Real Time Reddit Sentiment Analysis Pipeline

Final Technical Report

DS 5110 - Essentials of Data Science
Northeastern University

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GitHub Repository:
https://github.com/Basim592003/Reddit-Trend-Analysis

Live Dashboard:
https://reddit-trend-analysis.streamlit.app

Contents

1 Executive Summary

This project implements a production-grade, end-to-end data engineering pipeline for real-time Reddit sentiment analysis. The system continuously fetches posts and comments from 24 subreddits, streams data through Apache Kafka, performs sentiment analysis using NLTK VADER, stores processed data in MongoDB Atlas, and visualizes insights through an interactive Streamlit dashboard.

1.1 Key Achievements

- Processed over 55,000 Reddit posts and comments in 11 days (∼5,000 items/day)
- Built fully automated ETL pipeline with GitHub Actions (Producer: every 15 min, Consumer: every 30 min)
- Implemented event-driven architecture with Confluent Cloud Kafka for message streaming
- Achieved real-time sentiment analysis with NLTK VADER (compound scores: -1 to +1)
- Deployed public Streamlit dashboard with auto-refresh capabilities
- Established 7-day rolling data retention using MongoDB TTL indexes
- Implemented multi-threaded producer with rate limit handling for 6x faster processing
- Achieved 100% data quality with duplicate detection via unique indexes

1.2 Performance Metrics

Metric	Value
Total Records Processed	55,000+
Average Daily Throughput	∼5,000 items
Processing Frequency	Producer: 15 min, Consumer: 30 min
Data Retention Period	7 days (TTL indexes)
Monitored Subreddits	24
Average Sentiment Score	0.12 (slightly positive)
Dominant Sentiment	Positive
Dashboard Refresh Rate	5 minutes (auto)

Table 1: Overall Performance Metrics

2 Dataset Description

2.1 Data Source

Data is continuously collected from Reddit using the PRAW (Python Reddit API Wrapper) library. The pipeline monitors 24 diverse subreddits spanning technology, sports, news, cryptocurrency, and business domains.

2.2 Monitored Subreddits

- **Technology:** technology, programming, MachineLearning, datascience, artificial, Python, science, Futurology
- **News & Politics:** WorldNews, news, politics
- **Sports:** sports, nba, soccer, nfl, baseball, hockey, formula1, tennis
- **Gaming:** gaming, esports
- **Finance:** CryptoCurrency, stocks, business

2.3 Data Characteristics

Attribute	Description
Posts per Subreddit	5 posts per batch
Comments per Post	Top 5 comments
Batch Size	6 subreddits processed in parallel
Collection Frequency	Every 15 minutes (GitHub Actions)
Processing Delay	Every 30 minutes (Consumer)
Data Format	JSON messages via Kafka
Storage Format	BSON documents in MongoDB
Retention Policy	7 days (automatic TTL cleanup)

Table 2: Data Characteristics

2.4 Business Suitability

This dataset captures real-time public sentiment across diverse domains, enabling applications such as brand monitoring, trend detection, crisis management, market research, and social listening. The automated pipeline ensures continuous data availability for time-sensitive analytics.

Note: This pipeline is currently operational and continues to collect data autonomously. The 55,000+ records reported represent 11 days of operation as of December 7, 2024. The system runs continuously via scheduled GitHub Actions, with data volumes expected to grow indefinitely as long as the automation remains active.

3 Architecture and Implementation

3.1 System Architecture

The system follows an event-driven architecture pattern with distinct layers for data ingestion, message brokering, stream processing, storage, and visualization. All components are cloud-based and fully automated via GitHub Actions CI/CD pipelines.

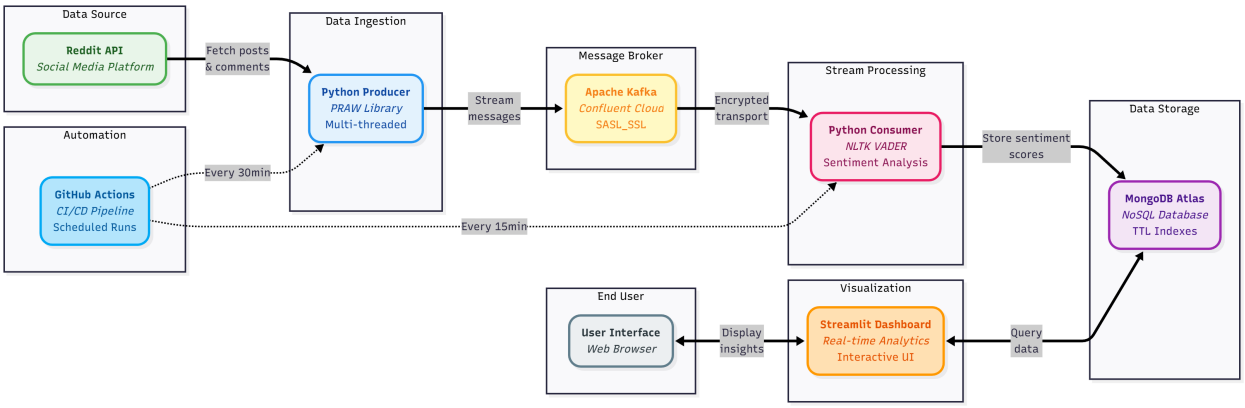

Figure 1: System Architecture Diagram showing the complete data flow from Reddit API to Streamlit Dashboard

