

Apache Kafka Fundamentals

The Complete Guide to Distributed Event Streaming

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The Birth of Kafka

2010–2011 at LinkedIn

The Problem

- Billions of events/day
- Real-time analytics needed
- Traditional brokers couldn't scale

The Solution Team

- Jay Kreps
- Neha Narkhede
- Jun Rao

Kafka Timeline

Timeline

Year	Milestone
2011	Open-sourced Kafka
2013	Apache Top-Level Project
2014	Confluent founded
2016	Kafka Streams introduced
2020	KRaft mode (no ZooKeeper)

What is Apache Kafka?

Definition

Apache Kafka is a *distributed, fault-tolerant event streaming platform* that stores, processes, and transports real-time data at scale.

Core Roles

Publish/subscribe • Durable storage • Stream processing

Analogy

Like a high-speed, persistent *data conveyor belt* where many apps can place and pick up packages.

Core Kafka Architecture

```
[Producer Apps] ---> [Kafka Brokers Cluster] ---> [Consumer Apps]
                        (Topics & Partitions)
```

Key Components

- **Producers** send messages to topics
- **Brokers** store and serve messages
- **Topics** are named categories of messages
- **Partitions** are parallel units of a topic
- **Consumers** read messages from topics
- **Cluster Coordination** via ZooKeeper or KRaft

Topics & Partitions

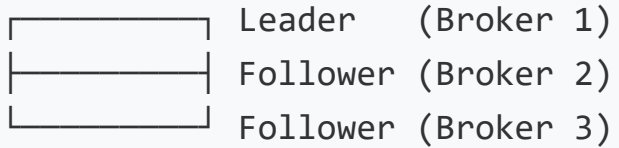
Topic: user-events

├ Partition 0: Msg1 → Msg2 → Msg3
├ Partition 1: Msg4 → Msg5 → Msg6
└ Partition 2: Msg7 → Msg8 → Msg9

- **Topics:** Logical streams of data
- **Partitions:** Scale & parallelize consumption
- **Keys:** Route to partitions; ordering within a partition

Replication & Fault Tolerance

Partition 0 (Replication Factor = 3)



- **Leader** handles reads/writes; **followers** replicate
- **ISR**: In-Sync Replicas
- Prevent data loss: `unclean.leader.election.enable=false`
- Best practice: `min.insync.replicas=2` with RF=3

ZooKeeper vs KRaft

ZooKeeper

External service for metadata & leader election.
More components to run and manage.

KRaft (Kafka Raft)

Built-in consensus; simpler ops, faster startup, better scalability.
Default in Kafka 3.5+.

How Kafka Stores Data

Commit Log

Append-only files on disk. Retain by *time* or *size*; optional *log compaction* keeps latest record per key.

Segments

Partitions split into segments. Old segments are deleted or compacted based on policy.

Producers

What is a Producer?

An application that publishes messages to Kafka topics.

Partitioning

- **Key-based** → same key → same partition
- **No key** → round-robin distribution

Key Settings

```
acks=all  
enable.idempotence=true  
compression.type=snappy
```

Consumers & Consumer Groups

Topic: orders (6 partitions)

Group: analytics

Consumer1	Consumer2	Consumer3
[P0, P1]	[P2, P3]	[P4, P5]

- Each **group** sees all messages
- Within a group, a **partition** is consumed by one member
- **Offsets** track read position

Kafka Connect

Purpose

Integrate Kafka with external systems *without custom code*.

Types

Source connectors (import) • Sink connectors (export)

Runs in standalone or distributed mode.

Kafka Streams

Purpose

Build real-time applications directly on Kafka.

Highlights

Java/Scala library • Stateful ops (aggregations, joins, windows) • Exactly-once semantics • Scales with partitions.

Kafka Use Cases

Great Fit

- Event streaming (user activity, IoT)
- Real-time analytics (fraud, dashboards)
- Microservice communication (EDA)

Not Ideal

- Ultra low latency trading
- Small simple queues
- OLTP DB replacement

Monitoring & Metrics

- Kafka CLI tools
- Prometheus + Grafana
- Confluent Control Center

Watch: Broker health • Topic/partition status • Consumer lag

Security in Kafka

AuthN

SASL/PLAIN • SASL/SCRAM • Kerberos • OAuth

Encryption

TLS in transit

AuthZ

ACLs per topic, group, and cluster resources

Hands-On Demo

We'll cover:

- Creating topics
- Producing and consuming messages
- Observing replication
- Checking consumer lag

Reference Handouts:

- `01-basic-commands.md`
- `02-kcat-examples.md`
- `03-python-examples.md`
- `04-load-test-commands.md`

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Wrap-Up

We covered:

- Kafka basics & architecture
- Topics, partitions, replication
- Producers & consumers
- Storage model, Connect, Streams
- Use cases, monitoring, security

Next: Hands-on practice & advanced configs

Appendix: Config Highlights

Producer

```
acks=all  
enable.idempotence=true  
compression.type=snappy
```

Consumer

```
group.id=my-group  
auto.offset.reset=earliest
```

Broker

```
default.replication.factor=3  
min.insync.replicas=2
```