Infrastructure Technologies for Large-Scale Service-Oriented Systems

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Kafka

- Data logged
  - User activity (logins, page views, clicks, likes, sharing, comments, search queries)
  - Operational metrics (call latency, errors, system metrics)

- Uses
  - Search relevance
  - Recommendations driven by item popularity or co-occurrence in activity stream
  - Ad targeting and reporting
  - Security applications
  - Newsfeed of user status for friends / connections to read

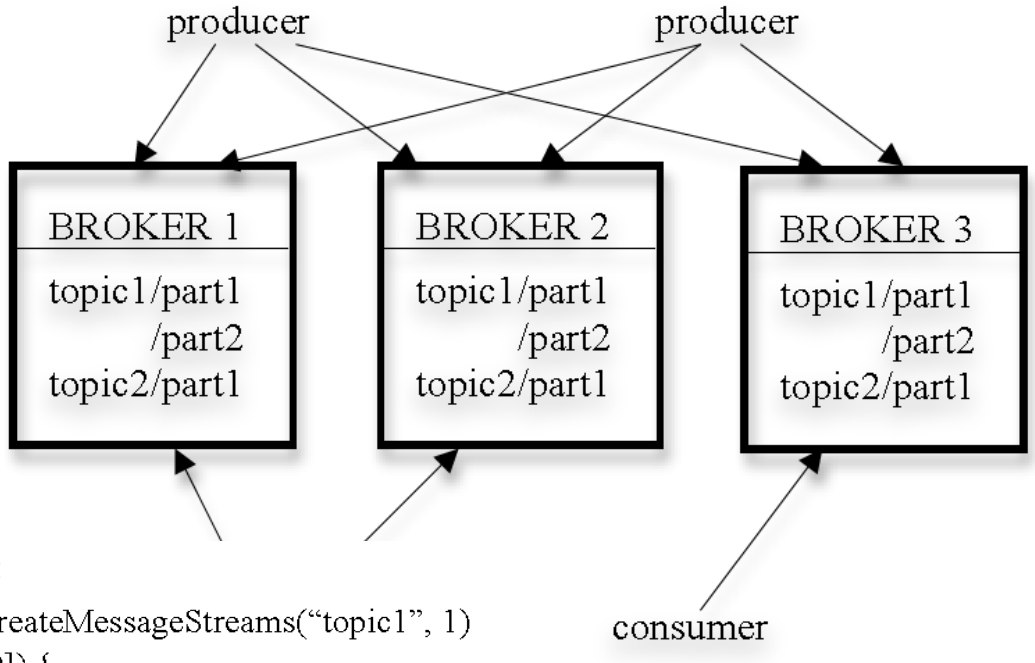
Challenges

- High event rates
  - Search, recommendations, and advertising require computing granular click-through rates
  - China Mobile 5-7TB of phone call records / day
  - Facebook gathers ~6TB of various user activity events / day
- Traditional enterprise messaging systems too strict
  - Unnecessarily rich set of delivery guarantees
    - IBM WebSphere MQ: allow atomic inserts into multiple queues
    - JMS spec: ack each individual message after consumption
  - Performance issues: No API to batch messages (JMS)
  - No easy way to partition and store msgs on many machines
  - Assuming near-immediate consumption of messages

Kafka architecture

Sample producer code:

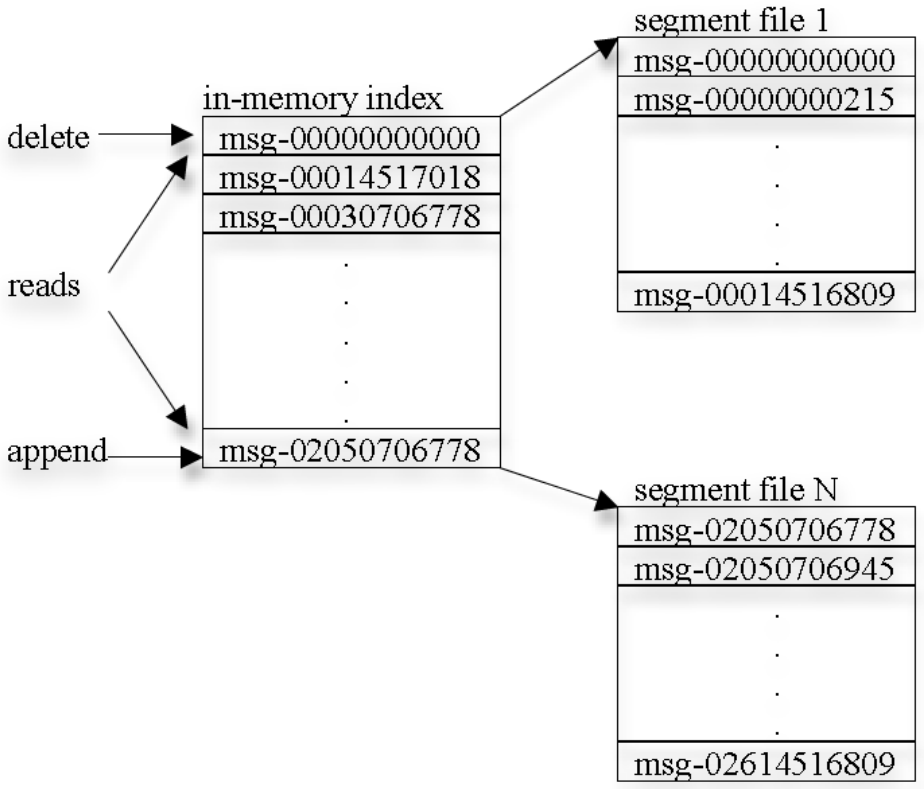
```
producer = new Producer(…);
message = new Message(“test message str”.getBytes());
set = new MessageSet(message);
producer.send(“topic1”, set);
```



