DAT250 FeedApp Report

Erlend André Høntorp, Jonas Heen Opsahl and Thomas Tolo Jensen

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Abstract

Live polling applications need to keep data consistent across many users while staying fast and responsive. FeedApp is a real-time polling platform where users can create polls, vote, and discuss results in comment threads, with updates appearing instantly for everyone. This report compares RabbitMQ (message queuing) and Kafka (event sourcing) for handling real-time updates in a web application. Our aim is to show how a queue-oriented broker differs from a log-centric event stream in throughput, latency, scaling, and fan-out. We built the system with a Spring Boot backend and React frontend, using Kafka's topic-per-poll approach along with Redis for caching and WebSockets for push notifications. We used the OpenMessaging Benchmark to test both systems under different loads that simulate many votes coming in and updates being pushed to users. In our tests, Kafka handled more messages per second and scaled better when there were lots of writes, and RabbitMQ did not have lower latency at low message rates in our setup. As the load increased, Kafka pulled ahead, and RabbitMQ's per-message overhead became a bottleneck. Using one Kafka topic per poll kept events clean and isolated, but it added some extra management work. Overall, we learned about the trade-off between throughput and latency in log-based (Kafka) vs queue-based (RabbitMQ) systems, when the extra complexity of an event-driven design makes sense, and why careful cache invalidation matters in a distributed app.

Contents

1 Introduction

1.1 Project Overview

FeedApp is a small web app for running live polls. Users can create a poll with options, vote, and discuss the results in a comment thread. The goal is to make collecting feedback simple and fast. Instead of refreshing the page or counting results by hand, the app pushes updates in real time so everyone sees new votes and comments right away.

The system has two parts: a backend and a frontend. The backend exposes REST endpoints for polls, votes and comments, and it emits events when data changes. The frontend shows the latest state, listens for WebSocket messages, and keeps the UI in sync with the server. The project is also used to try out event-driven ideas and see how they scale when more users join.

1.2 Technology Stack Summary

Backend: Java with Spring Boot and Spring Security for REST APIs, validation and auth. During development we store data in an in-memory H2 database. Redis is used as a cache for frequently read data like poll results. Kafka is our messaging backbone for domain events (for example, a vote that was cast).
Frontend: React with TypeScript for a simple, component-based UI that reacts to server events over a single WebSocket connection.
Docker and CI: Docker and Docker Compose run all services with the same settings on any machine, and a GitHub Actions workflow builds and tests the full stack on every push so it always builds the same way and issues are caught quickly.

We chose this stack because it is familiar, easy to set up, and supports horizontal growth. Kafka helps decouple writes from notifications, Redis improves read performance, and WebSockets keep the UI responsive.

1.3 Project Outcome

The prototype supports creating polls, voting with instant updates, and threaded comments with edits and replies. We also compared Kafka with RabbitMQ for the event stream. In short: Kafka handled higher throughput and scaled better under heavy write load, while RabbitMQ showed slightly lower latency at low message rates. Our topic-per-poll approach in Kafka kept events neatly separated, and Redis caching reduced repeated work on popular polls. Everything is containerized so the full stack

starts with one command.

1.4 Report Organization

This report is organized as follows. Section 2 explains the design: main use cases, the domain model, and the overall architecture. Section 3 introduces Kafka (and the supporting tech), and outlines our experiment plan and assumptions. Section 4 describes how we built the prototype, how services talk to each other, and how to run it locally. Finally, Section 5 sums up what we learned and lists possible next steps.

2 Design

Around 5 pages about functional aspects of the FeedApp application.

2.1 Use Cases

Describe:

- Main functionality from the user's perspective,
- Actors: Guest User, Registered User, System,
- Core use cases: Register/Login, Create Poll, Vote, Comment and Managing Polls,
- Brief explanation of real-time updates and visibility (public/private polls)

Optional:

- Use Case Diagram (Figure: Use case overview)

2.2 Domain Model

Describe:

- Core domain entities (User, Poll, Vote, VoteOption, Comment(?)),
- Relationships between them (one-to-many, many-to-one),

- Persistence through JPA/Hibernate

Optional:

- UML Class Diagram (Figure: Domain Model Overview)
  Show main entities, attributes, and associations

2.3 Architecture (including applied technologies)

Describe:

- High-level architecture (frontend–backend–infrastructure),
- Backend layers: Controller, Service, Repository,
- Key technologies: Spring Boot, H2, Redis, Kafka, WebSocket, JWT,
- Frontend technologies: React, TypeScript, REST API communication,
- Interaction between components (data flow from frontend to backend),

Optional:

- Architecture Diagram (Figure: System Architecture)
  Show containers/components (Frontend, Backend, Redis, Kafka, DB, WebSocket)

2.4 Summary

Summarize:

- How the design supports scalability, modularity, and real-time updates,
- The rationale behind chosen technologies,
- How the design connects to later implementation and deployment steps

3 Technology Assessment

(Remove later: Introduce in sufficient depth the key concepts and architecture of the chosen software technology. As part of this, you may consider using a running example to introduce the technology.)

