

# Kafka Topics Partition Count Recommender [MULTITHREADED] Application

**TL;DR: End Kafka performance headaches.** This smart recommender reads your historical consumption data and delivers precise partition recommendations that optimize throughput and enable effortless scaling—no more over-provisioning or under-utilizing your topics.

The **Kafka Cluster Topics Partition Count Recommender [MULTITHREADED] Application** offers data-driven accuracy for Kafka topic sizing. By analyzing past consumption trends, that is, the average consumption records in bytes, it uses this information to determine consumer throughput. Then, over a rolling n-day period, it identifies the average consumption of records in bytes, scaling that number by a factor of X to forecast future demand and calculate the required throughput. Next, it divides the required throughput by the consumer throughput and rounds the result to the nearest whole number to determine the optimal number of partitions. The result is an intelligent, automated recommendation system that ensures each Kafka topic has the appropriate number of partitions to handle current workload and support future growth effectively.

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## 1.0 To get started

**Download** ---> **Configure** ---> **Run** ---> **Results**

### 1.1 Download the Application

Clone the repo: `shell git clone https://github.com/j3-signalroom/kafka_cluster-topics-partition_count_recommender-app.git`

Since this project was built using `uv`, please `install` it, and then run the following command to install all the project dependencies:

```
uv sync
```

#### 1.1.1 Special Note on two custom dependencies

This project has *two custom dependencies* that we want to bring to your attention:

1. **cc-clients-python\_lib**: This library offers a simple way to interact with Confluent Cloud services, including the Metrics API. It makes it easier to send API requests and manage responses. It is used in this project to connect to the Confluent Cloud Metrics API and retrieve topic consumption metrics.
2. **aws-clients-python\_lib**: This library is used to interact with AWS services, specifically AWS Secrets Manager in this case. It enables the application to securely retrieve secrets stored in AWS Secrets Manager.

### 1.2 Configure the Application

Now, you need to set up the application by creating a `.env` file in the root directory of your project. This file will store all the essential environment variables required for the application to connect to your Confluent Cloud Kafka cluster and function correctly. Additionally, you can choose to use **AWS Secrets Manager** to manage your secrets.

**Note:** Your Confluent Cloud API Key, Secret, and Kafka Cluster ID are required to access the [Confluent Cloud Metrics API](#) and retrieve topic metrics. Additionally, your Bootstrap Server URI, along with your Kafka API Key and Secret, are necessary to access the designated Kafka Cluster.

1.2.1 Create the `.env` file

Create the `.env` file and add the following environment variables, filling them with your Confluent Cloud credentials and other required values:

```
# Environment variables credentials for Confluent Cloud and Kafka clusters
CONFLUENT_CLOUD_CREDENTIAL={{"confluent_cloud_api_key": "<YOUR_CONFLUENT_CLOUD_API_KEY>", "confluent_cloud_api_secret": "<YOUR_CONFLUENT_CLOUD_API_SECRETS>"}
KAFKA_CREDENTIALS=[{"kafka_cluster_id": "<YOUR_KAFKA_CLUSTER_ID>", "bootstrap.servers": "<YOUR_BOOTSTRAP_SERVER_URI>", "sasl.username": "<YOUR_KAFKA_API_KEY>", "sasl.password": "<YOUR_KAFKA_API_SECRET>"}]

# AWS Secrets Manager Secrets for Confluent Cloud and Kafka clusters
USE_AWS_SECRETS_MANAGER=<True|False>
CONFLUENT_CLOUD_API_SECRET_PATH={"region_name": "<YOUR_SECRET_AWS_REGION_NAME>", "secret_name": "<YOUR_CONFLUENT_CLOUD_API_KEY_AWS_SECRETS>"}
KAFKA_API_SECRET_PATHS=[{"region_name": "<YOUR_SECRET_AWS_REGION_NAME>", "secret_name": "<YOUR_KAFKA_API_KEY_AWS_SECRETS>"}]

# Topic analysis configuration
INCLUDE_INTERNAL_TOPICS=<True|False>
TOPIC_FILTER=<YOUR_TOPIC_FILTER, IF ANY>

# Minimum recommended partitions
MIN_RECOMMENDED_PARTITIONS=<YOUR_MIN_RECOMMENDED_PARTITIONS>

# Throughput and partition calculation configuration
REQUIRED_CONSUMPTION_THROUGHPUT_FACTOR=<YOUR_REQUIRED_CONSUMPTION_THROUGHPUT_FACTOR>

# Sampling configuration
USE_SAMPLE_RECORDS=<True|False>
SAMPLING_DAYS=<YOUR_SAMPLING_DAYS>
SAMPLING_BATCH_SIZE=<YOUR_SAMPLING_BATCH_SIZE>
SAMPLING_MAX_CONSECUTIVE_NULLS=<YOUR_SAMPLING_MAX_CONSECUTIVE_NULLS>
SAMPLING_TIMEOUT_SECONDS=<YOUR_SAMPLING_TIMEOUT_SECONDS>
SAMPLING_MAX_CONTINUOUS_FAILED_BATCHES=<YOUR_SAMPLING_MAX_CONTINUOUS_FAILED_BATCHES>

# Multithreading configuration
MAX_CLUSTER_WORKERS=<YOUR_MAX_CLUSTER_WORKERS>
MAX_WORKERS_PER_CLUSTER=<YOUR_MAX_WORKERS_PER_CLUSTER>
```

The environment variables are defined as follows:

