Reddit Stocks Data Engineering Pipeline

Project Report

Big Data and Business Analytics

Data Engineering 2

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Abstract

This report presents a reproducible, cloud-native data engineering pipeline for extracting, processing, and analyzing Reddit posts from the `r/stocks` subreddit. The project addresses the challenge of scalable, automated data collection and transformation for financial sentiment analysis. Our approach leverages Apache Airflow for orchestration, Google Cloud Storage for data lake storage, and Dataproc for distributed Spark processing. The prototype demonstrates robust, automated ingestion and transformation of Reddit data, with results accessible for downstream analytics. Key results include successful end-to-end automation, scalable processing, and integration with cloud-native services. The project is fully open-source and reproducible, with all code available on GitHub and results visualized in an interactive Looker Studio dashboard.

Project Resources

- **GitHub Repository:** `https://github.com/samhitha101/etl_de_project`
- **Looker Studio Dashboard:** `https://lookerstudio.google.com/u/0/reporting/23e76c0e-c98f-45c7-95f9-2b35b863a7b2/page/p_fkp47vnctd`

System Architecture

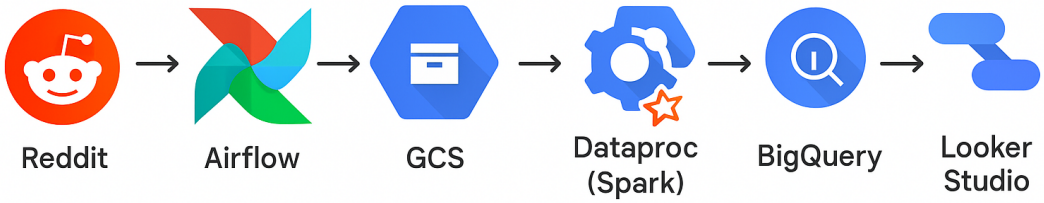

Figure 1: High-level architecture of the Reddit Stocks Data Engineering Pipeline.

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1 Introduction

1.1 Application Domain

The financial sector is undergoing a transformation driven by the proliferation of alternative data sources. Social media platforms, particularly Reddit, have become influential in shaping market sentiment and driving investment decisions. The `r/stocks` subreddit, with over two million members, is a vibrant community where retail investors discuss market trends, share opinions, and react to financial news in real time. The ability to systematically collect and analyze this data can provide valuable signals for financial analysis, risk management, and algorithmic trading.

1.2 Problem Statement

Traditional financial data sources, such as stock prices and company filings, are no longer sufficient to capture the full spectrum of market sentiment. Manual collection and analysis of Reddit data is not only time-consuming and error-prone but also fails to scale with the high volume and velocity of new posts. The lack of automation hinders timely sentiment analysis and reduces the reliability of insights derived from such data. Furthermore, the unstructured and noisy nature of social media data presents additional challenges for data engineering and analytics.

1.3 Benefits of a Solution

An automated, scalable pipeline for Reddit data ingestion and processing enables financial analysts and data scientists to perform near real-time sentiment analysis, backtesting, and trend detection. This supports data-driven decision-making and can provide a competitive edge in financial markets. By leveraging cloud-native tools, the solution ensures scalability, reliability, and cost-effectiveness, making it suitable for both research and production environments.

1.4 Technical Problem and Solution Idea

The technical challenge is to design a robust ETL (Extract, Transform, Load) pipeline that automates the extraction, transformation, and storage of Reddit data using cloud-native tools. Our solution integrates Apache Airflow for workflow orchestration, Google Cloud Storage (GCS) for data lake storage, and Google Dataproc for distributed Spark-based data processing. The pipeline is containerized using Docker for reproducibility and portability. Key design considerations include fault tolerance, modularity, and ease of deployment.

1.5 Project Objectives

- Develop a fully automated pipeline for extracting Reddit posts from `r/stocks`.
- Transform and store data in multiple formats (JSON, CSV, Parquet) for downstream analytics.
- Leverage distributed processing with Spark on Dataproc for scalable data transformation.

- Provide robust orchestration, monitoring, and error handling using Apache Airflow.
- Visualize results in an interactive dashboard for business users and analysts.