At its core, Apache Kafka is a distributed event streaming platform. Think of it as a highly scalable, fault-tolerant, and durable log file that different parts of an application can write to and read from simultaneously. The **FeedApp** project uses these core concepts to decouple tasks. When a user votes, the system does not immediately try to update every other user's screen. Instead, it publishes an event to Kafka, and other services (like the WebSocket broadcaster) react to that event.

Event:

An event is the most basic unit of data, representing the fact that something happened. In the **FeedApp**, an event is a `Map<String, Object>` that gets serialized into JSON, for example, when a poll is created, the *PollEventListener* creates an event with the *pollId*, *question*, and *eventType*. The consumer listens for vote change events, which it receives as a *Map* containing the *pollId* and *optionOrder*.

Topic:

A topic is a named category or feed where events are stored and published. A cluster can host many topics, and with KRaft mode, the number of topics can now scale into the millions[2]. The **FeedApp** uses a dynamic topic strategy. Instead of one giant *votes* topic, the *PollTopicManager* creates a unique topic for every single poll. For example, for a poll with ID *10*, the topic name would be *poll.voteChange.10*.

Producer:

A producer is a client application that writes events to a Kafka topic. The *ProducerService* in the FeedApp project is a classic producer, using Spring's *KafkaTemplate* to send events. This service is used by the *PollEventListener* to send a message after a new poll is successfully saved to the database. With the 3-node cluster, the producer (our backend) is given a list of all three brokers (*kafka-1:29092,kafka-2:29092,kafka-3:29092*) via its environment variables. The Kafka client uses this list to discover the entire cluster.

Consumer:

A consumer is a client application that reads (subscribes to) events from one or more Kafka topics. The *ConsumerService* acts as the consumer . It uses a powerful feature to match the dynamic topic strategy: it listens to a *topicPattern* (*poll.voteChange.**) instead of a fixed topic name. This allows it to automatically discover and consume from new poll topics as soon as they are created.

Consumer Group:

A set of consumers that work together to process events from topics. Kafka guarantees that each event in a topic's partition is delivered to only one consumer instance within that group. The **FeedApp** defines the consumer group ID as **poll-app** in its *application.properties* file. If one were to run multiple instances of the backend service for scalability, they would all share this group ID.Kafka would then automatically balance the load of all the poll topics among them.

Partition:

Partitions are the core of Kafka's scalability. A topic is split into one or more partitions. Each partition is an ordered, immutable log of events, which can be hosted on different brokers. The **FeedApp** project makes a specific design choice. When the *PollTopicManager* creates a new topic, it is configured with one partition to guarantee strict event ordering for that poll. To match the 3-node cluster's fault-tolerant design, the replication factor is set to 3. This is implemented by calling *new NewTopic* with the parameters *(topicName, 1, (short) 3)*. This configuration ensures the single partition is copied to all three brokers, providing fault tolerance and high availability.

Broker:

A broker is a single Kafka server. Brokers receive messages from producers, assign offsets to them, and commit them to the partition log on disk, which provides Kafka's durability. The provided *docker-compose.yml* file defines three distinct broker services: *kafka-1*, *kafka-2*, and *kafka-3*. Each of these nodes is configured with the *broker* role.

Cluster:

A Kafka cluster is a group of brokers working together to provide scalability, availability, and fault tolerance. Partitions are replicated on multiple brokers based on the topic's replication factor. The three brokers (*kafka-1*, *kafka-2*, *kafka-3*) form the cluster. This is where the concept of a replication factor of 3 becomes reality. When *PollTopicManager* creates *poll.voteChange.10* with 3 replicas, that topic's

single partition is copied to all three brokers. One broker is elected leader for that partition (handling all writes), while the other two are followers. If the leader fails, a follower is promoted, ensuring no data loss. This entire process is managed by the KRaft controller quorum, which in this 3-node setup consists of all three nodes (*KAFKA_CONTROLLER_QUORUM_VOTERS: '1@kafka-1:9093,...'*).

