

Real-Time E-commerce Transaction Monitoring

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E-Commerce Real-Time Analytics Pipeline Report

1. Introduction

The exponential growth of e-commerce platforms has created an urgent need for real-time analytics to understand customer behavior, detect fraud, and optimize sales strategies. Traditional batch processing systems are insufficient when businesses require immediate insights to act on customer interactions, inventory changes, or transaction risks.

This project builds a **real-time data pipeline** using **Apache Kafka, MongoDB, and Python-based consumers** to process and analyze e-commerce transaction data as it occurs. The pipeline ensures continuous ingestion, processing, enrichment, and storage of data, which can then be visualized on business dashboards for actionable insights.

2. Business Context

E-commerce companies generate millions of events per day, including transactions, clicks, reviews, and payments. Real-time monitoring provides several competitive advantages:

- **Fraud Detection:** Detect suspicious transactions instantly (e.g., high-value purchases from unusual locations).
- **Customer Experience:** Monitor failed payments or repeated cart abandonments and trigger interventions.
- Sales Optimization: Identify top-selling products and regions in real time to adjust promotions.
- Operational Efficiency: Track inventory depletion and restock proactively.

The implemented pipeline supports both **customer-centric insights** (e.g., purchase sentiment, repeat buyer patterns) and **business-centric insights** (e.g., revenue streams, risk alerts).

3. Pipeline Architecture

The real-time data pipeline follows a **four-stage architecture**:

Stage 1: Data Ingestion

- Transaction data (user, product, price, payment method, location, timestamp) is generated either from CSV simulation or live streams.
- A Kafka Producer pushes this data into the Kafka topic transactions.raw.

Stage 2: Data Processing & Enrichment

- A Kafka Consumer processes the raw stream.
- Business rules are applied:
 - Classification of transactions (low, medium, high-value).
 - o Flagging of suspicious patterns (e.g., unusual geolocation, excessive refunds).
 - o Aggregation of product-level sales.
- Enriched transactions are forwarded to transactions.enriched.

Stage 3: Real-Time Storage

- Data is stored in **MongoDB** under collections transactions and alerts.
- This enables queries, dashboards, and advanced analytics using MongoDB Compass or external BI tools.

Stage 4: Delivery & Visualization

- Business dashboards display KPIs such as:
 - Real-time revenue trend.
 - Top products and regions.
 - o Alerts on suspicious transactions.
- Visual dashboards enable management teams to make **immediate decisions**.

4. Example Flow Diagram

Pipeline Flow:

[Producer → Kafka Topic (transactions.raw) → Consumer Processing → Kafka Topic (transactions.enriched) → MongoDB Storage → Business Dashboard]

5. Sample Data & Processing

```
A sample transaction record:
 "transaction id": "T101",
 "user": "alice".
 "product": "Smartphone",
 "amount": 550,
 "payment method": "Credit Card",
 "location": "New York",
 "timestamp": "2025-09-30 14:32:00"
Enriched Output:
 "transaction id": "T101",
 "user": "alice",
 "product": "Smartphone",
 "amount": 550,
 "payment method": "Credit Card",
 "location": "New York",
 "timestamp": "2025-09-30 14:32:00",
 "value_category": "High-Value",
 "alert flag": false
}
```

If a transaction is suspicious (e.g., \$5000 purchase from an unusual country), an **alert document** is created and stored in the MongoDB alerts collection.

6. Business Insights

From the pipeline, a company can derive real-time KPIs:

- Revenue Growth by Minute: Continuous monitoring of total sales.
- Product Performance: Detect fast-selling SKUs to adjust stock.
- Geographical Trends: Identify new high-demand regions instantly.
- Fraud Alerts: Stop fraudulent transactions in seconds rather than hours.

This provides a **data-driven advantage** to the company by enabling **real-time decision-making** instead of reactive batch reports.

7. Visual Dashboards

Potential dashboards in MongoDB or BI tools:

- Transaction Volume Trend: Line chart showing transactions over time.
- Revenue by Product: Bar chart comparing sales by product categories.
- Geographic Heatmap: Map visualization of purchases by region.
- Alerts Feed: Table listing all flagged transactions.

8. Conclusion

The designed **real-time e-commerce analytics pipeline** empowers businesses to act instantly on customer behavior, operational bottlenecks, and potential risks.