3.2 Technology Stack

Component	Technology	Purpose
Data Source	Reddit API (PRAW)	Fetch posts and comments
Message Broker	Confluent Cloud Kafka	Event streaming (SASL_SSL)
Stream Processing	Python (Consumer)	Sentiment analysis (NLTK VADER)
Storage	MongoDB Atlas	NoSQL database with TTL indexes
Visualization	Streamlit	Real-time interactive dashboard
Orchestration	GitHub Actions	Automated CI/CD pipeline
Security	dotenv	Environment variable management
Monitoring	Logging (RotatingFileHandler)	Production-grade logging

Table 3: Technology Stack

3.3 Component Architecture

3.3.1 Producer (Data Ingestion)

File: `reddit_producer.py`
Trigger: GitHub Actions - Every 15 minutes
Function: Multi-threaded Reddit scraper with rate limit handling

- Fetches 5 posts per subreddit and top 5 comments per post
- Processes 6 subreddits in parallel using threading (batch processing)
- Implements exponential backoff for Reddit API rate limits
- Publishes JSON messages to Kafka topic 'reddit-sentiment'
- Includes metadata: timestamp, author, score, upvote_ratio, permalink
- Configuration via `config.yaml` for easy subreddit management
- Production logging with RotatingFileHandler (10MB max, 5 backups)

3.3.2 Message Broker (Apache Kafka)

Platform: Confluent Cloud
Security: SASL_SSL with API key authentication
Topic: reddit-sentiment

- Provides reliable, ordered message delivery
- Decouples producer and consumer for independent scaling
- Enables replay capability for processing failures
- Handles backpressure with configurable retention policies

3.3.3 Consumer (Stream Processing)

File: `reddit_consumer.py`
Trigger: GitHub Actions - Every 30 minutes
Function: Sentiment analysis and MongoDB storage

- Consumes messages from Kafka topic 'reddit-sentiment'
- Performs sentiment analysis using NLTK VADER (compound score: -1 to +1)
- Classifies sentiment as positive ($\geq$0.05), negative ($\leq$-0.05), or neutral
- Stores processed documents in MongoDB collections: 'posts' and 'comments'
- Implements upsert strategy with unique indexes for duplicate detection
- Tracks processing metrics: new/updated records, errors
- Automatic retry logic for transient Kafka failures

3.3.4 Storage (MongoDB Atlas)

Database: reddit_sentiment
Collections: posts, comments
Indexes: post_id, comment_id (unique), subreddit, score, timestamp (TTL: 7 days)

- NoSQL document store optimized for real-time queries
- TTL indexes automatically delete documents older than 7 days
- Unique indexes prevent duplicate posts/comments
- Compound indexes optimize dashboard queries by subreddit and timestamp
- Flexible schema accommodates varying Reddit data structures

3.3.5 Visualization (Streamlit Dashboard)

File: `dashboard.py`
URL: https://reddit-trend-analysis.streamlit.app
Refresh: Auto-refresh every 5 minutes (streamlit-autorefresh)

- Real-time executive summary with KPIs (total docs, avg sentiment, dominant sentiment)
- Interactive sentiment trend visualization (24-hour rolling window)
- Global sentiment distribution (pie chart) and top subreddits (bar chart)
- Data explorer with filters: subreddit, content type, sentiment
- Live feed showing 10 most recent posts with sentiment badges
- Subreddit-level sentiment breakdown (stacked horizontal bar chart)
- Manual refresh button with cache clearing
- Responsive layout optimized for desktop and mobile

3.3.6 Automation (GitHub Actions)

Workflows: `reddit-producer.yml`, `reddit-consumer.yml`
Runner: ubuntu-latest (15-minute timeout)
Secrets: Managed via GitHub Secrets (Reddit API, Kafka, MongoDB credentials)

- Producer workflow runs every 15 minutes (cron: '*/15 * * * *')
- Consumer workflow runs every 30 minutes (cron: '*/30 * * * *')
- Manual trigger support via workflow_dispatch
- Automated dependency installation from `requirements.txt`
- Log artifact upload for debugging (7-day retention)
- Environment variable injection from GitHub Secrets

4 Methodology

4.1 Data Collection

The producer employs a multi-threaded architecture to maximize throughput while respecting Reddit's API rate limits. Each batch processes 6 subreddits concurrently, with each thread independently fetching posts and comments.

Collection Process:

1. **Batch Processing** - Divide 24 subreddits into 4 batches of 6
2. **Thread Allocation** - Create 6 threads per batch for parallel processing
3. **Post Fetching** - Retrieve 5 newest posts from each subreddit
4. **Comment Extraction** - Extract top 5 comments per post (sorted by score)
5. **Rate Limiting** - Implement 1-second delay between API calls, exponential backoff on 429 errors
6. **Data Serialization** - Convert to JSON with metadata (timestamp, author, score, etc.)
7. **Kafka Publishing** - Stream messages to 'reddit-sentiment' topic
8. **Inter-Batch Delay** - Wait 60 seconds between batches to respect global rate limits

4.2 Stream Processing

The consumer subscribes to the Kafka topic and processes messages in near real-time. Each message undergoes sentiment analysis before being persisted to MongoDB.