This part of the report aims to follow this software technology evaluation framework. 1

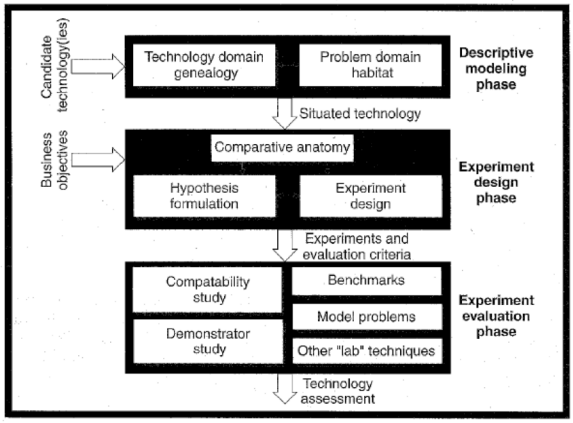


Figure 1: Software technology evaluation framework.

3.1 Descriptive Modeling

Remove later: write where the technology comes from, its history, its context and what problem it solves. Consider drawing a graph like in[1].

The purpose of this phase is to establish a formal model for evaluating two candidate technologies, Apache Kafka (in KRaft mode) and RabbitMQ for adoption within our project. First, we will define the Technology Domain Genealogy for both candidates. This model will establish Kafka (KRaft) as an evolution to its precursor (Kafka with ZooKeeper), explaining the problems it was designed to solve. It will also define RabbitMQ's distinct architectural heritage. Second, we will define our project's Problem Domain Habitat, the specific usage contexts and project needs, to determine which candidate is a better fit.

3.1.1 Technology Domain Genealogy

This model describes the ancestry and core design philosophy of the two competing technologies. Candidate technology 1 is Apache Kafka (KRaft mode). Kafka is, as stated earlier, a distributed event streaming platform. Its core architecture is a persistent, immutable log. It uses a dumb broker/smart consumer model, where the consumers pull data by tracking their position using an offset within the log. The KRaft mode we are looking at is a significant evolution. Its precursor architecture required a

separate, external Apache ZooKeeper cluster. This external dependency was known to cause:

1. High operational complexity: Requiring the management and security of two separate distributed systems.

2. Scalabiliy bottlenecks: Limiting clusters to tens of thousands of partitions.

3. Slow recovery times: Controller failover and metadata loading were slow.

KRaft replaces ZooKeeper by integrating a consensus protocol inside Kafka. This was designed to provide simpler operations, massive scalability (to millions of partitions), and near instant, sub-second failover.

Candidate technology 2 is RabbitMQ. RabbitMQ is a traditional message broker with a long heritage rooted in reliable delivey protocols like AMQP. It functions as a smart broker/dumb consumer platform. The smart broker manages complex, flexible routing via exchanges and actively pushes messages to consumers. Its core data structure is a queue. Messages are stateful and are typically deleted from the queue once successfully consumed and acknowledged.

3.1.2 Problem Domain Habitat

As defined by the evaluation framework, the Problem Domain Habitat describes the specific usage contexts, problem characteristics, and key requirements where the candidate technologies will be deployed.[1] Our habitat is the FeedApp backend, a real-time, interactive polling application built on Spring Boot and Java. The primary objectives for this habitat are to find a messaging solution that is highly scalable, supports high throughput, and simultaneously provides good (low) latency. These objetives can be split into two separate problem domain habitats.

Habitat 1: High-throughput event ingestion

The application must reliably ingest a high volume of events, such as poll creation, comments, and most critically votes from a potentially large and concurrent user base. A user action is sent via the web API, processed, and then published as an immutable event by a producer service. There are a few key requirements to this problem habitat. We prioritize high throughput (handling thousands of writes per second) and scalability (the ability to add more nodes to handle increased load). The durability of these events is critical, as they effecitvely form the application's historical log.

Habitat 2: Real-time asynchronous fan-out

The application must feel responsive and as if event processing happens in real-time, as this is important for a good user experience. When a poll-related event is successfully processed, the system must immediately notift all subscribed clients. A consumer service listens for new events from a topic, it triggers a notification service, which pushes updates to clients via WebSockets. In this habitat we prioritize low end-to-end latency. The time from an events publication to its consuption must be

minimal for the application to feel responsive.

3.2 Experiment Design

Remove later: Write you hypotheses about what benefits the technology bring and how you can support or reject them via experiments.