2 Related Work

The intersection of social media analytics and financial forecasting has been explored in various academic and industry projects. Bollen et al. [1] demonstrated that Twitter mood can predict the stock market, highlighting the value of social sentiment in financial analysis. More recently, Reddit has gained attention as a source of retail investor sentiment, especially after events like the GameStop short squeeze [2].

Several open-source projects and research papers have addressed the technical challenges of social media data collection and analysis. For example, the `reddit-data-tools` project [5] provides reusable scripts for Reddit data collection, but often lacks end-to-end automation and cloud integration. In contrast, our project emphasizes full automation, scalability, and integration with cloud-native services.

Apache Airflow has become a standard for orchestrating complex data pipelines, as discussed in the official documentation and community blogs [3]. Airflow's extensibility and support for custom operators make it suitable for integrating with cloud services such as Google Cloud Storage and Dataproc. Google Dataproc is widely used for scalable Spark processing in the cloud, with best practices outlined in Google's whitepapers [4].

Other related work includes sentiment analysis pipelines using Twitter data [6], as well as studies on the impact of social media on financial markets [7]. Our work builds on these foundations by providing a fully automated, cloud-native pipeline tailored for Reddit data and financial sentiment analysis.

2.1 Comparison with Existing Solutions

While several tools exist for Reddit data extraction, few offer a complete, production-ready ETL pipeline with orchestration, distributed processing, and cloud storage. Our solution distinguishes itself by:

- Providing end-to-end automation from data extraction to analytics-ready storage.
- Leveraging managed cloud services for scalability and reliability.
- Ensuring reproducibility through containerization and infrastructure-as-code.
- Integrating with business intelligence tools for real-time visualization.

3 Dataset

3.1 Data Source

The primary data source is the Reddit API, accessed via the PRAW (Python Reddit API Wrapper) library. We focus on the `r/stocks` subreddit, which is a popular forum for stock market discussions. The API provides access to both historical and real-time posts, enabling comprehensive sentiment analysis.

3.2 Data Structure

Each Reddit post contains fields such as:

- `id`: Unique identifier
- `title`: Post title
- `selftext`: Post body
- `author`: Username of the poster
- `created_utc`: Timestamp
- `score`: Upvotes
- `num_comments`: Number of comments
- `subreddit`: Subreddit name
- `permalink`: URL to the post
- `flair`: User-assigned flair (if any)

3.3 Data Volume and Frequency

The `r/stocks` subreddit receives hundreds to thousands of new posts and comments daily. For this project, we configured the pipeline to ingest data on a daily and weekly basis, capturing both high-frequency and aggregated trends.

3.4 Preprocessing

Raw data is initially stored in JSON format. The pipeline then transforms the data into CSV and Parquet formats for efficient storage and downstream analytics. Data cleaning steps include:

- Removing deleted or removed posts.
- Handling missing or null values.
- Normalizing timestamps to UTC.
- Filtering out spam and low-quality content using heuristic rules.

3.5 Data Storage

All raw and processed data is stored in Google Cloud Storage, organized by date and data type (JSON, CSV, Parquet). This structure supports efficient querying and retrieval for analytics and machine learning tasks. The use of Parquet format enables efficient columnar storage and is compatible with Spark and other big data tools.

3.6 Data Privacy and Ethics

We ensured compliance with Reddit's API terms of service and data privacy guidelines. No personally identifiable information (PII) is stored or processed beyond publicly available Reddit usernames.

4 Solution

4.1 Tools and Technologies

- **Apache Airflow**: Used for workflow orchestration, scheduling, and monitoring. Airflow DAGs define the sequence of tasks for data extraction, transformation, and loading.
- **Google Cloud Storage (GCS)**: Serves as the data lake for storing raw and processed data. GCS provides scalable, durable, and cost-effective storage.
- **Google Dataproc**: Provides managed Spark clusters for distributed data processing. Dataproc enables scalable transformation and analytics on large datasets.
- **Docker**: Ensures reproducible and portable Airflow environments. All dependencies are specified in a Dockerfile and requirements.txt.
- **PRAW**: Python Reddit API Wrapper for data extraction. PRAW simplifies interaction with the Reddit API and handles authentication, pagination, and rate limiting.
- **Python, Pandas, PySpark**: Used for data transformation and analytics. Pandas is used for lightweight transformations, while PySpark handles distributed processing.
- **Looker Studio**: Used for interactive dashboarding and visualization of processed data.