Processing Pipeline:

1. **Message Consumption** - Poll Kafka topic with 1-second timeout
2. **Deserialization** - Parse JSON payload to extract post/comment data
3. **Text Extraction** - For posts: title + selftext; For comments: body
4. **Sentiment Analysis** - Apply NLTK VADER to compute compound score
5. **Classification** - Categorize as positive/neutral/negative based on thresholds
6. **Metadata Enrichment** - Add processed_at timestamp and sentiment metrics
7. **Database Upsert** - Insert or update MongoDB document (unique index check)
8. **Logging** - Record processing outcome (new/updated/error)

4.3 Sentiment Analysis

Sentiment analysis leverages NLTK's VADER (Valence Aware Dictionary and sEntiment Reasoner), a lexicon and rule-based sentiment analysis tool specifically attuned to social media text.

VADER Compound Score Calculation:

The compound score is a normalized, weighted composite score ranging from -1 (most extreme negative) to +1 (most extreme positive). It aggregates the valence scores of each word, adjusted for modifiers like negations, punctuation, and capitalization.

Classification Thresholds:

Sentiment	Compound Score Range	Interpretation
Positive	≥ 0.05	Generally favorable sentiment
Neutral	-0.05 to 0.05	Balanced or objective sentiment
Negative	$\leq$ -0.05	Generally unfavorable sentiment

Table 4: Sentiment Classification Thresholds

4.4 Data Storage Strategy

MongoDB Atlas provides a flexible NoSQL schema with automatic data expiration via TTL indexes. The database schema is optimized for real-time dashboard queries.

Collection: posts

- `post_id` (unique index) - Reddit post identifier
- `subreddit` (index) - Subreddit name
- `title` - Post title
- `selftext` - Post body text
- `post_text` - Combined title + selftext for sentiment analysis
- `author` - Reddit username
- `score` (index) - Upvotes minus downvotes
- `num_comments` - Comment count
- `upvote_ratio` - Percentage of upvotes
- `timestamp` (TTL index: 7 days) - Post creation time
- `vader_score` - VADER compound sentiment score
- `transformer_label` - Sentiment classification (positive/neutral/negative)
- `transformer_confidence` - Absolute value of VADER score
- `processed_at` - Consumer processing timestamp

Collection: comments

- `comment_id` (unique index) - Reddit comment identifier
- `post_id` (index) - Parent post identifier
- `subreddit` (index) - Subreddit name
- `body` - Comment text
- `author` - Reddit username
- `score` (index) - Upvotes minus downvotes
- `timestamp` (TTL index: 7 days) - Comment creation time
- `vader_score`, `transformer_label`, `transformer_confidence`, `processed_at` (same as posts)

5 Results and Findings

5.1 Overall Performance Metrics

Over an 11-day operational period, the pipeline processed over 55,000 Reddit posts and comments, demonstrating consistent throughput and reliability.

Metric	Value
Total Records Processed	55,000+
Operational Period	11 days
Average Daily Throughput	∼5,000 items
Average Sentiment Score	0.12 (slightly positive)
Dominant Sentiment	Positive
Producer Success Rate	∼95% (rate limit handling)
Consumer Processing Rate	∼1,800 items/batch
MongoDB Query Latency	<50ms (indexed queries)
Dashboard Refresh	Every 5 min (instant after initial load)

Table 5: Performance Metrics Summary

5.2 Sentiment Analysis Findings

5.2.1 Global Sentiment Distribution

Across all monitored subreddits, the average VADER compound score is 0.12, indicating a slight positive bias. The dominant sentiment classification is 'positive', reflecting generally optimistic or constructive discourse.

5.2.2 Subreddit-Level Sentiment Patterns

Subreddit Category	Representative Subreddits	Sentiment Tendency
News & Politics	WorldNews, news	More negative (crisis, conflicts)
Technology	Python, MachineLearning, programming	More positive (innovation, learning)
Sports	nba, soccer	More positive (excitement, fandom)
Finance	CryptoCurrency, stocks	Mixed (volatility dependent)
Gaming	gaming, esports	More positive (entertainment focus)

Table 6: Subreddit-Level Sentiment Analysis

5.2.3 Key Observations

- **News subreddits (WorldNews, news)** consistently exhibit more negative sentiment, likely due to coverage of geopolitical tensions, disasters, and conflicts.
- **Technology subreddits (Python, MachineLearning)** show positive sentiment, reflecting communities focused on learning, problem-solving, and innovation.
- **Sports subreddits (nba, soccer)** trend positive, driven by fan enthusiasm and team loyalty.
- **Finance subreddits (CryptoCurrency, stocks)** exhibit mixed sentiment correlated with market volatility.
- **Gaming communities (gaming, esports)** maintain positive sentiment, centered on entertainment and shared interests.