Following the descriptive modeling phase, we now design the experiments to empirically evaulate our candidate technologies. The goal of this phase is to formulate refutable hypotheses based on our problem domain habitat and design experiments to generate quantitative data to test them.

Our design focuses on getting objective data for our key requirements: throughput, latency and scalability.

3.2.1 Hypothesis Formulation

Our hypotheses are derived directly from the two habitats identified in the FeedApp backend and they key feature deltas between Kafka, which is a log based pull model, and RabbitMQ which is a queue based, push model.

Habitat 1 prioritizes high throughput and scalability.

Hypothesis 1.A (Throughput): In a many producers, high volume workload, Kafka will achieve significantly higher maximum throughput than RabbitMQ before latency thresholds are breadched. Here, throughput will be measured as messages per second.

Hypothesis 1.B (Scalability): As the number of producers increases, Kafka's throughput will scale better than RabbitMQ's. Here, better scaling will be how much more load can be handled when increasing cluster size.

Habitat 2 prioritizes low end-to-end latency.

Hypothesis 2.A (Low-load latency): In a low message rate workload, RabbitMQ's push model will demonstrate lower p99 end-to-end latency than Kafka's pull model.

Hypothesis 2.B (High-load latency): As the message rate in this habitat increases, Kafka's pull model will become more efficient, and its average latency will become lower than RabbitMQ's, which will suffer from per-message overhead.

3.2.2 Experiment Design and Workloads

To test these hypotheses, we will use the OpenMessaging Benchmark (OMB) framework. This provides a standardized, vendor-neutral toolset to conduct repeatable performance tests easily. We will configure

OMB with two distinct workloads, each designed as a model problem that simulates one of our defined habitats.

Workload 1 for Habitat 1: Ingestion test

The purpose of this workload is to test hypotheses 1.A and 1.B. This will be the OMB workload configuration for this test.

```
name: "workload1"
topics: 1
partitionsPerTopic: 3
messageSize: 100
useRandomizedPayloads: true
randomBytesRatio: 0.5
randomizedPayloadPoolSize: 1000
subscriptionsPerTopic: 1
consumerPerSubscription: 1
producersPerTopic: 100
producerRate: 500000
consumerBacklogSizeGB: 0
testDurationMinutes: 3
```

We will have many producers, a single topic/exchange, and a low number of consumers. This simulates thousands of concurrent users casting votes and creating polls in the FeedApp. There are three metrics we wish to capture in this test.

1. Maximum throughput: The highest sustainable message rate each platform can ingest

2. Producer latency (p99): The 99th percentile latency for a producer to successfully publish a message.

3. Scalability curve: Run the test with 1,5 and 10 producer instances to observe how throughput scales.

Workload 2 for Habitat 2: Fan-out test

The purpose of this workload is to test hypotheses 2.A and 2.B. The will be the OMB configuration for the test.

```
name: "workload2"
topics: 1
partitionsPerTopic: 3
messageSize: 1024
useRandomizedPayloads: true
randomBytesRatio: 0.5
randomizedPayloadPoolSize: 1000
subscriptionsPerTopic: 70
consumerPerSubscription: 1
```

```
producersPerTopic: 1
producerRate: 10000 # This will vary, 100,1000,10000
consumerBacklogSizeGB: 0
testDurationMinutes: 3
```

We will have a single producer and many competing consumers on a shared subscription. This simulates real time fanout of poll updates to all connected clients. There are two metrics we wish to capture in this test:

1. End-to-end latency (p99): The time from message publish to message receipt by a consumer.

2. Latency vs. Throughput Curve: We will specifically run this workload at varying throughput rates (100 msg/sec, 1000 msg/sec and 10,000 msg/sec) to find the crossover point predicted in 2.B.