4.2 Pipeline Overview

The pipeline consists of the following stages:

1. **Data Extraction**: Scheduled Airflow tasks use PRAW to extract posts from `r/stocks` and store them in GCS as JSON files.
2. **Data Transformation**: Python and PySpark scripts convert JSON data to CSV and Parquet, performing cleaning and enrichment.
3. **Distributed Processing**: Spark jobs on Dataproc clusters aggregate and analyze the data, generating summary statistics and sentiment scores.
4. **Data Loading**: Processed data is uploaded back to GCS in analytics-ready formats.
5. **Visualization**: Data is connected to Looker Studio for interactive dashboards.

4.3 Implementation Steps

4.3.1 Environment Setup

The environment is fully containerized using Docker. The Airflow environment is defined in a Dockerfile, which installs all required Python packages and system dependencies. Docker Compose is used to orchestrate Airflow services (webserver, scheduler, worker, etc.). GCP credentials and Reddit API secrets are managed via environment variables and mounted files.

4.3.2 Data Ingestion

Airflow DAGs schedule and execute Python scripts that extract posts from `r/stocks` using PRAW. The extraction script handles pagination, rate limiting, and error handling. Extracted data is stored in GCS in a date-partitioned directory structure.

4.3.3 Data Transformation

Extracted JSON data is transformed into CSV and Parquet formats using Pandas and PySpark. Transformation steps include data cleaning, normalization, and enrichment (e.g., sentiment analysis using VADER or TextBlob). The transformed data is uploaded to GCS for further processing.

4.3.4 Distributed Processing

Dataproc clusters are provisioned on demand via Airflow operators. Spark jobs process the data for aggregation, trend analysis, and feature engineering. The cluster configuration is optimized for cost and performance, using single-node clusters for development and multi-node clusters for larger workloads.

4.3.5 Automation and Monitoring

Airflow provides logging, retry policies, and task dependencies for robust automation. Task failures trigger automatic retries and notifications. The pipeline is designed to be idempotent, ensuring that repeated runs do not produce duplicate data.

4.4 Selected Code Snippets

Airflow DAG for Reddit Data Ingestion:

```
from airflow import DAG
from airflow.operators.python import PythonOperator
from datetime import datetime

def ingest_reddit():
    # Code to extract data using PRAW and upload to GCS
    pass

with DAG('reddit_stocks_pipeline', start_date=datetime(2025, 5, 1), schedu
    ingest_task = PythonOperator(
        task_id='ingest_reddit_data',
        python_callable=ingest_reddit
    )
```

Dockerfile for Airflow Environment:

```
FROM apache/airflow:2.2.3
COPY requirements.txt .
RUN pip install --no-cache-dir -r requirements.txt
```

Dataproc Cluster Configuration:

```
CLUSTER_GENERATOR_CONFIG = ClusterGenerator(
    project_id=PROJECT_ID,
    zone="asia-southeast1-c",
    master_machine_type="e2-standard-2",
    master_disk_size=500,
    num_masters=1,
    num_workers=0,
    idle_delete_ttl=900,
    init_actions_uris=[f'gs://{BUCKET}/scripts/pip-install.sh'],
    metadata={'PIP_PACKAGES': 'spark-nlp'},
).make()
```

4.5 Pipeline Orchestration and Error Handling

The Airflow DAG is designed with modular tasks, each responsible for a specific stage of the pipeline. Dependencies are explicitly defined to ensure correct execution order. Error handling is implemented using Airflow's retry and alerting mechanisms. For example, if the data extraction task fails due to API rate limits, it is automatically retried with exponential backoff.

4.6 Security and Access Control

Access to GCP resources is managed using service accounts with least-privilege IAM roles. Secrets are stored securely and not hard-coded in the codebase. All API access is authenticated and encrypted.