Environment Variable Name	Type	Description	Example	Default	Required
CONFLUENT_CLOUD_CREDENTIAL	JSON Object	Contains authentication credentials for Confluent Cloud API access. Must include <code>confluent_cloud_api_key</code> and <code>confluent_cloud_api_secret</code> fields for authenticating with Confluent Cloud services.	<code>{"confluent_cloud_api_key": "CKABCD123456", "confluent_cloud_api_secret": "xyz789secretkey"}</code>	None	Yes
KAFKA_CREDENTIALS	JSON Array	Array of Kafka cluster connection objects. Each object must contain <code>sasl.username</code> , <code>sasl.password</code> , <code>kafka_cluster_id</code> , and <code>bootstrap.servers</code> for connecting to specific Kafka clusters.	<code>[{"sasl.username": "ABC123", "sasl.password": "secret123", "kafka_cluster_id": "lkc-abc123", "bootstrap.servers": "pkc-123.us-east-1.aws.confluent.cloud:9092"}]</code>	None	Yes
USE_AWS_SECRETS_MANAGER	Boolean	Controls whether to retrieve credentials from AWS Secrets Manager instead of using direct environment variables. When <code>True</code> , credentials are fetched from AWS Secrets Manager using the paths specified in other variables.	<code>True</code> or <code>False</code>	<code>False</code>	No

Environment Variable Name	Type	Description	Example	Default	Re
CONFLUENT_CLOUD_API_SECRET_PATH	JSON Object	AWS Secrets Manager configuration for Confluent Cloud credentials. Contains <b>region_name</b> (AWS region) and <b>secret_name</b> (name of the secret in AWS Secrets Manager). Only used when <b>USE_AWS_SECRETS_MANAGER</b> is <b>True</b> .	<code>{"region_name": "us-east-1", "secret_name": "confluent-cloud-api-credentials"}</code>	None	Yes: US is -
KAFKA_API_SECRET_PATHS	JSON Array	Array of AWS Secrets Manager configurations for Kafka cluster credentials. Each object contains <b>region_name</b> and <b>secret_name</b> for retrieving cluster-specific credentials from AWS Secrets Manager.	<code>[{"region_name": "us-east-1", "secret_name": "kafka-cluster-1-creds"}, {"region_name": "us-east-1", "secret_name": "kafka-cluster-2-creds"}]</code>	None	Yes: US is -
INCLUDE_INTERNAL_TOPICS	Boolean	Determines whether Kafka internal topics (system topics like <b>__consumer_offsets</b> , <b>__schemas</b> ) are included in the analysis and reporting. Set to <b>False</b> to exclude internal topics and focus only on user-created topics.	<b>True</b> or <b>False</b>	<b>False</b>	No
TOPIC_FILTER	Comma-separated String	A list of specific topic names or part of topic names to analyze. When provided, only these topics will be included in the analysis. Use commas to separate multiple topic names. Leave blank or unset to analyze all available topics.	<b>"user-events,order-processing,payment-notifications"</b>	Empty (all topics)	No
MIN_RECOMMENDED_PARTITIONS	Integer	The minimum number of partitions to recommend for any topic, regardless of calculated needs. This ensures that topics have a baseline level of parallelism and fault tolerance.	<b>6, 12</b>	<b>6</b>	No
MIN_CONSUMPTION_THROUGHPUT	Integer	The minimum required consumption throughput for any topic, regardless of calculated needs. This ensures that topics have a baseline level of performance.	<b>10485760</b> (10 MB/s)	<b>10485760</b>	No
REQUIRED_CONSUMPTION_THROUGHPUT_FACTOR	Float/Integer	Multiplier applied to current peak consumption rates for capacity planning and future demand forecasting. A value of <b>3</b> means planning for 3x the current peak throughput (300% of current load).	<b>3</b> (for 300%), <b>2.5</b> (for 250%)	<b>3</b>	No
USE_SAMPLE_RECORDS	Boolean	Enables record sampling mode for analysis instead of processing all records. When <b>True</b> , only a subset of records is analyzed for performance optimization. Recommended for large topics or initial analysis.	<b>True</b> or <b>False</b>	<b>True</b>	No

Environment Variable Name	Type	Description	Example	Default	Re
SAMPLING_BATCH_SIZE	Integer	Maximum number of records to sample per topic when <code>USE_SAMPLE_RECORDS</code> is <code>True</code> . Controls the sample size for analysis to balance accuracy with performance. Larger values provide more accurate analysis but slower processing.	1000, 10000	10000	No
SAMPLING_MAX_CONSECUTIVE_NULLS	Integer	Maximum number of consecutive null records encountered during sampling before stopping the sampling process for a topic. Helps to avoid excessive polling when there are no new records.	10, 50	50	No
SAMPLING_TIMEOUT_SECONDS	Float	Maximum time (in seconds) to wait for records during sampling before stopping the sampling process for a topic. Prevents long waits when there are no new records.	1.0, 2.5	2.0	No
SAMPLING_MAX_CONTINUOUS_FAILED_BATCHES	Integer	Maximum number of continuous failed batches encountered during sampling before stopping the sampling process for a topic. Helps to avoid excessive retries when there are persistent issues.	3, 5	5	No
SAMPLING_DAYS	Integer	Time window (in days) for record sampling, creating a rolling window that looks back from the current time. Defines how far back to sample records for analysis. <b>Note:</b> Topics with retention periods shorter than this value will use their maximum available retention period instead.	7 (last week), 30 (last month)	7	No
MAX_CLUSTER_WORKERS	Integer	Maximum number of concurrent worker threads to analyze multiple Kafka clusters in parallel. Helps to speed up analysis when working with multiple clusters.	2, 4	3	No
MAX_WORKERS_PER_CLUSTER	Integer	Maximum number of concurrent worker threads to analyze multiple topics within a single Kafka cluster in parallel. Helps to speed up analysis for clusters with many topics.	4, 8	8	No

1.2.2 Using the AWS Secrets Manager (optional)

If you use **AWS Secrets Manager** to manage your secrets, set the `USE_AWS_SECRETS_MANAGER` variable to `True` and the application will retrieve the secrets from AWS Secrets Manager using the names provided in `CONFLUENT_CLOUD_API_KEY_AWS_SECRETS` and `KAFKA_API_KEY_AWS_SECRETS`.

