs the user-provided processing logic on the machine where the data lives rather than dragging the data across the network; a huge win for performance.

For those interested in the history, Hadoop was modeled after two papers produced by Google, one of the many companies to have these kinds of data-intensive processing problems. The first, presented in 2003, describes a pragmatic, scalable, distributed filesystem optimized for storing enormous datasets, called the Google Filesystem (*http://research.google.com/archive/gfs.html*), or *GFS*. In addition to simple storage, GFS was built to support large-scale, data-intensive, distributed processing applications. The following year, another paper, titled "MapReduce: Simplified Data Processing on Large Clusters (*http://research.google.com/archive/mapreduce.html*)," was presented, defining a programming model and accompanying framework that provided automatic parallelization, fault tolerance, and the scale to process hundreds of terabytes of data in a single job over thousands of machines. When paired, these two systems could be used to build large data processing clusters on relatively inexpensive, commodity machines. These papers directly inspired the development of HDFS and Hadoop MapReduce, respectively.

Interest and investment in Hadoop has led to an entire ecosystem of related software both open source and commercial. Within the Apache Software Foundation alone, projects that explicitly make use of, or integrate with, Hadoop are springing up regularly. Some of these projects make authoring MapReduce jobs easier and more accessible, while others focus on getting data in and out of HDFS, simplify operations, enable deployment in cloud environments, and so on. Here is a sampling of the more popular projects with which you should familiarize yourself:

Apache Hive (http://hive.apache.org)
: Hive creates a relational database–style abstraction that allows developers to write a dialect of SQL, which in turn is executed as one or more MapReduce jobs on the cluster. Developers, analysts, and existing third-party packages already know and speak SQL (Hive's dialect of SQL is called HiveQL and implements only a subset of any of the common standards). Hive takes advantage of this and provides a quick way to reduce the learning curve to adopting Hadoop and writing MapReduce jobs. For this reason, Hive is by far one of the most popular Hadoop ecosystem projects.

  Hive works by defining a table-like schema over an *existing* set of files in HDFS and handling the gory details of extracting records from those files when a query is run. The data on disk is never actually changed, just parsed at query time. HiveQL statements are interpreted and an execution plan of prebuilt map and reduce classes is assembled to perform the MapReduce equivalent of the SQL statement.

Apache Pig (http://pig.apache.org)
: Like Hive, Apache Pig was created to simplify the authoring of MapReduce jobs, obviating the need to write Java code. Instead, users write data processing jobs in a high-level scripting language from which Pig builds an execution plan and executes a series of MapReduce jobs to do the heavy lifting. In cases where Pig doesn't support a necessary function, developers can extend its set of built-in operations by writing user-defined functions in Java (Hive supports similar functionality as well). If you know Perl, Python, Ruby, JavaScript, or even shell script, you can learn Pig's syntax in the morning and be running MapReduce jobs by lunchtime.

Apache Sqoop (http://sqoop.apache.org)
: Not only does Hadoop not want to replace your database, it wants to be friends with it. Exchanging data with relational databases is one of the most popular integration points with Apache Hadoop. Sqoop, short for "SQL to Hadoop," performs bidirectional data transfer between Hadoop and almost any database with a JDBC driver. Using MapReduce, Sqoop performs these operations in parallel with no need to write code.

  For even greater performance, Sqoop supports database-specific plug-ins that use native features of the RDBMS rather than incurring the overhead of JDBC. Many of these connectors are open source, while others are free or available from commercial vendors at a cost. Today, Sqoop includes native connectors (called *direct* support) for MySQL and PostgreSQL. Free connectors exist for Teradata, Netezza, SQL Server, and Oracle (from Quest Software), and are available for download from their respective company websites.

Apache Flume (http://flume.apache.org)
: Apache Flume is a streaming data collection and aggregation system designed to transport massive volumes of data into systems such as Hadoop. It supports native connectivity and support for writing directly to HDFS, and simplifies reliable, streaming data delivery from a variety of sources including RPC services, log4j appenders, syslog, and even the output from OS commands. Data can be routed,

load-balanced, replicated to multiple destinations, and aggregated from thousands of hosts by a tier of agents.

Apache Oozie (http://incubator.apache.org/oozie/)
It's not uncommon for large production clusters to run many coordinated MapReduce jobs in a workfow. Apache Oozie is a workflow engine and scheduler built specifically for large-scale job orchestration on a Hadoop cluster. Workflows can be triggered by time or events such as data arriving in a directory, and job failure handling logic can be implemented so that policies are adhered to. Oozie presents a REST service for programmatic management of workflows and status retrieval.

Apache Whirr (http://whirr.apache.org)
Apache Whirr was developed to simplify the creation and deployment of ephemeral clusters in cloud environments such as Amazon's AWS. Run as a command-line tool either locally or within the cloud, Whirr can spin up instances, deploy Hadoop, configure the software, and tear it down on demand. Under the hood, Whirr uses the powerful jclouds (*http://www.jclouds.org/*) library so that it is cloud provider–neutral. The developers have put in the work to make Whirr support both Amazon EC2 and Rackspace Cloud. In addition to Hadoop, Whirr understands how to provision Apache Cassandra, Apache ZooKeeper, Apache HBase, ElasticSearch, Voldemort, and Apache Hama.

Apache HBase (http://hbase.apache.org)
Apache HBase is a low-latency, distributed (nonrelational) database built on top of HDFS. Modeled after Google's Bigtable (*http://research.google.com/archive/bigtable.html*), HBase presents a flexible data model with scale-out properties and a very simple API. Data in HBase is stored in a semi-columnar format partitioned by rows into *regions*. It's not uncommon for a single table in HBase to be well into the hundreds of terabytes or in some cases petabytes. Over the past few years, HBase has gained a massive following based on some very public deployments such as Facebook's Messages platform (*http://www.facebook.com/note.php?note_id=454991608919*). Today, HBase is used to serve huge amounts of data to real-time systems in major production deployments.

Apache ZooKeeper (http://zookeeper.apache.org)
A true workhorse, Apache ZooKeeper is a distributed, consensus-based coordination system used to support distributed applications. Distributed applications that require leader election, locking, group membership, service location, and configuration services can use ZooKeeper rather than reimplement the complex coordination and error handling that comes with these functions. In fact, many projects within the Hadoop ecosystem use ZooKeeper for exactly this purpose (most notably, HBase).

Apache HCatalog (http://incubator.apache.org/hcatalog/)
A relatively new entry, Apache HCatalog is a service that provides shared schema and data access abstraction services to applications with the ecosystem. The