# Project Report

**Group 2e:**
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# 1. Project Overview

## 1.1 Major capabilities

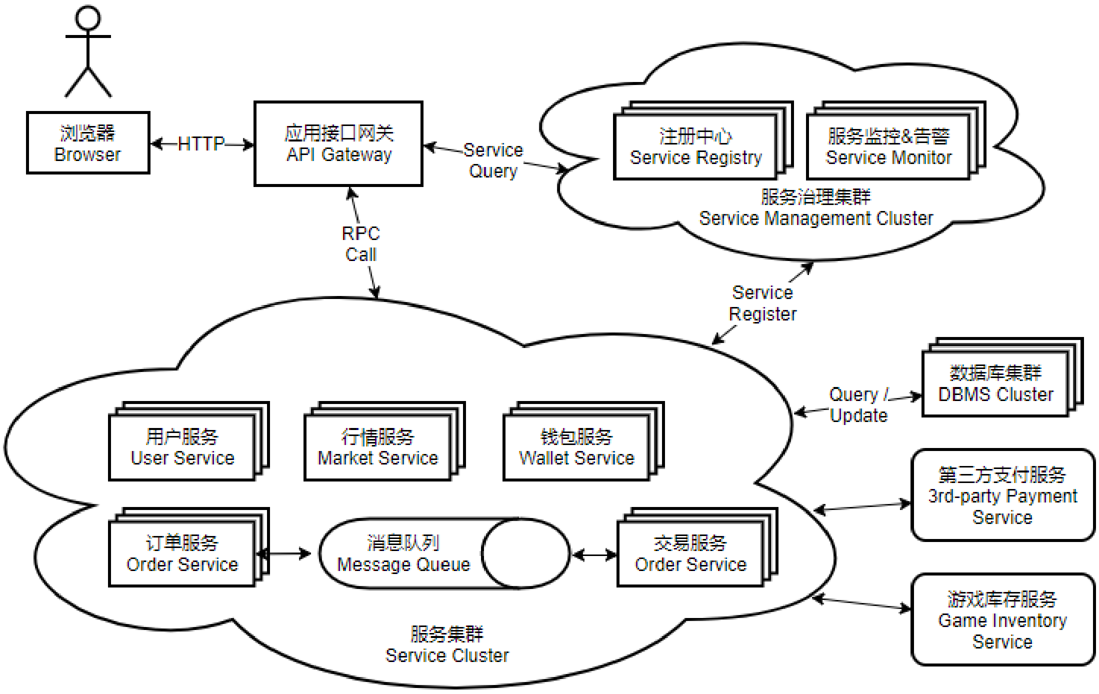
1) Items browsing: Users can browse the list of items for sale and sort them by price or trading volume.
2) Market quotations: Users can view quotations of a certain item, including the numbers of buy and sell orders, lowest ask price, highest bid price, recent transaction prices, trends of price and trading volume, etc.
3) Buy order: Users can set the bid price for a certain item and create a buy order. Trades are made automatically when a sell order with an ask price lower than or equal to the bid price occurs.
4) Sell order: Users can set the ask price for a certain item in his inventory and create a sell order. Trades are made automatically when a buy order with a bid price higher than or equal to the ask price occurs.
5) Order management: Users can view all his buy and sell orders, and cancel orders that are not yet completed.
6) Wallet: Each user has a personal wallet. Users can view income and expense records, add funds to account or withdraw from account (via third-party payment platforms).
7) Inventory: Users can check his own inventory of in-game items (via game operators).

## 1.2 Operational scenarios

Via in-game item trading system, users can sell their own items at an arbitrary ask price or quote certain items at an arbitrary bid price by issuing an order. The system automatically matches the orders so that trades are made when an ask price is fulfilled by a certain bid price.