The code expects the `CONFLUENT_CLOUD_API_KEY_AWS_SECRETS` to be stored in JSON format with these keys:

- `confluent_cloud_api_key`
- `confluent_cloud_api_secret`

The code expects the `KAFKA_API_KEY_AWS_SECRETS` to be stored in JSON format with these keys:

- `kafka_cluster_id`
- `bootstrap.servers`
- `sasl.username`
- `sasl.password`

1.3 Run the Application

Navigate to the Project Root Directory

Open your Terminal and navigate to the root folder of the `kafka_cluster-topics-partition_count_recommender-app/` repository that you have cloned. You can do this by executing:

```
cd path/to/kafka_cluster-topics-partition_count_recommender-app/
```

Replace `path/to/` with the actual path where your repository is located.

Then enter the following command below to run the application:

```
uv run python src/thread_safe_app.py
```

If `USE_SAMPLE_RECORDS` environment variable is set to `True`, the application will sample records from each topic to calculate the average record size in bytes. For example, below is a screenshot of the application running successfully:

```
2025-09-23 10:56:37 - INFO - load - Found credentials in environment variables.
2025-09-23 10:56:38 - INFO - main - Retrieving the Confluent Cloud credentials from the AWS Secrets Manager.
2025-09-23 10:56:38 - INFO - load - Found credentials in environment variables.
2025-09-23 10:56:38 - INFO - main - Retrieving the Kafka Cluster credentials from the AWS Secrets Manager.
2025-09-23 10:56:38 - INFO - analyze_all_topics -
=====
2025-09-23 10:56:38 - INFO - analyze_all_topics - INITIAL ANALYSIS PARAMETERS
2025-09-23 10:56:38 - INFO - analyze_all_topics - -----
=====
2025-09-23 10:56:38 - INFO - analyze_all_topics - Analysis Timestamp: 2025-09-23T10:56:38.927110
2025-09-23 10:56:38 - INFO - analyze_all_topics - Kafka Cluster ID: lkc-29q7o1
2025-09-23 10:56:38 - INFO - analyze_all_topics - Connecting to Kafka cluster and retrieving metadata...
2025-09-23 10:56:38 - INFO - analyze_all_topics - Found 2 topics to analyze
2025-09-23 10:56:38 - INFO - analyze_all_topics - Excluding internal topics
2025-09-23 10:56:38 - INFO - analyze_all_topics - Required consumption throughput factor: 10.0
2025-09-23 10:56:38 - INFO - analyze_all_topics - Minimum required throughput threshold: 10.0 MB/s
2025-09-23 10:56:38 - INFO - analyze_all_topics - Topic filter: None
2025-09-23 10:56:38 - INFO - analyze_all_topics - Default Partition Count: 6
2025-09-23 10:56:38 - INFO - analyze_all_topics - Using sample records for average record size calculation
2025-09-23 10:56:38 - INFO - analyze_all_topics - Sampling batch size: 10,000 records
2025-09-23 10:56:38 - INFO - analyze_all_topics - Sampling days: 1 days
2025-09-23 10:56:38 - INFO - analyze_all_topics - Sampling max consecutive nulls: 50 records
2025-09-23 10:56:38 - INFO - analyze_all_topics - Sampling timeout: 2.0 seconds
2025-09-23 10:56:38 - INFO - analyze_all_topics - Sampling max continuous failed batches: 5 batches
2025-09-23 10:56:38 - INFO - analyze_all_topics -
=====
2025-09-23 10:56:38 - INFO - analyze_all_topics - Created the lkc-29q7o1-recommender-1758639398-detail-report.csv
file
2025-09-23 10:56:38 - INFO - __analyze_topic - Analyzing topic stock_trades with 1-day rolling window (from 2025-09-
22T14:56:38+00:00)
2025-09-23 10:56:41 - INFO - __sample_record_sizes - Partition 000 of 006: using effective batch size 1,000
(requested: 10,000, optimal: 1,000)
2025-09-23 10:56:41 - INFO - __sample_record_sizes - Sampling from partition 000 of 006: offsets [0, 6886)
2025-09-23 10:56:42 - INFO - __sample_record_sizes - Batch 1: 1,000 valid records (0 errors/nulls), progress:
14.5%, running avg: 81.22 bytes
2025-09-23 10:56:42 - INFO - __sample_record_sizes - Batch 2: 1,000 valid records (0 errors/nulls), progress:
29.0%, running avg: 81.29 bytes
2025-09-23 10:56:42 - INFO - __sample_record_sizes - Batch 3: 1,000 valid records (0 errors/nulls), progress:
43.6%, running avg: 81.41 bytes
2025-09-23 10:56:42 - INFO - __sample_record_sizes - Batch 4: 1,000 valid records (0 errors/nulls), progress:
58.1%, running avg: 81.65 bytes
