Al-Najah National University

Faculty Of Engineering

Computer Engineering Department

DOS Project

Bazar Online Book Store –Part 2

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1 Overview

The program's goal is to provide examples of consistency, caching, and replication within the framework of a microservices architecture and multi-tiered web design. The objective is to show how caching boosts efficiency, consistency is maintained in a distributed context, and replication increases system resilience by building distributed services for order processing and catalog maintenance.

And we use the Spark web framework, a SQLite database, and Java to build a basic order and catalog system. Its essential parts, Order, FrontendService, and CatalogService, enable item purchases, oversee frontend interactions, and preserve catalog data, in that order.

CatalogService:

provides endpoints for topic searches and ID-based information retrieval regarding individual items. establishes a connection with a SQLite database to retrieve and modify catalog data.

FrontendService:

serves as a go-between for clients and the CatalogService. uses Replication, caching and load balancing techniques to improve performance.

OrderService:

oversees the purchase of products from the catalog. updates item stock upon a purchase by establishing a connection to the same SQLite database as CatalogService.

Caching:

To enhance performance, implement a primitive in-memory caching technique that stores and retrieves previously requested data. After purchases, check cache entries to make sure the data is up to date.

2 Running the Program

To run the program, ensure that Java is installed on the system and that the required libraries and dependencies (Spark, SQLite JDBC driver) are available. Compile and run each Java class separately, making sure the SQLite database file (sqliteDB.db) is in the same directory as the compiled classes. Access the services through the specified ports (CatalogService: http://localhost:8087, FrontendService: http://localhost:8087, order: http://localhost:8085), and interact with the provided API endpoints for catalog search, item information retrieval, and item purchases

API Endpoints:

Catalog Search: GET http://localhost:8087/search/topic

Item Information: GET http://localhost:8087/info/ID

Purchase Item: PUT http://localhost:8085/purchase/ID

3 Tradeoffs

Write Operation Overhead: Replication and caching could result in extra expense(introduce additional overhead), particularly for workloads that need much of writing (such as purchases).

Consistency Complexity: It can be difficult to guarantee cache consistency between replicas.

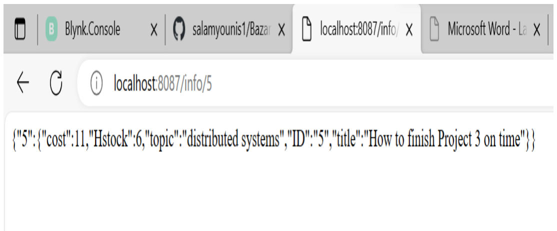
4 Improvements and extensions

Asynchronous Replication: The system can acknowledge writes without waiting for all replicas to be updated due to asynchronous replication.

Load Balancing Strategy: Choose a load balancing algorithm that suits the system's characteristics

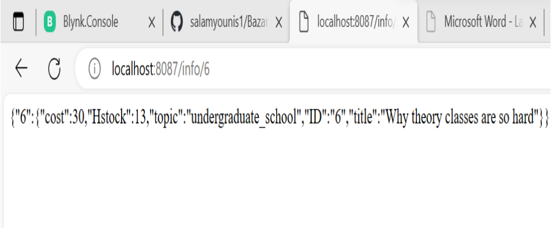
Cache Partitioning: Cache efficiency can be increased by partitioning the cache according to various criteria (such as categories).

5 Result



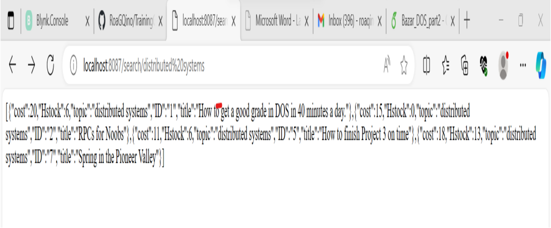
```
{"5":{"cost":11,"Hstock":6,"topic":"distributed systems","ID":"5","title":"How to finish Project 3 on time"}}
```

Figure 1: Info for item with id 5 .