Unlike traditional reporting systems, this pipeline:

- Captures streaming transactions from multiple sources.
- Processes and enriches them in milliseconds.
- Stores actionable data in MongoDB.
- Delivers dashboards and alerts for immediate response.

This ensures better fraud prevention, enhanced customer experience, and improved revenue strategies, making it a powerful asset for any e-commerce business.

Producer file

```
1 from kafka import KafkaProducer
 2 import pandas as pd
 3 import json
 4 import time
 5
 6 KAFKA_BROKER = "localhost:9092"
 7 TOPIC = "transactions.raw"
 8
9 producer = KafkaProducer(
10
       bootstrap_servers=KAFKA_BROKER,
       value_serializer=lambda v: json.dumps(v).encode("utf-8")
11
12
   )
13
14 df = pd.read csv("transactions.csv")
15
16 for _, row in df.iterrows():
17
       transaction = row.to_dict()
18
       producer.send(TOPIC, transaction)
19
       print(f"Sent: {transaction}")
       time.sleep(1) # simulate real-time
20
21
```

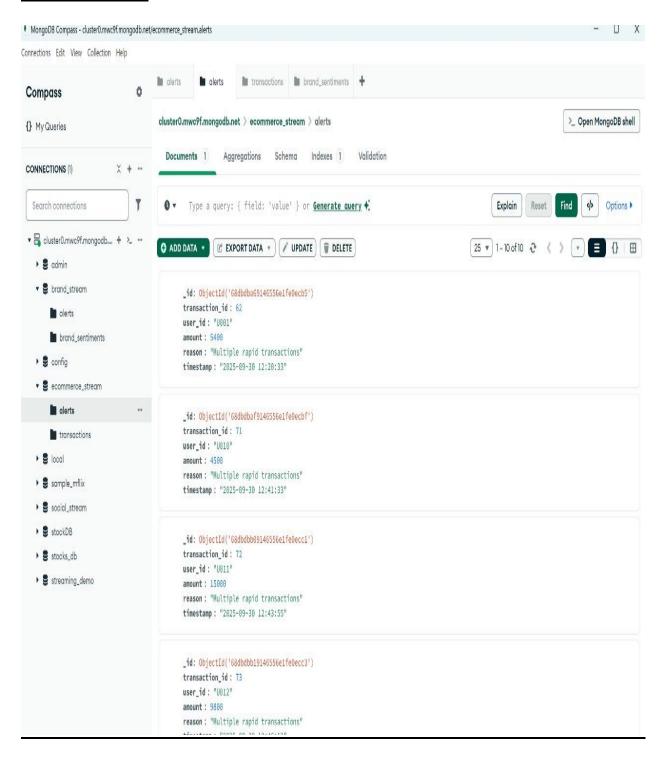
Consumer file

```
1 from kafka import KafkaConsumer, KafkaProducer
2 import json
3 from datetime import datetime
5 KAFKA_BROKER = "localhost:9092"
6 INPUT TOPIC = "transactions.raw"
7 OUTPUT_TOPIC = "transactions.processed"
8
9 consumer = KafkaConsumer(
10
       INPUT_TOPIC,
       bootstrap_servers=KAFKA_BROKER,
11
       auto_offset_reset="earliest",
12
       value_deserializer=lambda v: json.loads(v.decode("utf-8"))
13
14 )
15
16 producer = KafkaProducer(
17
       bootstrap_servers=KAFKA_BROKER,
       value_serializer=lambda v: json.dumps(v).encode("utf-8")
18
19 )
20
21 for message in consumer:
22
       txn = message.value
23
       txn["processed_time"] = datetime.now().strftime("%Y-%m-%d %H:%M:%S")
24
       producer.send(OUTPUT TOPIC, txn)
       print(f"Processed & forwarded: {txn}")
25
26
```