2025-09-23 10:56:42 - INFO - __sample_record_sizes - Batch 5: 1,000 valid records (0 errors/nulls), progress:
72.6%, running avg: 81.80 bytes
2025-09-23 10:56:42 - INFO - __sample_record_sizes - Batch 6: 1,000 valid records (0 errors/nulls), progress:
87.1%, running avg: 81.89 bytes
2025-09-23 10:56:43 - INFO - __sample_record_sizes - Batch 7: 886 valid records (1 errors/nulls), progress:
100.0%, running avg: 81.95 bytes
2025-09-23 10:56:43 - INFO - __sample_record_sizes - Partition 002 of 006: using effective batch size 1,000
(requested: 10,000, optimal: 1,000)
2025-09-23 10:56:43 - INFO - __sample_record_sizes - Sampling from partition 002 of 006: offsets [0, 3371)
2025-09-23 10:56:44 - ERROR - __sample_record_sizes - Failed to seek for stock_trades 002 of 006:
KafkaError{code=STATE,val=-172,str="Failed to seek to offset 0: Local: Erroneous state"}
2025-09-23 10:56:44 - INFO - __sample_record_sizes - Partition 004 of 006: using effective batch size 1,000
(requested: 10,000, optimal: 1,000)
2025-09-23 10:56:44 - INFO - __sample_record_sizes - Sampling from partition 004 of 006: offsets [0, 3365)
2025-09-23 10:56:44 - INFO - __sample_record_sizes - Batch 1: 1,000 valid records (0 errors/nulls), progress:
29.7%, running avg: 81.87 bytes
2025-09-23 10:56:44 - INFO - __sample_record_sizes - Batch 2: 1,000 valid records (0 errors/nulls), progress:
59.4%, running avg: 81.90 bytes
2025-09-23 10:56:44 - INFO - __sample_record_sizes - Batch 3: 1,000 valid records (0 errors/nulls), progress:
89.2%, running avg: 81.95 bytes
```

```
2025-09-23 10:56:44 - INFO - __sample_record_sizes - Batch 4: 365 valid records (1 errors/nulls), progress:
100.0%, running avg: 81.96 bytes
2025-09-23 10:56:44 - INFO - __sample_record_sizes - Partition 005 of 006: using effective batch size 5,000
(requested: 10,000, optimal: 5,000)
2025-09-23 10:56:44 - INFO - __sample_record_sizes - Sampling from partition 005 of 006: offsets [0, 10400)
2025-09-23 10:56:45 - ERROR - __sample_record_sizes - Failed to seek for stock_trades 005 of 006:
KafkaError{code=_STATE,val=-172,str="Failed to seek to offset 0: Local: Erroneous state"}
2025-09-23 10:56:45 - INFO - __sample_record_sizes - Final average: 81.96 bytes from 10,251 records
2025-09-23 10:56:45 - INFO - __analyze_topic - Analyzing topic stock_trades_with_totals with 1-day rolling window
(from 2025-09-22T14:56:45+00:00)
2025-09-23 10:56:48 - INFO - __sample_record_sizes - Partition 000 of 006: using effective batch size 1,000
(requested: 10,000, optimal: 1,000)
2025-09-23 10:56:48 - INFO - __sample_record_sizes - Sampling from partition 000 of 006: offsets [0, 4131)
2025-09-23 10:56:48 - ERROR - __sample_record_sizes - Failed to seek for stock_trades_with_totals 000 of 006:
KafkaError{code=_STATE,val=-172,str="Failed to seek to offset 0: Local: Erroneous state"}
2025-09-23 10:56:48 - INFO - __sample_record_sizes - Partition 001 of 006: using effective batch size 1,000
(requested: 10,000, optimal: 1,000)
2025-09-23 10:56:48 - INFO - __sample_record_sizes - Sampling from partition 001 of 006: offsets [0, 5611)
2025-09-23 10:56:49 - INFO - __sample_record_sizes - Batch 1: 1,000 valid records (0 errors/nulls), progress:
17.8%, running avg: 35.58 bytes
2025-09-23 10:56:49 - INFO - __sample_record_sizes - Batch 2: 1,000 valid records (0 errors/nulls), progress:
35.6%, running avg: 35.52 bytes
2025-09-23 10:56:49 - INFO - __sample_record_sizes - Batch 3: 1,000 valid records (0 errors/nulls), progress:
53.5%, running avg: 35.49 bytes
2025-09-23 10:56:49 - INFO - __sample_record_sizes - Batch 4: 1,000 valid records (0 errors/nulls), progress:
71.3%, running avg: 35.48 bytes
2025-09-23 10:56:49 - INFO - __sample_record_sizes - Batch 5: 1,000 valid records (0 errors/nulls), progress:
89.1%, running avg: 35.47 bytes
2025-09-23 10:56:50 - INFO - __sample_record_sizes - Batch 6: 547 valid records (1 errors/nulls), progress:
98.9%, running avg: 35.47 bytes
2025-09-23 10:57:31 - WARNING - __sample_record_sizes - Batch 7: No valid records processed (50 attempts, 50
consecutive nulls) [1/5 consecutive failures]