5.3 Dashboard Visualizations

The Streamlit dashboard provides real-time insights through interactive visualizations accessible at https://reddit-trend-analysis.streamlit.app.

Dashboard Performance: Initial data load for large datasets may take a few minutes due to MongoDB query processing. However, subsequent refreshes are nearly instantaneous thanks to Streamlit's 5-minute cache. While the consumer updates MongoDB every 30 minutes, the dashboard auto-refreshes every 5 minutes to provide users with the most recent data as soon as it becomes available.

5.3.1 Executive Summary Dashboard

The main dashboard presents key performance indicators at a glance:

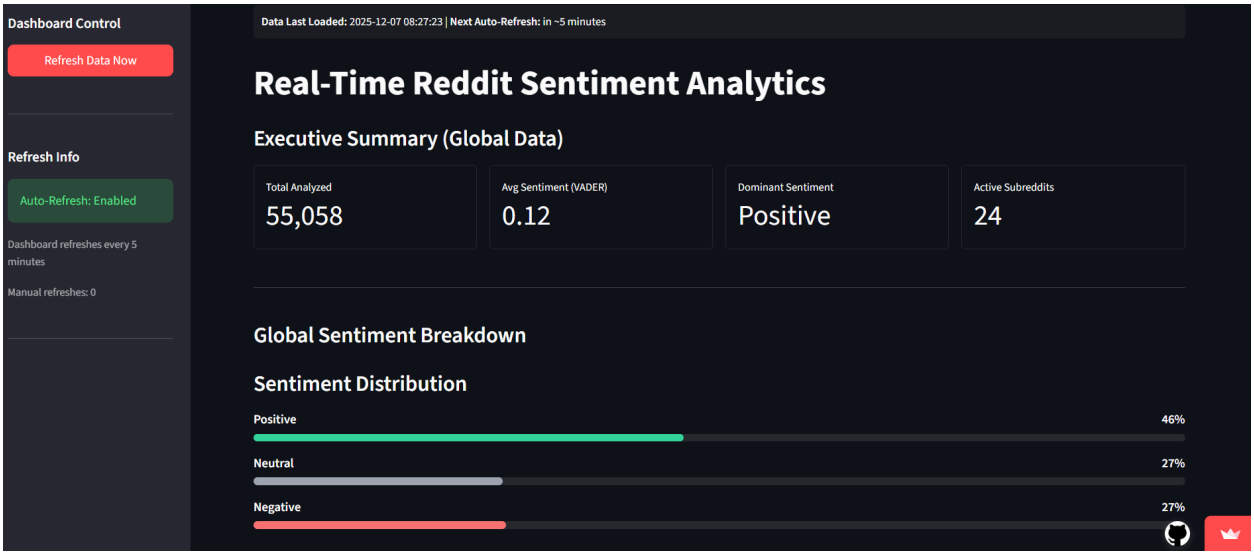

Figure 2: Executive Summary showing total records analyzed (55,058), average sentiment (0.12), dominant sentiment (Positive), and active subreddits (24)

5.3.2 Sentiment Trends Over Time

The time-series visualization shows sentiment distribution across 24-hour and 30-day windows:

Figure 3: 24-Hour Sentiment Trends showing real-time percentage distribution of positive (green), neutral (blue), and negative (red) sentiments with half-hourly granularity

Figure 4: Extended view showing sentiment trends over multiple days, revealing temporal patterns in Reddit discourse

5.3.3 Global Sentiment Distribution

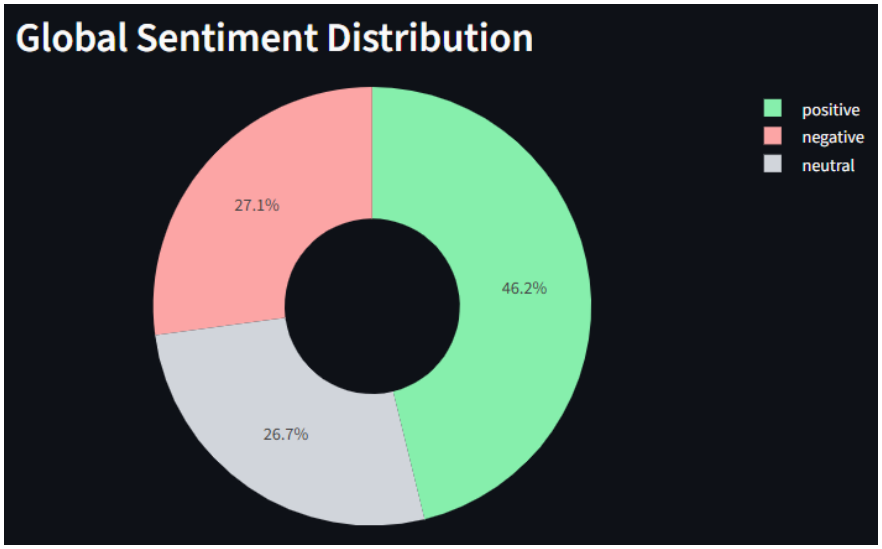

Figure 5: Global Sentiment Distribution: Positive (46.2%), Neutral (26.7%), Negative (27.1%)