Alerts file

```
1 from kafka import KafkaConsumer
 2 from pymongo import MongoClient
 3 import json
 4 from collections import defaultdict
 5 from datetime import datetime
 6
 7 KAFKA_BROKER = "localhost:9092"
 8 INPUT_TOPIC = "transactions.processed"
9
10 MONGO_URI = "mongodb+srv://055039:saloni1234@cluster0.mwc9f.mongodb.net/"
11 DB_NAME = "ecommerce_stream"
12 TXN COLLECTION = "transactions"
13 ALERT_COLLECTION = "alerts"
14
15 # Mongo setup
16 client = MongoClient(MONGO_URI)
17 db = client[DB_NAME]
18 transactions = db[TXN_COLLECTION]
19 alerts = db[ALERT_COLLECTION]
20
21 consumer = KafkaConsumer(
22
      INPUT_TOPIC,
23
       bootstrap_servers=KAFKA_BROKER,
       auto_offset_reset="earliest",
24
25
      value_deserializer=lambda v: json.loads(v.decode("utf-8"))
26 )
27
28 user_activity = defaultdict(list)
29
30 for message in consumer:
31
      txn = message.value
32
       transactions.insert_one(txn)
      print(f"Saved txn: {txn['transaction id']}")
33
34
        suspicious = False
reason = ""
35
36
37
38
        # Rule 1: High-value transaction
        if txn["amount"] > 50000:
39
             suspicious = True
40
             reason = "High transaction amount"
41
42
43
        # Rule 2: Too many transactions in short time
        user_activity[txn["user_id"]].append(datetime.now())
44
45
        if len(user_activity[txn["user_id"]]) > 3:
46
             suspicious = True
             reason = "Multiple rapid transactions"
47
48
49
        if suspicious:
50
             alert_doc = {
51
                  "transaction_id": txn["transaction_id"],
                 "user_id": txn["user_id"],
52
                 "amount": txn["amount"],
53
                  "reason": reason,
54
55
                 "timestamp": txn["timestamp"]
56
57
             alerts.insert_one(alert_doc)
58
             print(f" ALERT: {alert_doc}")
59
```