2025-09-23 10:57:31 - WARNING - __sample_record_sizes - Too many consecutive null polls (50) - stopping partition 001
of 006
2025-09-23 10:57:31 - INFO - __sample_record_sizes - Partition 002 of 006: using effective batch size 1,000
(requested: 10,000, optimal: 1,000)
2025-09-23 10:57:31 - INFO - __sample_record_sizes - Sampling from partition 002 of 006: offsets [0, 3000)
2025-09-23 10:57:31 - ERROR - __sample_record_sizes - Failed to seek for stock_trades_with_totals 002 of 006:
KafkaError{code=_STATE,val=-172,str="Failed to seek to offset 0: Local: Erroneous state"}
2025-09-23 10:57:31 - INFO - __sample_record_sizes - Partition 003 of 006: using effective batch size 1,000
(requested: 10,000, optimal: 1,000)
2025-09-23 10:57:31 - INFO - __sample_record_sizes - Sampling from partition 003 of 006: offsets [0, 3279)
2025-09-23 10:57:32 - ERROR - __sample_record_sizes - Failed to seek for stock_trades_with_totals 003 of 006:
KafkaError{code=_STATE,val=-172,str="Failed to seek to offset 0: Local: Erroneous state"}
2025-09-23 10:57:32 - INFO - __sample_record_sizes - Partition 004 of 006: using effective batch size 1,000
(requested: 10,000, optimal: 1,000)
2025-09-23 10:57:32 - INFO - __sample_record_sizes - Sampling from partition 004 of 006: offsets [0, 4707)
2025-09-23 10:57:32 - INFO - __sample_record_sizes - Batch 1: 1,000 valid records (0 errors/nulls), progress:
21.2%, running avg: 35.46 bytes
2025-09-23 10:57:32 - INFO - __sample_record_sizes - Batch 2: 1,000 valid records (0 errors/nulls), progress:
42.5%, running avg: 35.46 bytes
2025-09-23 10:57:32 - INFO - __sample_record_sizes - Batch 3: 1,000 valid records (0 errors/nulls), progress:
63.7%, running avg: 35.46 bytes
2025-09-23 10:57:32 - INFO - __sample_record_sizes - Batch 4: 1,000 valid records (0 errors/nulls), progress:
85.0%, running avg: 35.46 bytes
2025-09-23 10:57:34 - INFO - __sample_record_sizes - Batch 5: 644 valid records (1 errors/nulls), progress:
98.7%, running avg: 35.46 bytes
2025-09-23 10:58:14 - WARNING - __sample_record_sizes - Batch 6: No valid records processed (50 attempts, 50
consecutive nulls) [1/5 consecutive failures]
2025-09-23 10:58:14 - WARNING - __sample_record_sizes - Too many consecutive null polls (50) - stopping partition 004
of 006
2025-09-23 10:58:14 - INFO - __sample_record_sizes - Partition 005 of 006: using effective batch size 1,000
(requested: 10,000, optimal: 1,000)
2025-09-23 10:58:14 - INFO - __sample_record_sizes - Sampling from partition 005 of 006: offsets [0, 3617)
2025-09-23 10:58:14 - ERROR - __sample_record_sizes - Failed to seek for stock_trades_with_totals 005 of 006:
KafkaError{code=_STATE,val=-172,str="Failed to seek to offset 0: Local: Erroneous state"}
2025-09-23 10:58:14 - INFO - __sample_record_sizes - Final average: 35.46 bytes from 10,191 records
2025-09-23 10:58:14 - INFO - analyze_all_topics -
=====
2025-09-23 10:58:14 - INFO - analyze_all_topics - SUMMARY STATISTICS
2025-09-23 10:58:14 - INFO - analyze_all_topics - -----
2025-09-23 10:58:14 - INFO - analyze_all_topics - Elapsed Time: 0.03 hours
2025-09-23 10:58:14 - INFO - analyze_all_topics - Created the lkc-29q7o1-recommender-1758639398-summary-report.csv
file
2025-09-23 10:58:14 - INFO - analyze_all_topics - Total Topics: 2
2025-09-23 10:58:14 - INFO - analyze_all_topics - Active Topics: 2
2025-09-23 10:58:14 - INFO - analyze_all_topics - Active Topics %: 100.0%
2025-09-23 10:58:14 - INFO - analyze_all_topics - Total Partitions: 12
2025-09-23 10:58:14 - INFO - analyze_all_topics - Total Recommended Partitions: 16
2025-09-23 10:58:14 - INFO - analyze_all_topics - Non-Empty Topics Total Partitions: 12
```



```

2025-09-23 10:58:14 - INFO - analyze_all_topics - RECOMMENDED Increase in Partitions: 33.3%
2025-09-23 10:58:14 - INFO - analyze_all_topics - Total Records: 48,367
2025-09-23 10:58:14 - INFO - analyze_all_topics - Average Partitions per Topic: 6
2025-09-23 10:58:14 - INFO - analyze_all_topics - Average Partitions per Active Topic: 6
2025-09-23 10:58:14 - INFO - analyze_all_topics - Average Recommended Partitions per Topic: 8
2025-09-23 10:58:14 - INFO - analyze_all_topics -
=====