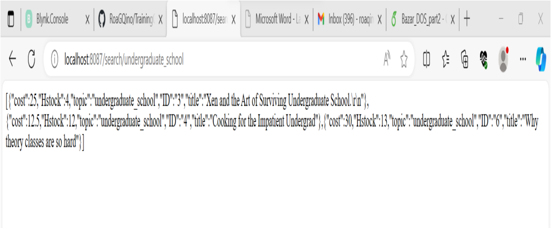
```
{"6":{"cost":30,"Hstock":13,"topic":"undergraduate_school","ID":"6","title":"Why theory classes are so hard"}}
```

Figure 2: Info for item with id 6 .



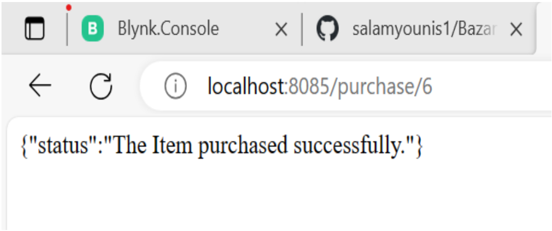
```
[{"cost":20,"Hstock":6,"topic":"distributed systems","ID":"1","title":"How to get a good grade in DOS in 40 minutes a day."},{"cost":15,"Hstock":0,"topic":"distributed
systems","ID":"2","title":"RPCs for Noobs"},{"cost":11,"Hstock":6,"topic":"distributed systems","ID":"5","title":"How to finish Project 3 on time"},{"cost":18,"Hstock":13,"topic":"distributed
systems","ID":"7","title":"Spring in the Pioneer Valley"}]
```

Figure 3: search for topic distributed systems .



```
[{"cost":25,"Hstock":4,"topic":"undergraduate_school","ID":"3","title":"Xen and the Art of Surviving Undergraduate School.\r\n"},
{"cost":12.5,"Hstock":12,"topic":"undergraduate_school","ID":"4","title":"Cooking for the Impatient Undergrad"},{"cost":30,"Hstock":13,"topic":"undergraduate_school","ID":"6","title":"Why
theory classes are so hard"}]
```

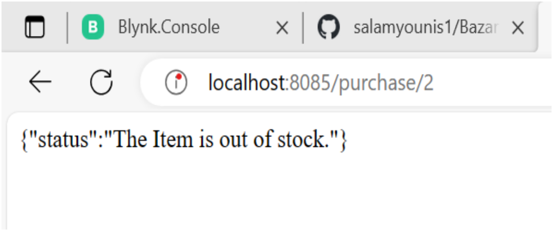
Figure 4: search for topic undergraduate school .



localhost:8085/purchase/6

{"status":"The Item purchased successfully."}

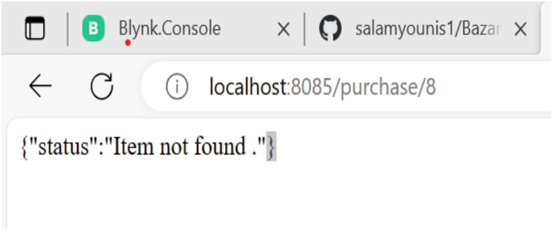
Figure 5: purchase for item with id 6 .



localhost:8085/purchase/2

{"status":"The Item is out of stock."}

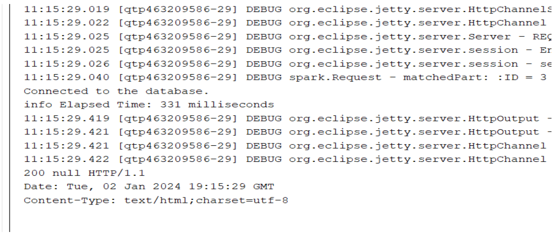
Figure 6: purchase for item with id 2(out of stock) .



localhost:8085/purchase/8

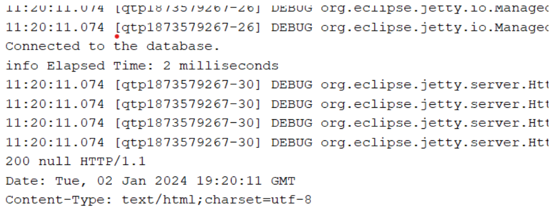
{"status":"Item not found ."}

Figure 7: purchase for item id 8(not in stock) .