Transactions file



1	Α	В	С	D	E	F
	transaction_id	user_id	amount	payment_method	location	timestamp
2	1	U001	4500	Credit Card	Mumbai	30-09-2025 10:05
3	2	U002	1200	UPI	Delhi	30-09-2025 10:06
4	3	U001	56000	Debit Card	Mumbai	30-09-2025 10:07
5	4	U003	2300	Net Banking	Bangalore	30-09-2025 10:09
5		U004		Wallet	Chennai	30-09-2025 10:11
7		U005		Credit Card	Kolkata	30-09-2025 10:11
3	-	U006	9800		Hyderabad	30-09-2025 10:14
9	8	U007		Debit Card	Pune	30-09-2025 10:16
0	9	U008	6700	Net Banking	Mumbai	30-09-2025 10:18
1	10	U009	12300	Wallet	Delhi	30-09-2025 10:20
2	11	U010	5400	Credit Card	Bangalore	30-09-2025 10:23
3	12	U011	8700	UPI	Chennai	30-09-2025 10:25
4		U012		Debit Card	Kolkata	30-09-2025 10:27
5		U013		Net Banking	Hyderabad	30-09-2025 10:30
6		U014		Wallet		
					Pune	30-09-2025 10:32
7		U015		Credit Card	Mumbai	30-09-2025 10:34
8	17	U016	3400	UPI	Delhi	30-09-2025 10:36
9	18	U017	12000	Debit Card	Bangalore	30-09-2025 10:38
0	19	U018	5600	Net Banking	Chennai	30-09-2025 10:41
1	20	U019	7800	Wallet	Kolkata	30-09-2025 10:43
2		U020		Credit Card	Hyderabad	30-09-2025 10:45
3		U001	2300		Pune	30-09-2025 10:43
4		U002		Debit Card	Mumbai	30-09-2025 10:47
5		U003		Net Banking	Delhi	30-09-2025 10:51
26	25	U004		Wallet	Bangalore	30-09-2025 10:53
27	26	U005	5400	Credit Card	Chennai	30-09-2025 10:56
8	27	U006	8700	UPI	Kolkata	30-09-2025 10:58
9	28	U007	2300	Debit Card	Hyderabad	30-09-2025 11:00
10	29	U008	4500	Net Banking	Pune	30-09-2025 11:03
1		U009		Wallet	Mumbai	30-09-2025 11:05
2		U010		Credit Card	Delhi	30-09-2025 11:07
		-				
3		U011	5400		Bangalore	30-09-2025 11:10
4	33	U012	6700	Debit Card	Chennai	30-09-2025 11:12
35	34	U013	2300	Net Banking	Kolkata	30-09-2025 11:14
36	35	U014	4500	Wallet	Hyderabad	30-09-2025 11:17
_	_					
<u>⊿</u> 37	Α 25	B U015	C 15000	D Credit Card	E	F 30-09-2025 11:19
38		U016	9800		Pune Mumbai	30-09-2025 11:22
39		U017		Debit Card	Delhi	30-09-2025 11:24
10	39	U018		Net Banking	Bangalore	30-09-2025 11:26
11			12200	Wallet	Chennai	30-09-2025 11:29
-	40	U019	12500			30-09-2023 11.29
		U019 U020		Credit Card	Kolkata	30-09-2025 11:31
12 13	41 42	U020 U001	5400 4500	Credit Card UPI	Kolkata Hyderabad	30-09-2025 11:31 30-09-2025 11:33
12 13 14	41 42 43	U020 U001 U002	5400 4500 15000	Credit Card UPI Debit Card	Kolkata Hyderabad Pune	30-09-2025 11:31 30-09-2025 11:33 30-09-2025 11:36
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12 13 14 15 16	41 42 43 44 45	U020 U001 U002 U003 U004	5400 4500 15000 9800 2300	Credit Card UPI Debit Card Net Banking Wallet	Kolkata Hyderabad Pune Mumbai Delhi	30-09-2025 11:31 30-09-2025 11:33 30-09-2025 11:36 30-09-2025 11:38 30-09-2025 11:40
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12 13 14 15 16 17 18 19 50 51	41 42 43 44 45 46 47 48 49 50	U020 U001 U002 U003 U004 U005 U006 U007 U008 U009 U010	5400 4500 15000 9800 2300 6700 5400 4500 15000 9800 6700	Credit Card UPI Debit Card Net Banking Wallet Credit Card UPI Debit Card Net Banking Wallet Credit Card	Kolkata Hyderabad Pune Mumbai Delhi Bangalore Chennai Kolkata Hyderabad Pune Mumbai	30-09-2025 11:31 30-09-2025 11:33 30-09-2025 11:36 30-09-2025 11:43 30-09-2025 11:43 30-09-2025 11:47 30-09-2025 11:52 30-09-2025 11:52
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72	71	U010	4500	Credit Card	Pune	30-09-2025 12:41
73	72	U011	15000	UPI	Mumbai	30-09-2025 12:43
74	73	U012	9800	Debit Card	Delhi	30-09-2025 12:46
75	74	U013	5400	Net Banking	Bangalore	30-09-2025 12:48
76	75	U014	6700	Wallet	Chennai	30-09-2025 12:50
77	76	U015	2300	Credit Card	Kolkata	30-09-2025 12:53
78	77	U016	4500	UPI	Hyderabad	30-09-2025 12:55
79	78	U017	15000	Debit Card	Pune	30-09-2025 12:57
80	79	U018	9800	Net Banking	Mumbai	30-09-2025 13:00
81	80	U019	5400	Wallet	Delhi	30-09-2025 13:02
82	81	U020	6700	Credit Card	Bangalore	30-09-2025 13:04
83	82	U001	2300	UPI	Chennai	30-09-2025 13:07
84	83	U002	4500	Debit Card	Kolkata	30-09-2025 13:09
85	84	U003	15000	Net Banking	Hyderabad	30-09-2025 13:11
86	85	U004	9800	Wallet	Pune	30-09-2025 13:14
87	86	U005	5400	Credit Card	Mumbai	30-09-2025 13:16
88	87	U006	6700	UPI	Delhi	30-09-2025 13:18
89	88	U007	2300	Debit Card	Bangalore	30-09-2025 13:21
90	89	U008	4500	Net Banking	Chennai	30-09-2025 13:23
91	90	U009	15000	Wallet	Kolkata	30-09-2025 13:25
92	91	U010	9800	Credit Card	Hyderabad	30-09-2025 13:28
93	92	U011	5400	UPI	Pune	30-09-2025 13:30
94	93	U012	6700	Debit Card	Mumbai	30-09-2025 13:32
95	94	U013	2300	Net Banking	Delhi	30-09-2025 13:35
96	95	U014	4500	Wallet	Bangalore	30-09-2025 13:37
97	96	U015	15000	Credit Card	Chennai	30-09-2025 13:39
98	97	U016	9800	UPI	Kolkata	30-09-2025 13:42
99	98	U017	5400	Debit Card	Hyderabad	30-09-2025 13:44
100	99	U018	6700	Net Banking	Pune	30-09-2025 13:46
101	100	U019	2300	Wallet	Mumbai	30-09-2025 13:49
102						
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