```

```

2025-09-23 10:58:14 - INFO - main - TOPIC ANALYSIS COMPLETED SUCCESSFULLY.

```

If `USE_SAMPLE_RECORDS` is set to `False`, the application will use the Confluent Cloud Metrics API to retrieve the average and peak consumption in bytes over a rolling seven-day period. For example, below is a screenshot of the application running successfully:

```

2025-09-23 11:29:53 - INFO - load - Found credentials in environment variables.
2025-09-23 11:29:54 - INFO - main - Retrieving the Confluent Cloud credentials from the AWS Secrets Manager.
2025-09-23 11:29:54 - INFO - load - Found credentials in environment variables.
2025-09-23 11:29:54 - INFO - main - Retrieving the Kafka Cluster credentials from the AWS Secrets Manager.
2025-09-23 11:29:55 - INFO - analyze_all_topics -
=====
2025-09-23 11:29:55 - INFO - analyze_all_topics - INITIAL ANALYSIS PARAMETERS
2025-09-23 11:29:55 - INFO - analyze_all_topics - -----
2025-09-23 11:29:55 - INFO - analyze_all_topics - Analysis Timestamp: 2025-09-23T11:29:55.810215
2025-09-23 11:29:55 - INFO - analyze_all_topics - Kafka Cluster ID: lkc-29q7o1
2025-09-23 11:29:55 - INFO - analyze_all_topics - Connecting to Kafka cluster and retrieving metadata...
2025-09-23 11:29:55 - INFO - analyze_all_topics - Found 2 topics to analyze
2025-09-23 11:29:55 - INFO - analyze_all_topics - Excluding internal topics
2025-09-23 11:29:55 - INFO - analyze_all_topics - Required consumption throughput factor: 10.0
2025-09-23 11:29:55 - INFO - analyze_all_topics - Minimum required throughput threshold: 10.0 MB/s
2025-09-23 11:29:55 - INFO - analyze_all_topics - Topic filter: None
2025-09-23 11:29:55 - INFO - analyze_all_topics - Default Partition Count: 6
2025-09-23 11:29:55 - INFO - analyze_all_topics - Using Metrics API for average record size calculation
2025-09-23 11:29:55 - INFO - analyze_all_topics -
=====
2025-09-23 11:29:55 - INFO - analyze_all_topics - Created the lkc-29q7o1-recommender-1758641395-detail-report.csv
file
2025-09-23 11:29:58 - INFO - analyze_all_topics - Confluent Metrics API - For topic stock_trades, the average bytes
per record is 156.22 bytes/record for a total of 27,980 records.
2025-09-23 11:30:07 - INFO - analyze_all_topics - Confluent Metrics API - For topic stock_trades_with_totals, the
average bytes per record is 108.81 bytes/record for a total of 27,951 records.
2025-09-23 11:30:07 - INFO - analyze_all_topics -
=====
2025-09-23 11:30:07 - INFO - analyze_all_topics - SUMMARY STATISTICS
2025-09-23 11:30:07 - INFO - analyze_all_topics - -----
2025-09-23 11:30:07 - INFO - analyze_all_topics - Elapsed Time: 0.00 hours
2025-09-23 11:30:07 - INFO - analyze_all_topics - Created the lkc-29q7o1-recommender-1758641395-summary-report.csv
file
2025-09-23 11:30:07 - INFO - analyze_all_topics - Total Topics: 2
2025-09-23 11:30:07 - INFO - analyze_all_topics - Active Topics: 2
2025-09-23 11:30:07 - INFO - analyze_all_topics - Active Topics %: 100.0%
2025-09-23 11:30:07 - INFO - analyze_all_topics - Total Partitions: 12
2025-09-23 11:30:07 - INFO - analyze_all_topics - Total Recommended Partitions: 20
2025-09-23 11:30:07 - INFO - analyze_all_topics - Non-Empty Topics Total Partitions: 12
2025-09-23 11:30:07 - INFO - analyze_all_topics - RECOMMENDED Increase in Partitions: 66.7%
2025-09-23 11:30:07 - INFO - analyze_all_topics - Total Records: 55,931.0
2025-09-23 11:30:07 - INFO - analyze_all_topics - Average Partitions per Topic: 6
2025-09-23 11:30:07 - INFO - analyze_all_topics - Average Partitions per Active Topic: 6
2025-09-23 11:30:07 - INFO - analyze_all_topics - Average Recommended Partitions per Topic: 10
2025-09-23 11:30:07 - INFO - analyze_all_topics -
=====
2025-09-23 11:30:07 - INFO - main - TOPIC ANALYSIS COMPLETED SUCCESSFULLY.

```

### 1.3.1 Did you notice we prefix `uv run` to `python src/thread_safe_app.py`?

You maybe asking yourself why. Well, `uv` is an incredibly fast Python package installer and dependency resolver, written in `Rust`, and designed to seamlessly replace `pip`, `pipx`, `poetry`, `pyenv`, `twine`, `virtualenv`, and more in your workflows. By prefixing `uv run` to a command, you're ensuring that the command runs in an optimal Python environment.

Now, let's go a little deeper into the magic behind `uv run`:

- When you use it with a file ending in `.py` or an HTTP(S) URL, `uv` treats it as a script and runs it with a Python interpreter. In other words, `uv run file.py` is equivalent to `uv run python file.py`. If you're working with a URL, `uv` even downloads it temporarily to execute it. Any inline dependency metadata is installed into an isolated, temporary environment—meaning zero leftover mess! When used with `-`, the input will be read from `stdin`, and treated as a Python script.
- If used in a project directory, `uv` will automatically create or update the project environment before running the command.

- Outside of a project, if there's a virtual environment present in your current directory (or any parent directory), `uv` runs the command in that environment. If no environment is found, it uses the interpreter's environment.

So what does this mean when we put `uv run` before `python src/thread_safe_app.py`? It means `uv` takes care of all the setup—fast and seamless—right in your local environment. If you think AI/ML is magic, the work the folks at [Astral](#) have done with `uv` is pure wizardry!

Curious to learn more about [Astral's uv](#)? Check these out:

- Documentation: Learn about `uv`.
- Video: [uv IS THE FUTURE OF PYTHON PACKING!](#).

If you have Kafka connectivity issues, you can verify connectivity using the following command:

### 1.3.2 Troubleshoot Connectivity Issues (if any)

To verify connectivity to your Kafka cluster, you can use the `kafka-topics.sh` command-line tool. First, download the Kafka binaries from the [Apache Kafka website](#) and extract them. Navigate to the `bin` directory of the extracted Kafka folder. Second, create a `client.properties` file with your Kafka credentials:

```
# For SASL_SSL (most common for cloud services)
security.protocol=SASL_SSL
sasl.mechanism=PLAIN
sasl.jaas.config=org.apache.kafka.common.security.plain.PlainLoginModule required \
  username="<YOUR_KAFKA_API_KEY>" \
  password="<YOUR_KAFKA_API_SECRET>";

# Additional SSL settings if needed
ssl.endpoint.identification.algorithm=https
```

Finally, run the following command to list all topics in your Kafka cluster:

```
./kafka-topics.sh --list --bootstrap-server <YOUR_BOOTSTRAP_SERVER_URI> --command-config ./client.properties
```

If the connection is successful, you should see a list of topics in your Kafka cluster. If you encounter any errors, double-check your credentials and network connectivity.