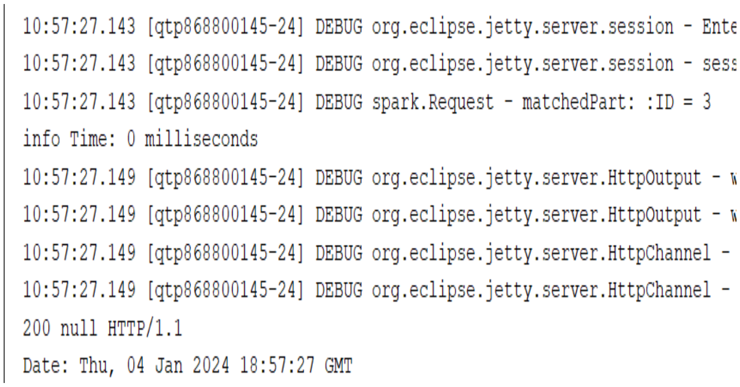
```
11:15:29.019 [qtp463209586-29] DEBUG org.eclipse.jetty.server.HttpChannelS
11:15:29.022 [qtp463209586-29] DEBUG org.eclipse.jetty.server.HttpChannel
11:15:29.025 [qtp463209586-29] DEBUG org.eclipse.jetty.server.Server - REQ
11:15:29.025 [qtp463209586-29] DEBUG org.eclipse.jetty.server.session - Er
11:15:29.026 [qtp463209586-29] DEBUG org.eclipse.jetty.server.session - se
11:15:29.040 [qtp463209586-29] DEBUG spark.Request - matchedPart: :ID = 3
Connected to the database.
info Elapsed Time: 331 milliseconds
11:15:29.419 [qtp463209586-29] DEBUG org.eclipse.jetty.server.HttpOutput -
11:15:29.421 [qtp463209586-29] DEBUG org.eclipse.jetty.server.HttpOutput -
11:15:29.421 [qtp463209586-29] DEBUG org.eclipse.jetty.server.HttpChannel
11:15:29.422 [qtp463209586-29] DEBUG org.eclipse.jetty.server.HttpChannel
200 null HTTP/1.1
Date: Tue, 02 Jan 2024 19:15:29 GMT
Content-Type: text/html;charset=utf-8
```

Figure 8: Time of info without chach and replication



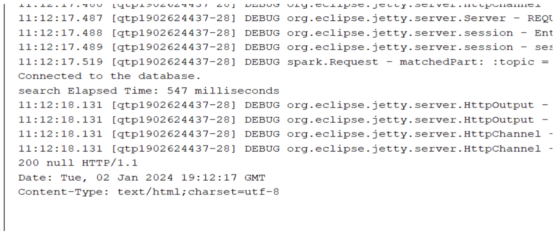
```
11:20:11.074 [qtp1873579267-26] DEBUG org.eclipse.jetty.io.Managec
11:20:11.074 [qtp1873579267-26] DEBUG org.eclipse.jetty.io.Managec
Connected to the database.
info Elapsed Time: 2 milliseconds
11:20:11.074 [qtp1873579267-30] DEBUG org.eclipse.jetty.server.Htt
11:20:11.074 [qtp1873579267-30] DEBUG org.eclipse.jetty.server.Htt
11:20:11.074 [qtp1873579267-30] DEBUG org.eclipse.jetty.server.Htt
11:20:11.074 [qtp1873579267-30] DEBUG org.eclipse.jetty.server.Htt
200 null HTTP/1.1
Date: Tue, 02 Jan 2024 19:20:11 GMT
Content-Type: text/html;charset=utf-8
```

Figure 9: Time of info with chach and replication(chach miss)