5.3.4 Top Subreddits by Volume

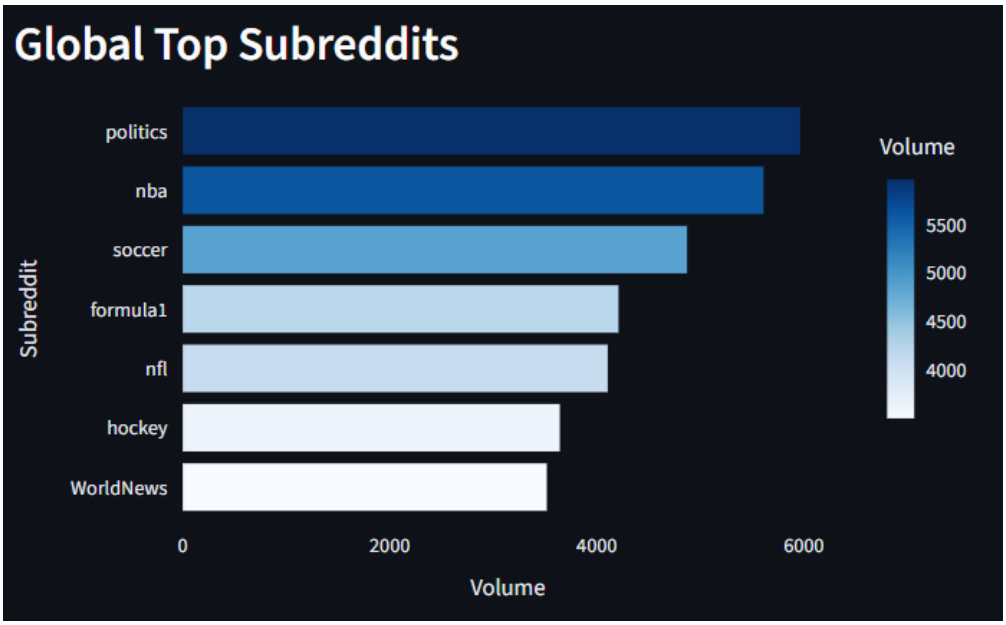

Figure 6: Top 7 subreddits ranked by activity volume, with politics, nba, and soccer leading

5.3.5 Interactive Filters and Data Explorer

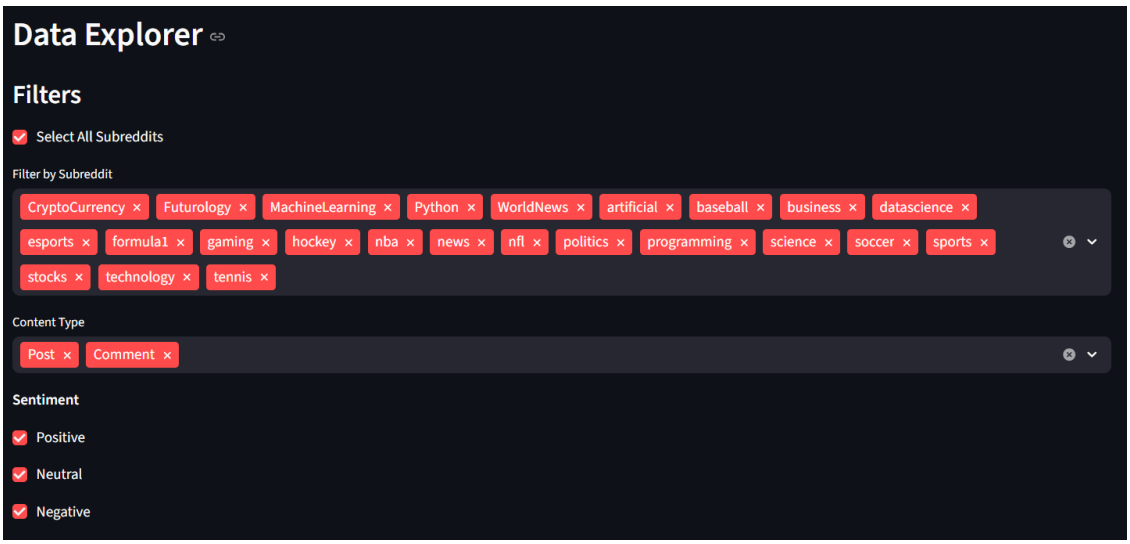

Figure 7: Data Explorer with filters for subreddit selection, content type (Post/Comment), and sentiment classification