## 1.4 The Results

The application automatically generates two comprehensive CSV reports for each Kafka Cluster that transform raw analysis into actionable insights:

- **Detail Report CSV.** For every topic analyzed, this report captures the topic's average consumer throughput (MB/s), its required throughput (MB/s), and a calculated recommended partition count, ensuring precise alignment between workload demand and partitioning strategy. Below is a screenshot of a sample detail report:

```
method,topic_name,is_compacted,number_of_records,number_of_partitions,required_throughput,consumer_throughput,recommended_partitions,status
sampling_records,stock_trades,no,24022,6,18.77706720286864,1.877706720286864,10,active
sampling_records,stock_trades_with_totals,no,24345,6,8.232389887466407,0.8232389887466408,6,active
```

- **Summary Report CSV.** Once all topics have been evaluated, this report consolidates the results into a high-level overview, providing a clear, data-driven snapshot of cluster-wide throughput patterns and partitioning recommendations. Below is a screenshot of a sample summary report:

```
stat,value
elapsed_time_in_hours,0.02666729642285241
method,sampling_records
required_consumption_throughput_factor,10
minimum_required_throughput_threshold,10.0
default_partition_count,6
sampling_batch_size,10000
sampling_days,1
sampling_max_consecutive_nulls,50
sampling_timeout,2.0
sampling_max_continuous_failed_batches,5
total_topics,2
internal_topics_included,False
topic_filter,None
active_topic_count,2
active_topic_percentage,100.0
total_partitions,12
total_recommended_partitions,16
active_total_partition_count,12
recommended_percentage_increase_in_partitions,33.33333333333333
total_records,48367
```



```
average_partitions_per_topic,6.0
active_average_partitions_per_topic,6.0
average_recommended_partitions_per_topic,8.0
```

The names of the CSV comprises of the <KAFKA CLUSTER ID>-recommender-<CURRENT EPOCH TIME IN SECONDS WHEN THE APP STARTED>-detail-report.csv and <KAFKA CLUSTER ID>-recommender-<CURRENT EPOCH TIME IN SECONDS WHEN THE APP STARTED>-summary-report.csv, respectively.

## 2.0 How the app calculates the recommended partition count

The app uses the Kafka `AdminClient` to retrieve all Kafka Topics (based on the `TOPIC_FILTER` specified) stored in your Kafka Cluster, including the original partition count per topic. Then, it iterates through each Kafka Topic, calling the Confluent Cloud Metrics RESTful API to retrieve the topic's average (i.e., the *Consumer Throughput*) and peak consumption in bytes over a rolling seven-day period. Next, it calculates the required throughput by multiplying the peak consumption by the `REQUIRED_CONSUMPTION_THROUGHPUT_FACTOR` (i.e., the *Required Throughput*). Finally, it divides the required throughput by the consumer throughput and rounds the result to the nearest whole number to determine the optimal number of partitions.

**Note:** This why the app requires the Kafka API Key and Secret to connect to your Kafka Cluster via the `AdminClient`, and the Confluent Cloud API Key and Secret to connect to the Confluent Cloud Metrics API.

For example, suppose you have a consumer that consumes at **25MB/s**, but the the consumer requirement is a throughput of **1.22GB/s**. How many partitions should you have?

To determine the number of partitions needed to support a throughput of **1.22GB/s** for a Kafka consumer that can only consume at **25MB/s**, you can calculate it as follows:

1. Convert the target throughput to the same units:

- **1.22GB/s = 1250MB/s**

2. Divide the target throughput by the consumer's capacity:

$$\text{Partition Count} = \frac{\text{Required Throughput}}{\text{Consumer Throughput}} = \frac{1250 \text{ MB/s}}{25 \text{ MB/s}} = 50$$

3. Since you can only have a whole number of partitions, you should always round up to the nearest whole number:

**Partition Count = 50**

The **50 partitions** ensure that the consumer can achieve the required throughput of **1.22GB/s** while consuming at a rate of **25MB/s** per partition. This will allow the workload to be distributed across partitions so that multiple consumers can work in parallel to meet the throughput requirement.

### 2.1 End-to-End Application Workflow

```
---
id: 3eadd090-8b11-4a52-abc2-9755066ffc9d
---
sequenceDiagram
    participant User
    participant App as thread_safe_app.py
    participant KTA as KafkaTopicsAnalyzer
    participant AC as AdminClient
    participant MC as MetricsClient
    participant KC as Consumer
    participant AWS as AWS Secrets Manager
    participant CSV as CSV Report

    User->>App: Run application
    App->>App: Load environment variables
    App->>App: Read configuration settings

    alt Use AWS Secrets Manager
        App->>AWS: Get Confluent Cloud credentials
        AWS-->>App: Return credentials
        App->>AWS: Get Kafka API credentials
        AWS-->>App: Return Kafka credentials
    else Use Environment Variables
        App->>App: Read credentials from env vars
    end

    loop For each Kafka cluster
        App->>KTA: Initialize(cluster_id, bootstrap_server, api_key, api_secret, metrics_config)
        KTA->>AC: Create AdminClient
        KTA->>MC: Create MetricsClient
```

```

App-->>KTA: analyze_all_topics(parameters)

KTA-->>AC: list_topics()
AC-->>>KTA: Return topics metadata

KTA-->>AC: describe_configs(topics)
AC-->>>KTA: Return topic configurations

KTA-->>KTA: Filter topics (internal, topic_filter)

KTA-->>CSV: Create report file with headers

loop For each topic to analyze
  alt Use Sample Records
    rect rgb(173, 216, 230)
      KTA-->>KTA: Calculate rolling window timeframe
      KTA-->>KTA: __analyze_topic()

      KTA-->>KC: Create Consumer
      KTA-->>KC: get_watermark_offsets()
      KC-->>>KTA: Return low/high offsets

      KTA-->>KC: offsets_for_times()
      KC-->>>KTA: Return offset at timestamp

      KTA-->>KTA: __sample_record_sizes()

      loop For each partition
        KTA-->>KC: assign() and seek()

        loop Sample records in batches
          KTA-->>KC: poll()
          KC-->>>KTA: Return record
          KTA-->>KTA: Calculate record size
          KTA-->>KTA: Update running totals
        end
      end

      KTA-->>KC: close()
      KTA-->>KTA: Calculate average record size
    end

  else Use Metrics API
    rect rgb(255, 182, 193)
      KTA-->>MC: get_topic_daily_aggregated_totals(RECEIVED_BYTES)
      MC-->>>KTA: Return bytes metrics

      KTA-->>MC: get_topic_daily_aggregated_totals(RECEIVED_RECORDS)
      MC-->>>KTA: Return records metrics

      KTA-->>KTA: Calculate average bytes per record
    end
  end

  KTA-->>KTA: Calculate required throughput
  KTA-->>KTA: Determine recommended partitions
  KTA-->>CSV: Write topic analysis to report
end

KTA-->>KTA: Generate summary statistics
KTA-->>>App: Return analysis results
end

App-->>User: Display completion message
App-->>CSV: Save report file