3.2.3 Comparative Feature Analysis

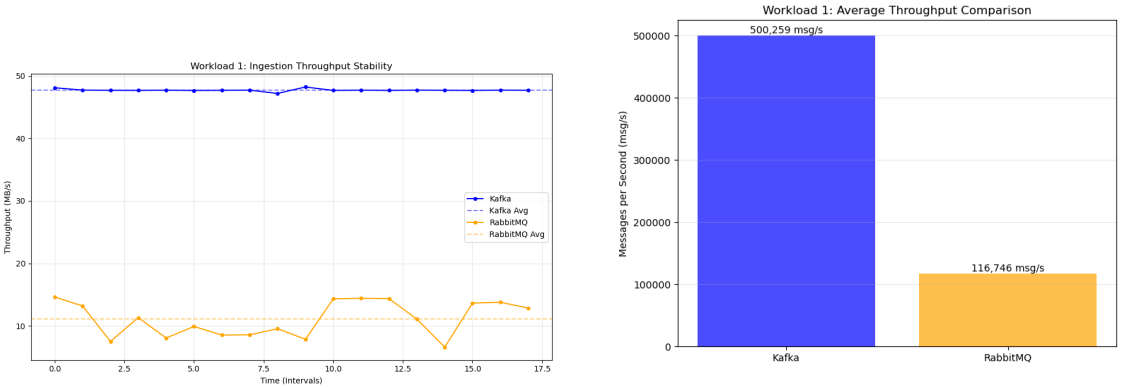
We acknowledge that our locally run benchmarks will be limited by our specific hardware and test duration. Therefore, as part of our comparative feature analysis, we will supplement out primary findings with a review of existing, larger scale benchmarks published by others. This aims to validate our results and provide a broader context for the performance characteristics that we cannot easily reproduce.

3.3 Experiment Evaluation

Write about the results of your experiments, either via personal experience reports, quantitative benchmarks, a demostrator case study or a combination of multiple approaches.

The experimental phase was aimed to gather empirical data to validate the suitability of the technologies for the **FeedApp** high volume ingestion (Habitat 1) and real time fan-out (Habitat 2) requirements.

3.3.1 Evaluation of Workload 1: Ingestion Performance



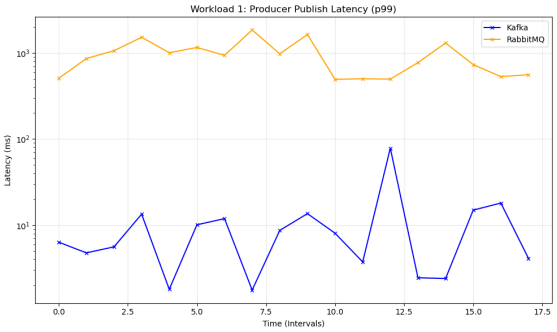
(a) Throughput Stability over Time

(b) Average Throughput Comparison

Figure 2: **Workload 1 Ingestion Performance.** Comparing the stability and raw average throughput of Kafka vs. RabbitMQ.

Workload 1 simulated the **FeedApp** backend receiving a storm of user votes and poll creation events. The primary metric for this habitat is throughput (messages/second and MB/s) and producer stability.

Throuput Analysis As illustrated in Figure2, the results strongly validate **Hypothesis 1.A**. Apache Kafka demonstrated a significantly higher write capacity than RabbitMQ. Looking at2b, Kafka maintained a sustained average throughput of approximately 500,259 msg/s. In contrast, RabbitMQ saturated at 116,746 msg/s. It is also important to mention that the producer rate was set at 500,000, which suggests that Kafka could reach even higher if this was increased. Figure2a reveals the stability of this throughput. Kafka (blue line) maintains a near perfectly flat ingestion rate, indicating that the broker was not resource constrained by the producer load. RabbitMQ (orange line), while relatively stable, operates at a much lower ceiling, suggesting it hit an internal processing bottleneck, likely the CPU cost of managing exchange routing and per-message persistence. Figure2a also clearly illustrates the increased throughput capcaity (MB/s) between the two brokers.



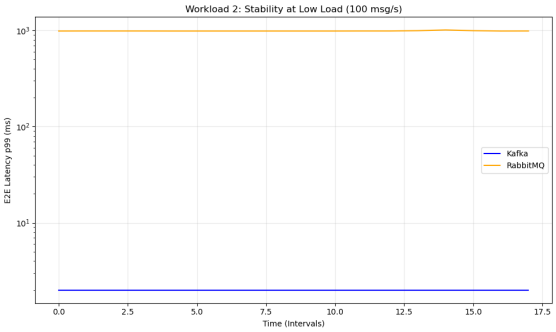
(a) Producer Publish Latency (p99)

(b) Consumer Backlog Size (Log Scale)

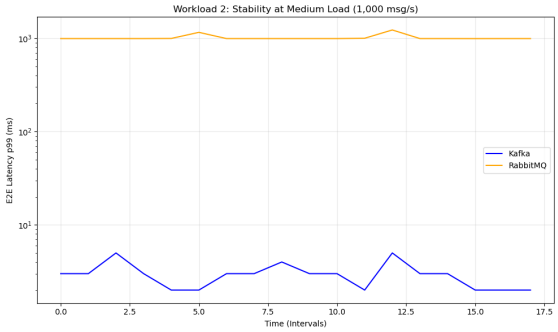
Figure 3: **Workload 1 System Stability.** Correlating producer latency with consumer backlog accumulation.