Sample consumer code:

```
streams[] = Consumer.createMessageStreams(“topic1”, 1)
for (message : streams[0]) {
  bytes = message.payload();
  // do something with the bytes
}
```

Kafka log



- Each partition of a topic corresponds to a logical log
- Flush to disk after configurable number of published messages

Efficiency of single partition

- Simple storage
  - Consumer acknowledges message offsets
  - Under the cover, consumer issues async pull requests
  - Broker locates segment file, sends data back to consumer
- Efficient transfer
  - No user-space caching by brokers, reduces JVM GC costs
  - Direct transfer from files to network sockets
- Stateless broker
  - Does not know whether all subscribers have consumed msg
  - Automatic message deletions after 7 days
  - Subscribers can rewind and replay messages

Consumer groups

- One or more consumers that jointly consume a set of subscribed topics
  - Each message delivered to only one consumer within CG
- No coordination needed across CGs
- Goal is to divide messages stored in brokers evenly among consumers
- All messages from one partition consumed by single consumer in a CG
  - Multiple consumers of a partition would need to coordinate
  - To balance load, multiple partitions per consumer

Coordination service: ZooKeeper

- Simple file-like API on znodes
- Can register watcher on a path, get notified
- Ephemeral vs. persistent paths
- Highly available service

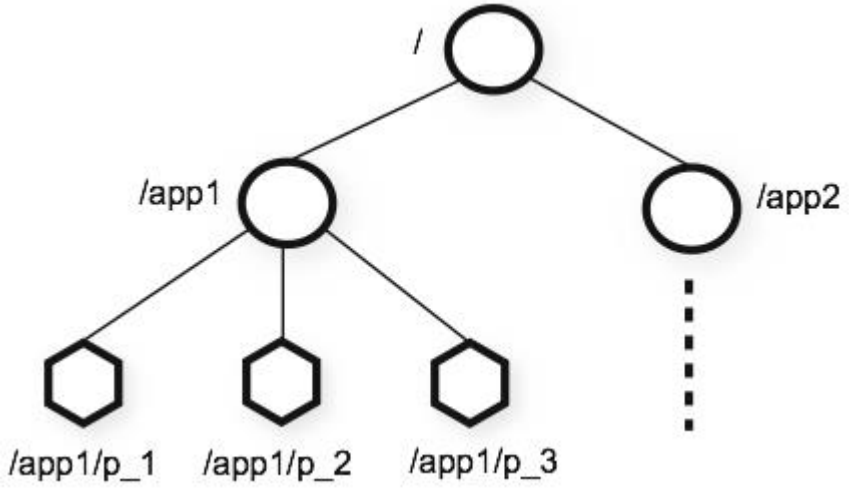
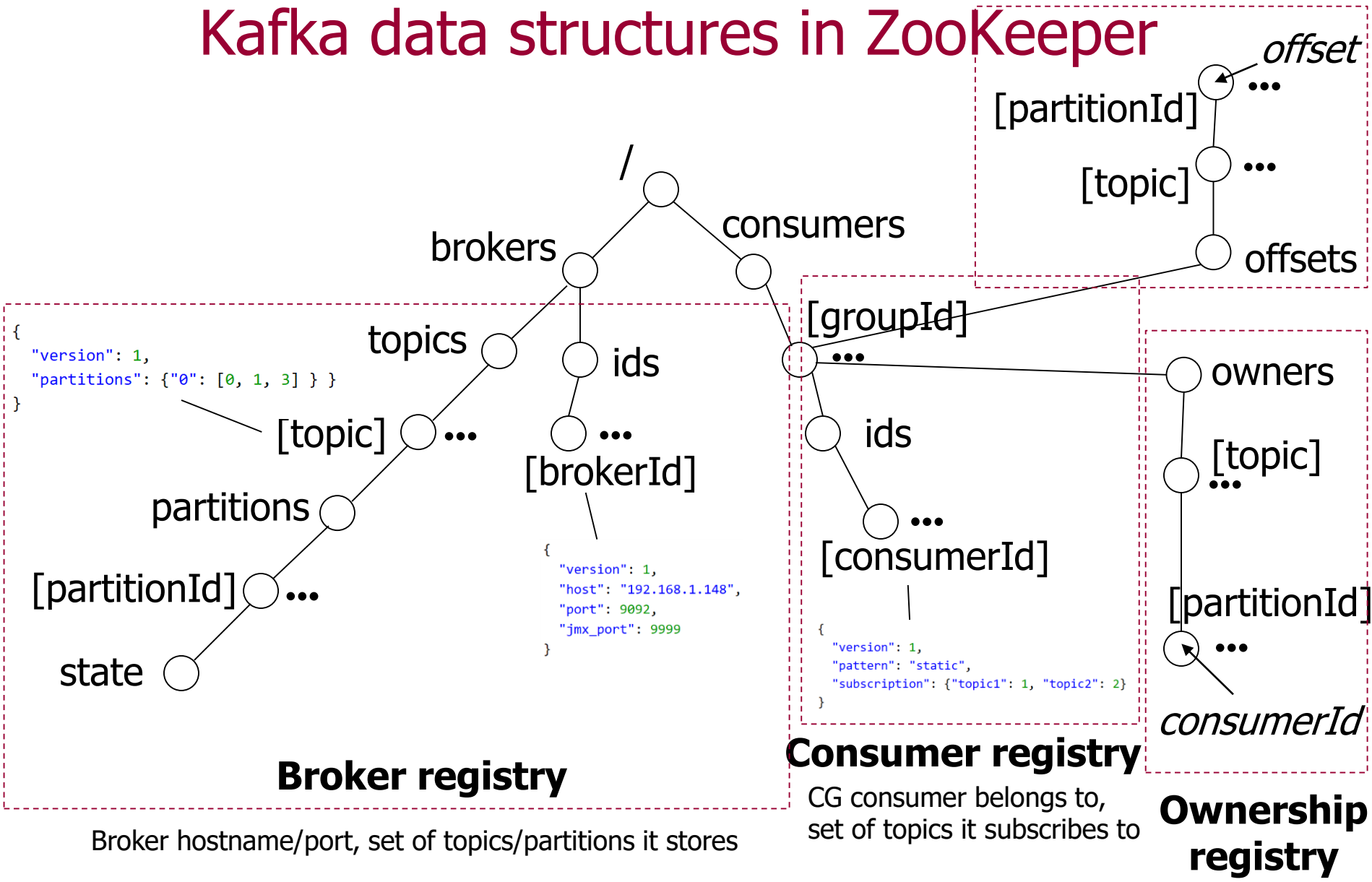


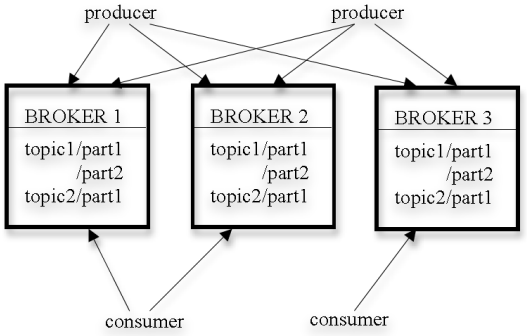
Image courtesy of https://zookeeper.apache.org

Kafka data structures in ZooKeeper



Rebalancing partitions

- Detect the addition or removal of brokers or consumers
- Trigger a re-balance process when that happens



Algorithm 1: rebalance process for consumer C_i in group G

For each topic T that C_i subscribes to {
  remove partitions owned by C_i from the ownership registry
  read the broker and the consumer registries from Zookeeper
  compute P_T = partitions available in all brokers under topic T
  compute C_T = all consumers in G that subscribe to topic T
  sort P_T and C_T
  let j be the index position of C_i in C_T and let $N = |P_T|/|C_T|$
  assign partitions from j*N to (j+1)*N - 1 in P_T to consumer C_i
  for each assigned partition p {
    set the owner of p to C_i in the ownership registry
    let O_p = the offset of partition p stored in the offset registry
    invoke a thread to pull data in partition p from offset O_p
  }
}

Typical Kafka deployment