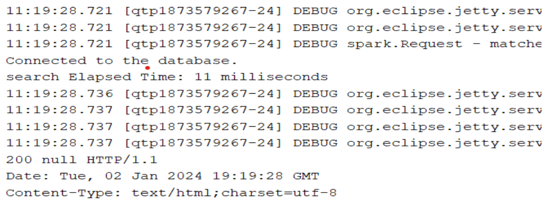
```
10:57:27.143 [qtp868800145-24] DEBUG org.eclipse.jetty.server.session - Ente
10:57:27.143 [qtp868800145-24] DEBUG org.eclipse.jetty.server.session - sess
10:57:27.143 [qtp868800145-24] DEBUG spark.Request - matchedPart: :ID = 3
info Time: 0 milliseconds
10:57:27.149 [qtp868800145-24] DEBUG org.eclipse.jetty.server.HttpOutput - w
10:57:27.149 [qtp868800145-24] DEBUG org.eclipse.jetty.server.HttpOutput - w
10:57:27.149 [qtp868800145-24] DEBUG org.eclipse.jetty.server.HttpChannel -
10:57:27.149 [qtp868800145-24] DEBUG org.eclipse.jetty.server.HttpChannel -
200 null HTTP/1.1
Date: Thu, 04 Jan 2024 18:57:27 GMT
```

Figure 10: Time of info from chach.(Cache Hit:)



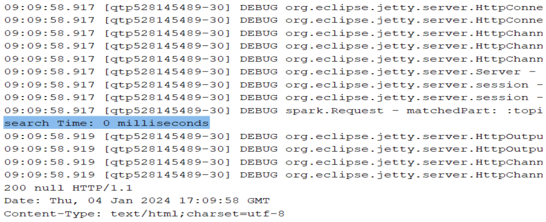
```
11:12:17.486 [qtp1902624437-28] DEBUG org.eclipse.jetty.server.HttpChannel
11:12:17.487 [qtp1902624437-28] DEBUG org.eclipse.jetty.server.Server - REQU
11:12:17.488 [qtp1902624437-28] DEBUG org.eclipse.jetty.server.session - Ent
11:12:17.489 [qtp1902624437-28] DEBUG org.eclipse.jetty.server.session - ses
11:12:17.519 [qtp1902624437-28] DEBUG spark.Request - matchedPart: :topic =
Connected to the database.
search Elapsed Time: 547 milliseconds
11:12:18.131 [qtp1902624437-28] DEBUG org.eclipse.jetty.server.HttpOutput -
11:12:18.131 [qtp1902624437-28] DEBUG org.eclipse.jetty.server.HttpOutput -
11:12:18.131 [qtp1902624437-28] DEBUG org.eclipse.jetty.server.HttpChannel -
11:12:18.131 [qtp1902624437-28] DEBUG org.eclipse.jetty.server.HttpChannel -
200 null HTTP/1.1
Date: Tue, 02 Jan 2024 19:12:17 GMT
Content-Type: text/html;charset=utf-8
```

Figure 11: Time of search without chach and replication



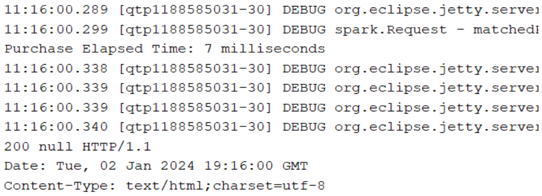
```
11:19:28.721 [qtp1873579267-24] DEBUG org.eclipse.jetty.serv
11:19:28.721 [qtp1873579267-24] DEBUG org.eclipse.jetty.serv
11:19:28.721 [qtp1873579267-24] DEBUG spark.Request - matche
Connected to the database.
search Elapsed Time: 11 milliseconds
11:19:28.736 [qtp1873579267-24] DEBUG org.eclipse.jetty.serv
11:19:28.737 [qtp1873579267-24] DEBUG org.eclipse.jetty.serv
11:19:28.737 [qtp1873579267-24] DEBUG org.eclipse.jetty.serv
11:19:28.737 [qtp1873579267-24] DEBUG org.eclipse.jetty.serv
200 null HTTP/1.1
Date: Tue, 02 Jan 2024 19:19:28 GMT
Content-Type: text/html;charset=utf-8
```

Figure 12: Time of search with chach and replication.(cache miss)