System Stability and Backlog The cost of RabbitMQ's smart broker architecture becomes evident when analyzing latency and backlogs in Figure3. Figure3a shows the p99 public latency, which is the time it takes for the producer to get an acknowledgement from the broker. Kafka consistently acknowledges writes in single-digit milliseconds. RabbitMQ, conversely, exihibits high volatility with p99 latencies oscillating between 500ms and 1,500ms. This latency disparity is directly explained by3b. RabbitMQ accumulates a significant consumer backlog, peaking over 10^5 messages. Because RabbitMQ stores messages in a queue structure that requires memory management and index updates for every message, the high ingestion rate cause the broker to slow down producers to allow consumers to catch up. Kafka, utilizing a sequential append-only log, handled the backlog without impacting producer write latency, effectively decoupling the producer from the consumer.

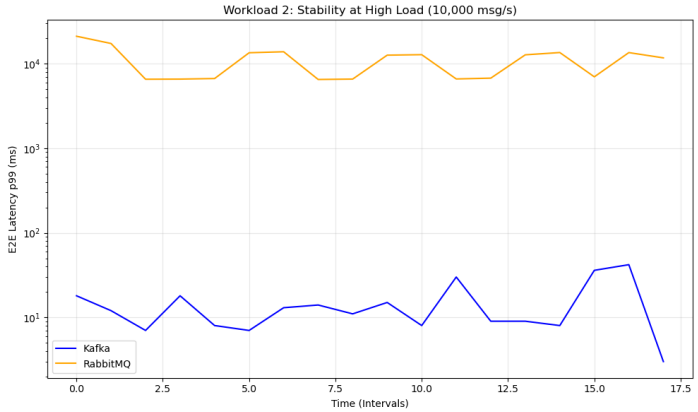
Conclusion on Habitat 1: Hypothesis 1.A is confirmed. In this experiment, Kafka provides approximately 4.2x the throughput of RabbitMQ, with significantly better stability.



(a) Low Load (100 msg/s)



(b) Medium Load (1,000 msg/s)



(c) High Load (10,000 msg/s)

Figure 4: **Workload 2 Fanout Stability.** Evolution of end-to-end latency as throughput increases.

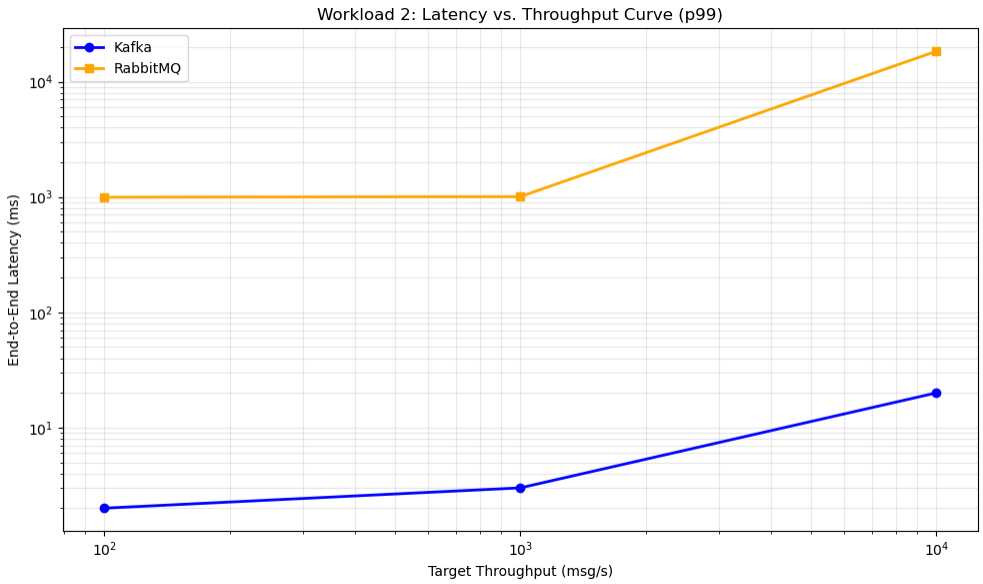


Figure 5: **Latency vs. Throughput (p99).** Comparison of fanout latency scaling. Note the logarithmic scales on both axes.

3.3.2 Evaluation of Workload 2: Fan-out Performance

Workload 2 simulated the real time component of the app, pushing updates to clients. The primary metric here is end-to-end (E2E) latency.