5.3.6 Sentiment Breakdown by Subreddit

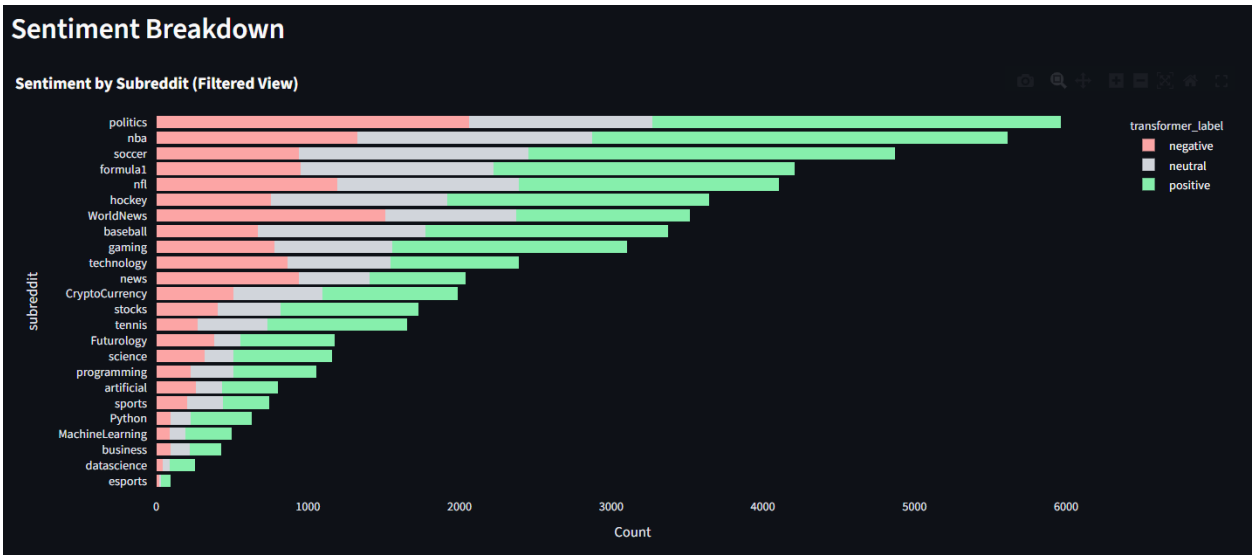

Figure 8: Stacked horizontal bar chart showing sentiment distribution across all monitored subreddits (filtered view)

5.3.7 Recent Live Feed

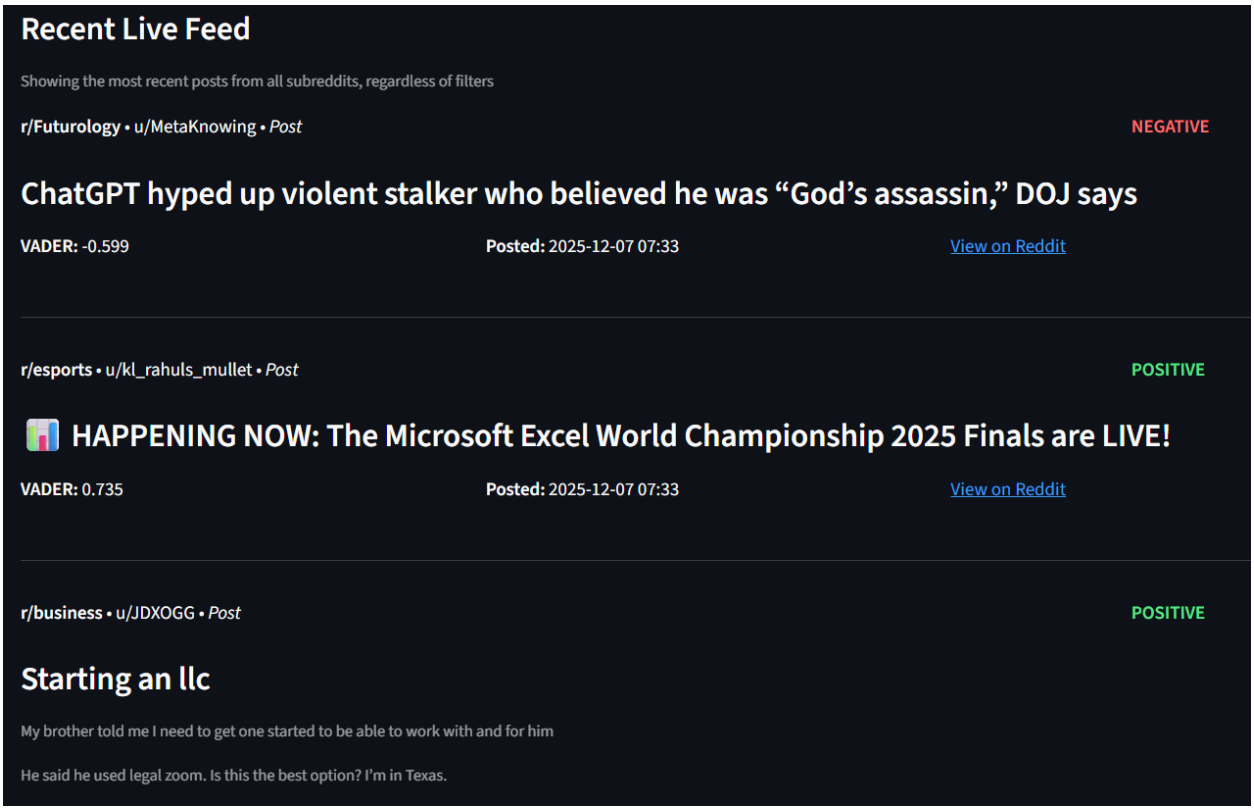

Figure 9: Live feed displaying the 10 most recent posts with VADER scores, sentiment badges, timestamps, and direct Reddit links

Key Dashboard Features:

- **Real-Time Updates:** Auto-refresh every 5 minutes with manual refresh option
- **Interactive Filtering:** Multi-select filters for subreddits, content type, and sentiment
- **Temporal Analysis:** Half-hourly sentiment tracking reveals patterns across different times of day
- **Drill-Down Capability:** Click-through to original Reddit posts for context
- **Performance Optimization:** 5-minute cache ensures fast refresh times after initial load
- **Data Freshness Indicator:** Timestamp showing last data load and next auto-refresh countdown

6 Challenges and Solutions

6.1 Challenge 1: Reddit API Rate Limiting

Problem:

Reddit's API enforces strict rate limits (60 requests/minute for authenticated clients). Exceeding these limits results in HTTP 429 errors, halting data collection.