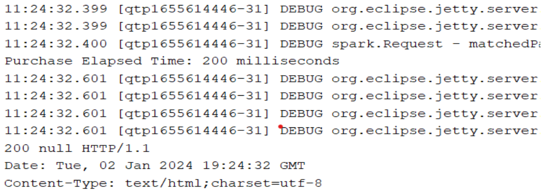
```
09:09:58.917 [qtp528145489-30] DEBUG org.eclipse.jetty.server.HttpConne
09:09:58.917 [qtp528145489-30] DEBUG org.eclipse.jetty.server.HttpConne
09:09:58.917 [qtp528145489-30] DEBUG org.eclipse.jetty.server.HttpChann
09:09:58.917 [qtp528145489-30] DEBUG org.eclipse.jetty.server.HttpChann
09:09:58.917 [qtp528145489-30] DEBUG org.eclipse.jetty.server.HttpChann
09:09:58.917 [qtp528145489-30] DEBUG org.eclipse.jetty.server.Server -
09:09:58.917 [qtp528145489-30] DEBUG org.eclipse.jetty.server.session -
09:09:58.917 [qtp528145489-30] DEBUG org.eclipse.jetty.server.session -
09:09:58.917 [qtp528145489-30] DEBUG spark.Request - matchedPart: :topi
search Time: 0 milliseconds
09:09:58.919 [qtp528145489-30] DEBUG org.eclipse.jetty.server.HttpOutpu
09:09:58.919 [qtp528145489-30] DEBUG org.eclipse.jetty.server.HttpOutpu
09:09:58.919 [qtp528145489-30] DEBUG org.eclipse.jetty.server.HttpChann
09:09:58.919 [qtp528145489-30] DEBUG org.eclipse.jetty.server.HttpChann
200 null HTTP/1.1
Date: Thu, 04 Jan 2024 17:09:58 GMT
Content-Type: text/html;charset=utf-8
```

Figure 13: Time of info from chach.(Cache Hit)



```
11:16:00.289 [qtp1188585031-30] DEBUG org.eclipse.jetty.serve
11:16:00.299 [qtp1188585031-30] DEBUG spark.Request - matched
Purchase Elapsed Time: 7 milliseconds
11:16:00.338 [qtp1188585031-30] DEBUG org.eclipse.jetty.serve
11:16:00.339 [qtp1188585031-30] DEBUG org.eclipse.jetty.serve
11:16:00.339 [qtp1188585031-30] DEBUG org.eclipse.jetty.serve
11:16:00.340 [qtp1188585031-30] DEBUG org.eclipse.jetty.serve
200 null HTTP/1.1
Date: Tue, 02 Jan 2024 19:16:00 GMT
Content-Type: text/html;charset=utf-8
```

Figure 14: Time of purchase without chach and replication.



```
11:24:32.399 [qtp1655614446-31] DEBUG org.eclipse.jetty.server
11:24:32.399 [qtp1655614446-31] DEBUG org.eclipse.jetty.server
11:24:32.400 [qtp1655614446-31] DEBUG spark.Request - matchedP
Purchase Elapsed Time: 200 milliseconds
11:24:32.601 [qtp1655614446-31] DEBUG org.eclipse.jetty.server
11:24:32.601 [qtp1655614446-31] DEBUG org.eclipse.jetty.server
11:24:32.601 [qtp1655614446-31] DEBUG org.eclipse.jetty.server
11:24:32.601 [qtp1655614446-31] DEBUG org.eclipse.jetty.server
200 null HTTP/1.1
Date: Tue, 02 Jan 2024 19:24:32 GMT
Content-Type: text/html;charset=utf-8
```

Figure 15: Time of purchase with chach and replication.

Type	Old System	New System
info Time	331 ms	2 ms
search Time	547 ms	11 ms
Purchase Time	7 ms	200 ms
Cache(Cache Hit)	—-	0 ms

Table 1: Comparison of Old and New Systems

Because caching and replication has been added, the new system exhibits noticeably faster response times for read operations (info and search). The purchase transaction does come with a cost, though, since it necessitates extra processing for cache invalidation and replication (cache consistency).