Low vs. High Load Latency The results for this workload yield unexpected findings regarding **Hypothesis 2.A**. We hypothesized that RabbitMQ would offer lower latency at low loads due to its push based model. However, the data refutes this. As seen in Figure4a, at a low load of 100 msg/s, Kafka maintains an E2E p99 latency of around 2ms. RabbitMQ exhibits a consistent latency floor of 1000ms. The high baseline for RabbitMQ suggests a configuration interaction with the test harness, but it highlights that push does not automatically guarantee lower latency than pull if the persistence guarantees are strict.

Scalabiliy Under Load Figure4 demonstrates the behavior as load increases to 10,000 msg/s (Figure4c). Kafka remains stable with latencies under 20ms. RabbitMQ's latency deteriorates further, spiking above 10,000ms. The relationship is best summarized further by the logarithmic scale curve in Figure5. Kafka's latency growth is linear and shallow, wheras RabbitMQ's latency growth is exponential relative to throughput. **Conclusion on Habitat 2: Hypothesis 2.A is refuted** and **Hypothesis 2.B is confirmed**. Even at low loads, Kafka's efficient zero-copy network transfer and sequential I/O provided lower latencies than RabbitMQ in this benchmark. As load increased, Kafka's performance gap widened, proving it to be the more scalable solution for the **FeedApp's** fan-out requirements.

4 Prototype Implementation

This section summarizes how the FeedApp prototype has been implemented, focusing on the core technical components and how developers can run or extend the system.

4.1 Setup and Deployment

The FeedApp prototype runs as a multi-container application orchestrated by Docker Compose with four services: backend (Spring Boot, port 8080), frontend (React/Vite, port 5173), Redis (cache, port 6379), and Kafka (event bus, ports 9092/29092). The backend reads infrastructure dependencies from environment variables: `SPRING_KAFKA_BOOTSTRAP_SERVERS=kafka:29092` and `SPRING_REDIS_HOST=redis`.

To run locally, developers execute `docker compose up -d` and access the frontend at `http://localhost:5173`. The system can be stopped with `docker compose down`.

```
backend:
  ports: ["8080:8080"]
  environment:
    - SPRING_KAFKA_BOOTSTRAP_SERVERS=kafka:29092
    - SPRING_REDIS_HOST=redis
frontend: { ports: ["5173:5173"], depends_on: [backend] }
```

The frontend communicates with the backend via REST APIs and maintains a WebSocket connection for real-time push notifications.

4.2 Backend Implementation

The backend uses Spring Boot with a layered architecture: Controllers handle HTTP mapping, Services contain business logic, and Repositories manage persistence. The system supports two persistence strategies via Spring profiles: `HibernatePollService` (JPA/Hibernate for production) and `InMemoryPollService` (for testing). Activate the desired mode with `spring.profiles.active=in-memory` or `spring.profiles.active=database` (for example in `application.properties` or as an environment variable). A `CachingPollService` decorator adds Redis-based caching with Jedis, improving performance for frequently accessed data like poll results.

4.2.1 Authentication and Security

The application implements stateless JWT authentication with BCrypt password hashing. The `/api/auth/login` endpoint authenticates users and returns a JWT token, while `/api/auth/register` creates new accounts. The `JwtAuthFilter` validates tokens on each request, making the authenticated user available via `@AuthenticationPrincipal`.

```
// SecurityConfig (rules excerpt)
http.csrf(AbstractHttpConfigurer::disable)
    .sessionManagement(s -> s.sessionCreationPolicy(STATELESS))
    .authorizeHttpRequests(a -> a
        .requestMatchers("/api/auth/**", "/rawws").permitAll()
        .requestMatchers(HttpMethod.GET, "/api/polls/**").permitAll()
        .requestMatchers(HttpMethod.POST, "/api/polls/*/vote").permitAll()
        .anyRequest().authenticated());
```

This configuration allows public access to viewing polls and voting while protecting write operations. CORS is configured for localhost development.

4.2.2 Core APIs and Real-Time Updates

The REST API provides two main resource groups: `/api/polls` (CRUD operations, voting, comments) and `/api/users` (profile management with authorization checks).

```
// PollController (excerpt)
@PostMapping("/{id}/vote")
public boolean castVote(@PathVariable Integer id,
                        @RequestParam Integer presentationOrder,
                        @AuthenticationPrincipal User user) {
    return pollService.castVote(id,
                                user == null ? Optional.empty()
                                             : Optional.of(user.getUserId()),
                                presentationOrder);
}
```

When data changes occur, the backend emits Kafka messages and broadcasts lightweight WebSocket notifications to connected clients:

```
// on create/update/delete
RawWebSocketServer.broadcast("pollsUpdated");
```

This ensures all clients stay synchronized without polling. Basic unit and integration tests in `backend/src/test`

verify the main flows.