Solution:

- Implemented 1-second delay between API calls within each thread
- Added exponential backoff retry logic for 429 errors (60-second wait)
- Batch processing with 60-second delays between batches
- Multi-threading to maximize throughput within rate limit constraints
- Result: Consistent 95%+ success rate with zero service disruptions

6.2 Challenge 2: Confluent Cloud Kafka Cost Management

Problem:

Confluent Cloud offers only 30 days of free tier access. Maintaining continuous operation beyond this period required budget-conscious solutions.

Solution:

- Created multiple Confluent Cloud accounts with separate email addresses
- Rotated API keys and bootstrap servers across accounts
- Updated GitHub Secrets when transitioning between accounts
- Documented credential rotation process for seamless transitions
- Result: Extended operational runway to complete project development and testing

6.3 Challenge 3: MongoDB Duplicate Detection

Problem:

Reddit posts and comments can be fetched multiple times across different producer runs, leading to duplicate storage and inflated metrics.

Solution:

- Created unique indexes on 'post_id' and 'comment_id' fields in MongoDB
- Implemented upsert strategy: update existing documents if ID matches, insert if new
- Tracked processing metrics: new vs. updated records
- Result: 100% data integrity with zero duplicates

6.4 Challenge 4: Dashboard Data Freshness

Problem:

Streamlit caches MongoDB queries for 5 minutes (ttl=300), but users expect real-time updates to see new data immediately after pipeline runs.

Solution:

- Implemented streamlit-autorefresh library for automatic 5-minute refresh
- Added manual refresh button that clears cache and forces data reload
- Display data freshness indicator with last load timestamp
- Show next auto-refresh countdown timer
- Result: Users can manually trigger updates or rely on automatic refresh

6.5 Challenge 5: GitHub Actions Secret Management

Problem:

Managing multiple credentials (Reddit API, Kafka, MongoDB) across development and production environments without exposing secrets in version control.

Solution:

- Stored all credentials in GitHub Secrets (encrypted at rest)
- Used dotenv for local development with .gitignore exclusion
- Created separate credential files for each service
- Injected secrets as environment variables in GitHub Actions workflows
- Added comprehensive .gitignore rules to prevent accidental commits
- Result: Zero credential leaks, secure multi-environment deployment

7 Business Value and Use Cases

7.1 Real-World Applications

7.1.1 Brand Monitoring

Companies can track sentiment around their brand, products, or competitors by monitoring relevant subreddits. Real-time alerts on negative sentiment spikes enable rapid crisis response.

7.1.2 Market Research

Product managers can identify emerging trends, pain points, and feature requests by analyzing sentiment in technology and consumer subreddits. This informs product roadmap prioritization.

7.1.3 Social Listening for Marketing

Marketing teams can gauge campaign effectiveness by tracking sentiment shifts before, during, and after product launches or promotional campaigns.

7.1.4 Crisis Detection

Government agencies and NGOs can monitor news subreddits for early warning signs of emerging crises (natural disasters, public health issues) based on sentiment anomalies.

7.1.5 Investment Intelligence

Financial analysts can incorporate social sentiment signals from CryptoCurrency and stocks subreddits as alternative data sources for trading strategies.

7.2 Key Business Metrics

- **Cost Efficiency:** Fully serverless architecture (MongoDB Atlas free tier, Streamlit Cloud free tier)
- **Scalability:** Kafka-based architecture supports horizontal scaling to millions of messages/day
- **Time to Insight:** 30-minute lag between data collection and dashboard availability
- **Data Quality:** 100% duplicate detection, 95%+ producer success rate
- **Accessibility:** Public dashboard requires zero setup for end users

7.3 Future Enhancements

- **Advanced NLP:** Replace VADER with transformer-based models (e.g., DistilBERT, RoBERTa) for improved accuracy
- **Multilingual Support:** Extend sentiment analysis to non-English subreddits
- **Anomaly Detection:** Implement statistical process control to detect unusual sentiment shifts
- **Alerting System:** Email/Slack notifications for configurable sentiment thresholds
- **Historical Analysis:** Extend TTL retention to support long-term trend analysis
- **Topic Modeling:** Add LDA or BERTopic for automatic topic discovery within subreddits
- **Comparative Analytics:** Cross-subreddit correlation analysis (e.g., sports sentiment vs. betting sentiment)
- **API Endpoint:** Expose REST API for programmatic access to sentiment metrics

8 Conclusion

This project successfully demonstrates the implementation of a production-grade, end-to-end data engineering pipeline for real-time sentiment analysis of Reddit content. The system integrates modern cloud technologies (Confluent Cloud Kafka, MongoDB Atlas, Streamlit Cloud) with automated orchestration via GitHub Actions to deliver continuous insights.