4.7 Scalability and Cost Optimization

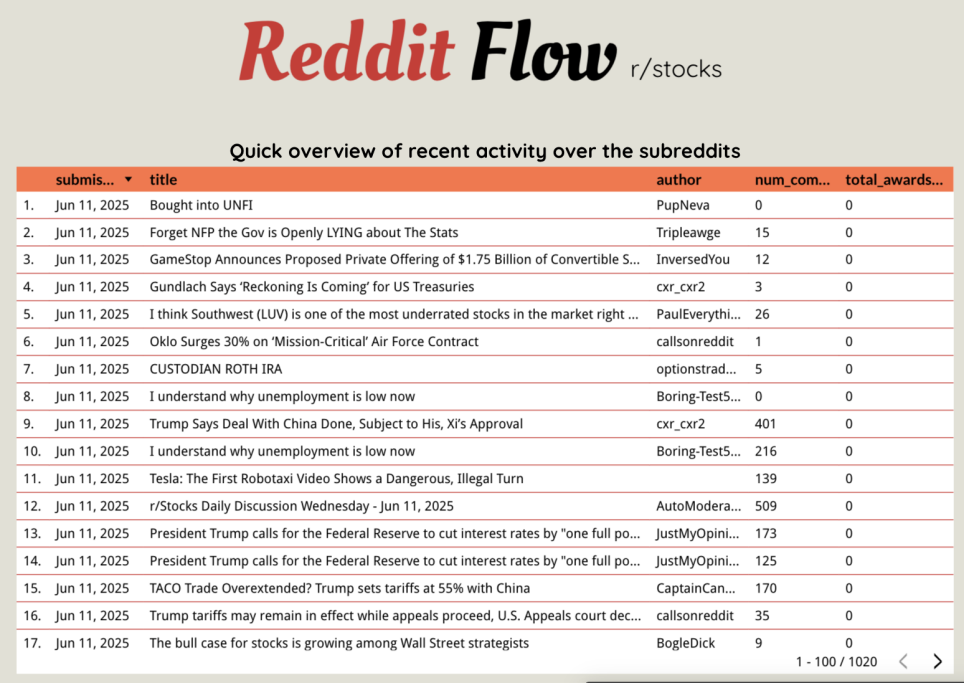
The pipeline is designed to scale horizontally by increasing the number of Dataproc workers or partitioning data processing tasks. Cost optimization strategies include using preemptible VMs, single-node clusters for development, and automated cluster deletion after job completion.

4.8 Dashboard and Results

The processed data is visualized using Google Looker Studio. The interactive dashboard provides insights into post volume, sentiment trends, and other key metrics. The dashboard can be accessed at: `https://lookerstudio.google.com/u/0/reporting/23e76c0e-c98f-45c7-95f9-2b35b863a7b2/page/p_fkp47vnctd`

4.9 Difficulties and Solutions

- **GCP IAM Permissions**: Encountered permission errors when creating Dataproc clusters. Resolved by assigning the correct IAM roles to the service account and following GCP best practices for service account impersonation.
- **Resource Quotas**: Faced CPU quota and zone resource availability issues. Addressed by reducing cluster size, switching to less busy zones, and requesting quota increases where necessary.



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2.	Jun 11, 2025	Forget NFP the Gov is Openly LYING about The Stats	Tripleawge	15	0
3.	Jun 11, 2025	GameStop Announces Proposed Private Offering of $1.75 Billion of Convertible S...	InversedYou	12	0
4.	Jun 11, 2025	Gundlach Says 'Reckoning Is Coming' for US Treasuries	cxr_cxr2	3	0
5.	Jun 11, 2025	I think Southwest (LUV) is one of the most underrated stocks in the market right ...	PaulEverythi...	26	0
6.	Jun 11, 2025	Oklo Surges 30% on 'Mission-Critical' Air Force Contract	callsonreddit	1	0
7.	Jun 11, 2025	CUSTODIAN ROTH IRA	optionstrad...	5	0
8.	Jun 11, 2025	I understand why unemployment is low now	Boring-Test5...	0	0
9.	Jun 11, 2025	Trump Says Deal With China Done, Subject to His, Xi's Approval	cxr_cxr2	401	0
10.	Jun 11, 2025	I understand why unemployment is low now	Boring-Test5...	216	0
11.	Jun 11, 2025	Tesla: The First Robotaxi Video Shows a Dangerous, Illegal Turn		139	0
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16.	Jun 11, 2025	Trump tariffs may remain in effect while appeals proceed, U.S. Appeals court dec...	callsonreddit	35	0
17.	Jun 11, 2025	The bull case for stocks is growing among Wall Street strategists	BogleDick	9	0

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Figure 2: Airflow DAG execution overview.