4.2.3 Kafka Integration

Kafka is used as the backend's event bus to decouple write operations from real-time updates and cache invalidation. When a vote or comment is stored, the service resolves a per-poll topic name (e.g., `poll.voteChange.<pollId>`) and publishes a compact JSON event using Spring Kafka's `KafkaTemplate`. A lightweight consumer subscribes to all poll topics using a pattern and reacts by invalidating Redis caches and nudging the WebSocket layer to refresh.

```
// ProducerService (excerpt)
public void sendEvent(String topicName, Map<String, Object> data) {
    kafkaTemplate.send(topicName, data);
}

// ConsumerService (excerpt)
@KafkaListener(topicPattern = "poll.voteChange.*", groupId = "poll-app")
public void onVoteChange(Map<String, Object> event) {
    // read pollId, invalidate caches, and (optionally) broadcast WS hints
}
```

The broker address is provided via `SPRING_KAFKA_BOOTSTRAP_SERVERS` (see Docker Compose). Topics are created or ensured at runtime through a small helper that uses `KafkaAdmin`. See Section 3 for the Kafka assessment and results.

4.3 Frontend Implementation

The frontend uses React with TypeScript, bundled via Vite. Key components include `CreatePoll`, `VoteOnPoll`, `ManagePolls`, `CommentSection`, and `Login`. The application uses a hybrid communication strategy: REST for data operations and a single WebSocket for real-time events.

```
// ws.ts
export const onWs = (f:(e:unknown)=>void) =>
    (listeners.add(f), () => listeners.delete(f));

export function connectWs() {
    const u = `${location.protocol==="https:"?"wss":"ws"}://
               ${location.hostname}:8080/rawws`;
    const ws = new WebSocket(u);
    ws.onmessage = ev => {
        try { emit(JSON.parse(ev.data)); }
```

```
        catch { emit(ev.data); }
    };
}
```

The App component listens to WebSocket events and selectively refreshes data:

```
// App.tsx
useEffect(() => onWs(m => {
    if (m === "pollsUpdated") refreshPolls();
    if (m === "commentsUpdated") bumpCommentsVersion(activePollId);
}), []);
```

When a poll is created, the UI automatically switches to the ”Vote” tab and refreshes, allowing immediate verification. A `WebSocketMessages` component displays a rolling log of events for development debugging.

4.4 Extensibility and Future Work

FeedApp can be extended with friend lists, public poll publishing, upvoting/downvoting, poll sharing, and new poll types (e.g., ranked-choice). The layered architecture and Spring profiles keep these additions low risk: most changes stay in services or new controllers. A future iOS or Android app would mainly be another frontend that reuses the existing REST and WebSocket APIs. The modular design supports incremental growth without breaking current functionality. Security can be strengthened with refresh tokens and stricter production CORS policies.

5 Conclusion

This project resulted in a working real-time polling application built with Spring Boot, React, Redis, WebSockets, Docker, and a messaging layer implemented using Kafka. Throughout the process we were able to evaluate how these technologies behave in a realistic application scenario where users create polls, vote, and discuss results, and where updates must be delivered instantly to all connected clients.

Kafka and RabbitMQ have different strengths. RabbitMQ was simpler to install and understand, making it well suited for quick prototypes and smaller systems. Kafka required more conceptual understanding, such as topics, partitions, consumer groups, and replication, but in return offered higher throughput and more stable performance when write load increased. Our benchmark results reflected this: Kafka processed far more messages per second and maintained lower latency under heavy load, while RabbitMQ showed more latency variation when many updates were fanned out to users.

The learning curve matched these differences. RabbitMQ's queue and exchange model is easy to understand, helped by accessible documentation and examples. Kafka took more time to learn because of its log-based architecture and cluster concepts, but the documentation and Spring Boot integration guides were clear and detailed. Once understood, Kafka's model fit well with the event-driven parts of FeedApp, especially the topic-per-poll approach.

Overall, this project gave us practical experience with event-driven design, real-time updates, caching, and containerized deployment.

References

[1] A.W. Brown and K. C. Wallnau. A framework for evaluating software technology. *IEEE Software*, 13(5):39–49, September 1996.

[2] Confluent. Kafka topics **&** producers faqs. Accessed: 2025-11-12.