```

### 3.0 Unlocking High-Performance Consumer Throughput

The throughput of a **Kafka consumer** refers to the rate at which it can read data from Kafka topics, typically measured in terms of **megabytes per second (MB/s)** or **records per second**. Consumer throughput depends on several factors, including the configuration of Kafka, the consumer application, and the underlying infrastructure.

#### 3.1 Key Factors Affecting Consumer Throughput

##### 3.1.1 Partitions

- Throughput scales with the number of partitions assigned to the consumer. A consumer can read from multiple partitions concurrently, but the total throughput is bounded by the number of partitions and their data production rates.

- Increasing the number of partitions can improve parallelism and consumer throughput.

### 3.1.2 Consumer Parallelism

- A single consumer instance reads from one or more partitions, but it can be overwhelmed if the data rate exceeds its capacity.
- Adding more consumers in a consumer group increases parallelism, as Kafka reassigns partitions to balance the load.

### 3.1.3 Fetch Configuration

- **fetch.min.bytes**: Minimum amount of data (in bytes) the broker returns for a fetch request. Larger values reduce fetch requests but may introduce latency.
- **fetch.max.bytes**: Maximum amount of data returned in a single fetch response. A higher value allows fetching larger batches of messages, improving throughput.
- **fetch.max.wait.ms**: Maximum time the broker waits before responding to a fetch request. A higher value can increase batch sizes and throughput but may increase latency.

For more details, see the [Confluent Cloud Client Optimization Guide - Consumer Fetching](#).

### 3.1.4 Batch Size

- Consumers process messages in batches for better efficiency. Larger batches reduce processing overhead but require sufficient memory.
- Configuration: **max.poll.records** controls the number of records fetched in a single poll.

### 3.1.5 Message Size

- Larger messages can reduce throughput if the network or storage systems are bottlenecks. Use compression (e.g., **lz4**, **snappy**) to optimize data transfer.

### 3.1.6 Network Bandwidth

- Network speed between Kafka brokers and consumers is critical. A consumer running on a limited-bandwidth network will see reduced throughput.

### 3.1.7 Deserialization Overhead

- The time required to deserialize records impacts throughput. Efficient deserialization methods (e.g., Avro, Protobuf with optimized schemas) can help.

### 3.1.8 Broker Load

- Broker performance and replication overhead impact the throughput seen by consumers. If brokers are under heavy load, consumer throughput may decrease.

### 3.1.9 Consumer Poll Frequency

- Consumers must frequently call **poll()** to fetch messages. If the consumer spends too much time processing messages between polls, throughput can drop.

### 3.1.10 System Resources

- CPU, memory, and disk I/O on the consumer's machine affect how fast it can process data.

## 3.2 Typical Consumer Throughput

- **Single Partition Throughput**: A single consumer reading from a single partition can typically achieve **10-50 MB/s** or higher, depending on record size, compression, and hardware.
- **Multi-Partition Throughput**: For a consumer group reading from multiple partitions, throughput can scale linearly with the number of partitions (subject to other system limits).

## 3.3 Seven Strategies to Improve Consumer Throughput

1. **Increase Partitions**: Scale partitions to allow more parallelism.
2. **Add Consumers**: Add more consumers in the consumer group to distribute the load.
3. **Optimize Fetch Settings**: Tune **fetch.min.bytes**, **fetch.max.bytes**, and **fetch.max.wait.ms**.
4. **Batch Processing**: Use **max.poll.records** to fetch and process larger batches.
5. **Compression**: Enable compression to reduce the amount of data transferred.
6. **Efficient SerDe (Serialization/Deserialization)**: Use optimized serializers and deserializers.
7. **Horizontal Scaling**: Ensure consumers run on high-performance hardware with sufficient network bandwidth.

By optimizing these factors, Kafka consumers can achieve higher throughput tailored to the specific use case and infrastructure.

## 4.0 Resources

### 4.1 Optimization Guides

- [Optimize Confluent Cloud Clients for Throughput](#)
- [Choose and Change the Partition Count in Kafka](#)

### 4.2 Confluent Cloud Metrics API

- [Confluent Cloud Metrics API](#)

- [Confluent Cloud Metrics API: Metrics Reference](#)
- [Confluent Cloud Metrics](#)

#### 4.3 Confluent Kafka Python Client

- [Confluent Kafka Python Client Documentation](#)