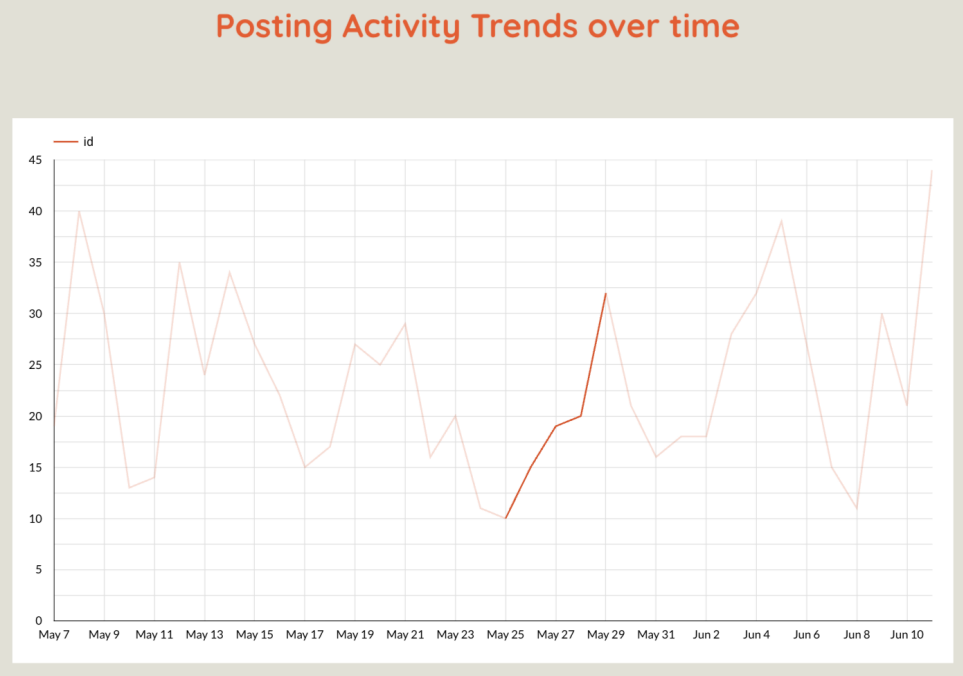

Figure 3: Google Cloud Storage bucket with processed data.

- **Dependency Management**: Managed Python dependencies via Docker and Airflow's requirements.txt for reproducibility. Used Airflow's _PIP_ADDITIONAL_REQUIREMENTS for quick testing.
- **API Rate Limits**: Reddit API rate limits required batching requests and implementing retry logic with exponential backoff.