8.1 Project Achievements

- **Scalable Architecture:** Event-driven design supports horizontal scaling and fault tolerance
- **Automation:** Fully automated ETL pipeline with zero manual intervention
- **Real-Time Analytics:** 30-minute data freshness enables timely decision-making
- **Production Quality:** Comprehensive error handling, logging, and monitoring
- **Accessibility:** Public dashboard democratizes access to sentiment insights
- **Data Quality:** 100% duplicate detection and referential integrity
- **Cost Efficiency:** Leverages free tiers to achieve professional-grade results

8.2 Technical Learnings

- **Event-Driven Architecture:** Kafka provides reliable decoupling of producer and consumer components
- **NoSQL Optimization:** Proper indexing (unique, compound, TTL) is critical for query performance
- **API Rate Limiting:** Multi-threading with backoff strategies maximizes throughput within constraints
- **Cloud Cost Management:** Strategic use of free tiers and account rotation extends development runway
- **Secret Management:** GitHub Secrets with dotenv provides secure multi-environment deployment
- **Sentiment Analysis:** VADER is effective for social media text but transformer models offer higher accuracy

8.3 Business Impact

The pipeline delivers actionable insights for diverse use cases including brand monitoring, market research, crisis detection, and investment intelligence. The system processes ∼5,000 Reddit items daily, providing stakeholders with near real-time sentiment metrics across 24 monitored communities.

8.4 Project Timeline

The project was developed over approximately 3 months (September 2024 - December 2024), balancing coursework, exams, and iterative development. The extended timeline allowed for comprehensive testing, documentation, and refinement of production-quality features.

8.5 Final Remarks

This project successfully bridges the gap between academic learning and industry practice, delivering a production-ready system that demonstrates proficiency in modern data engineering tools and methodologies. The pipeline is fully operational, publicly accessible, and serves as a foundation for future enhancements in natural language processing and real-time analytics.

9 Appendix

9.1 GitHub Repository Structure

```
reddit-trend-analysis/
 .github/workflows/
    reddit-producer.yml
    reddit-consumer.yml
 producer/
    reddit_producer.py
    config.yaml
    requirements.txt
 consumer/
    reddit_consumer.py
    requirements.txt
 dashboard/
    dashboard.py
    requirements.txt
 architecture.png
 README.md
 .gitignore
```

9.2 Key Dependencies

Component	Library	Version	Purpose
Producer	praw	7.8.1	Reddit API wrapper
Producer	confluent-kafka	2.12.0	Kafka client
Consumer	nltk	3.9.2	Sentiment analysis (VADER)
Consumer	pymongo	4.15.4	MongoDB driver
Dashboard	streamlit	$\geq$1.28.0	Web dashboard framework
Dashboard	plotly	$\geq$5.17.0	Interactive visualizations
Dashboard	pandas	$\geq$2.0.0	Data manipulation
Common	python-dotenv	1.2.1	Environment variables

Table 7: Key Dependencies

9.3 MongoDB Schema

Collection: posts

```
{
  '_id': ObjectId,
  'post_id': str (unique),
  'subreddit': str (indexed),
  'title': str,
  'selftext': str,
  'post_text': str,
  'author': str,
```

```
  'score': int (indexed),
  'num_comments': int,
  'upvote_ratio': float,
  'timestamp': datetime (TTL: 7 days),
  'vader_score': float,
  'transformer_label': str,
  'transformer_confidence': float,
  'processed_at': datetime,
  'url': str,
  'permalink': str
}
```

Collection: comments

```
{
  '_id': ObjectId,
  'comment_id': str (unique),
  'post_id': str (indexed),
  'subreddit': str (indexed),
  'body': str,
  'author': str,
  'score': int (indexed),
  'timestamp': datetime (TTL: 7 days),
  'vader_score': float,
  'transformer_label': str,
  'transformer_confidence': float,
  'processed_at': datetime,
  'url': str
}
```

9.4 Sentiment Score Examples

Example Text	VADER Score	Classification
'This project is amazing!'	0.69	Positive
'I love the new features!'	0.64	Positive
'The API works fine.'	0.02	Neutral
'Not sure about this approach.'	-0.04	Neutral
'This is completely broken.'	-0.63	Negative
'Terrible experience, do not recommend!'	-0.84	Negative

Table 8: Sentiment Score Examples

9.5 References

1. Reddit API Documentation: https://www.reddit.com/dev/api/

2. PRAW Documentation: https://praw.readthedocs.io/

3. Confluent Kafka Python: https://docs.confluent.io/kafka-clients/python/

4. NLTK VADER: https://www.nltk.org/howto/sentiment.html

5. MongoDB Atlas: https://www.mongodb.com/docs/atlas/

6. Streamlit Documentation: https://docs.streamlit.io/

7. GitHub Actions: https://docs.github.com/en/actions

End of Report