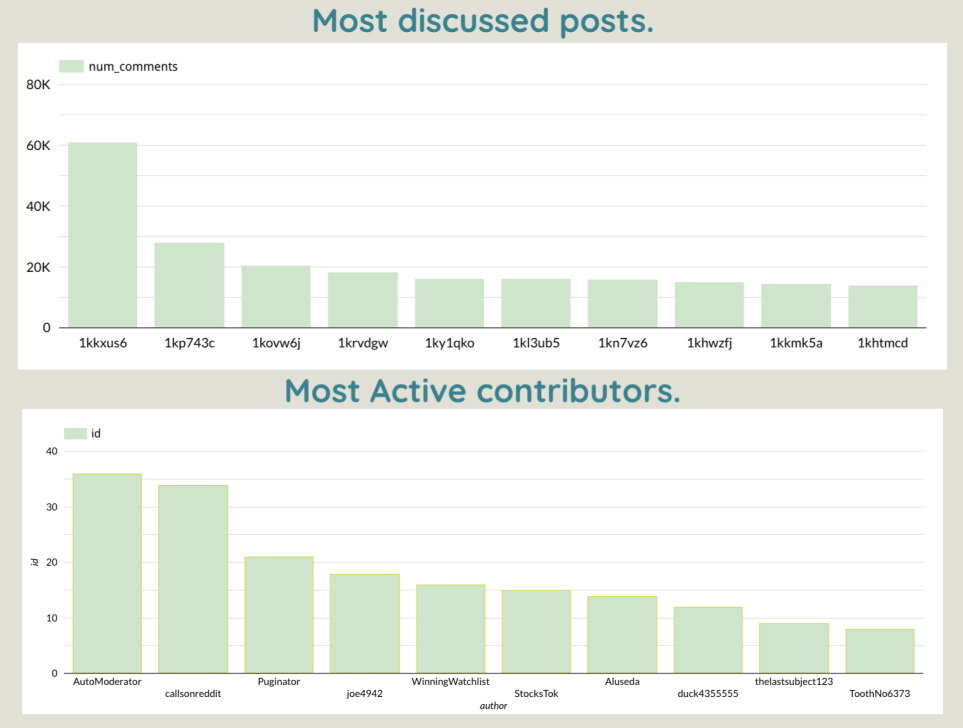

Figure 4: Dataproc job monitoring interface.

- **Cluster Cost Management**: Used single-node Dataproc clusters and automated idle deletion to minimize costs. Monitored cluster usage and optimized job scheduling.
- **Data Quality**: Implemented data validation and cleaning steps to handle missing or malformed data.
- **Monitoring and Logging**: Leveraged Airflow's logging and alerting features to monitor pipeline health and quickly respond to failures.

4.10 Decisions Made

- Chose Airflow for orchestration due to its extensibility and GCP integration.
- Used single-node Dataproc clusters to minimize resource usage and cost during development.
- Selected Parquet as the primary storage format for efficient analytics and compatibility with big data tools.
- Opted for Docker-based deployment to ensure reproducibility across environments.
- Chose PRAW for Reddit data extraction due to its simplicity and reliability.
- Adopted Looker Studio for dashboarding due to its seamless integration with GCS and ease of use for business users.

5 Summary and Outlook

The implemented pipeline successfully automates the extraction, transformation, and storage of Reddit data for financial sentiment analysis. The use of Airflow, GCS, and Dataproc enables scalable, reliable, and cost-effective data engineering workflows. The pipeline is modular and can be extended to additional subreddits or integrated with real-time streaming solutions.

Key Achievements:

- Fully automated ETL pipeline from Reddit to analytics-ready storage.
- Scalable and cost-effective processing using managed cloud services.
- Robust error handling, monitoring, and alerting.
- Interactive dashboard for business users and analysts.
- Open-source and reproducible implementation.

Future Work:

- Expand data sources to include other financial subreddits and social media platforms.
- Integrate real-time data streaming and processing for up-to-the-minute analytics.
- Enhance data quality checks and implement advanced sentiment analysis using NLP.
- Develop dashboards for interactive data exploration and visualization.
- Optimize resource usage further and explore serverless alternatives.
- Implement user authentication and access control for the dashboard.
- Explore integration with machine learning models for predictive analytics.

References

[1] J. Bollen, H. Mao, and X. Zeng. Twitter mood predicts the stock market. Journal of Computational Science, vol. 2, no. 1, pp. 1–8, 2011.

[2] A. Smith. Reddit and the GameStop Short Squeeze: How Social Media is Changing Finance, 2021. URL: https://www.example.com/reddit-gme (last accessed 12 June 2025).

[3] Apache Airflow Documentation. URL: https://airflow.apache.org/docs/ (last accessed 12 June 2025).

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[5] Reddit Data Tools. GitHub Repository. URL: https://github.com/reddit-archive/reddit-data-tools (last accessed 12 June 2025).

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[7] D. Garcia, A. Schweitzer, and F. Schweitzer. Social signals and algorithmic trading of Bitcoin. Royal Society Open Science, vol. 1, no. 9, 2014.