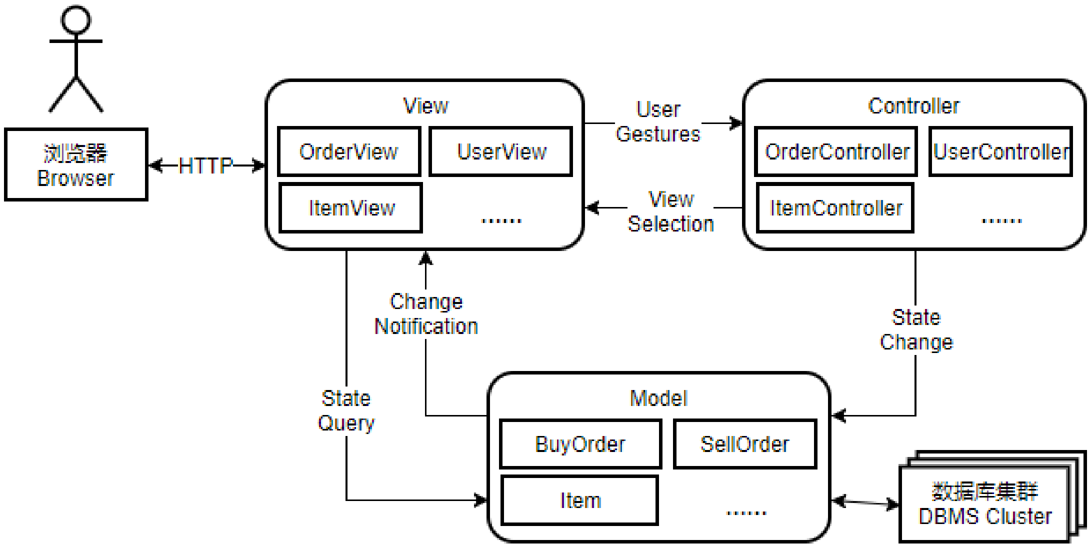
## 2. Architecture Options

### 2.1 Microservices architecture pattern




Distributed microservices architecture, which is widely applied nowadays, is adopted in this pattern. Here the service management cluster is responsible for the registration, naming and monitoring, while the highly decoupled service cluster discomposes the business functions into multiple services each of which only assumes its own duties, thereby improving modifiability and extensibility. API Gateway handles all external interfaces, accepting requests from users' browsers and re-assembling the responses accordingly. High-efficiency RPC protocols are used to implement remote calls between API Gateway and services. Moreover, service cluster supports software load-balancing and hot swapping features, which enables the system to elevate performance and availability and to sustain high concurrency situations.

## 2.2 MVC architecture pattern




MVC design pattern helps minimize the coupling between modules, where model, view and controller are three independent components so that one of them can be modified without affecting any other one. Reusability is enhanced since different views can access a single model component simultaneously. Meanwhile, MVC architecture pattern enables quick development and quick deployment with high maintainability and extensibility, which is beneficial to software engineering management and life cycle cost optimization.

# 3. ADD Procedures for Microservices Pattern

## 3.1 Iteration 1

### 3.1.1 Requirements information

#### 3.1.1.1 Functional requirements

See also 1.1 Major capabilities.

#### 3.1.1.2 Scenarios

**Scenario 1: >1000 users trading at the same time [Reliability, Performance]**

| Element | Possible values |
|---|---|
| **Source** | User |
| **Stimulus** | >1000 users trading at the same time |
| **Artifact** | Load balancing module, business module, database system |
| **Environment** | System functioning properly |
| **Response** | System can execute purchase operations by users normally<br>Server delivers large-scale requests to computational nodes<br>Data stored in database are modified normally |
| **Response measures** | >99% of user requests are properly handled<br>>85% of user requests are handled within 1s |

**Scenario 2: Normal trade operation by user [Usability, Performance]**

| Element | Possible values |
|---|---|
| **Source** | User |
| **Stimulus** | User performing normal trade operation |
| **Artifact** | System |
| **Environment** | System functioning properly |
| **Response** | User operation is guided correctly<br>Operation is simple and easy to learn |
| **Response measures** | Finishing simple, medium and complicated tasks take no longer than 20s, 1min and 2min respectively<br>>99% of users can use system correctly<br>>90% of users can get familiar with system operations within 1h |

**Scenario 3: Trade operation by unauthorized user [Security]**

| Element | Possible values |
|---|---|
| **Source** | Unauthorized user |
| **Stimulus** | Making a payment (or other security-critical operations) |
| **Artifact** | System security module |
| **Environment** | System functioning properly, user not authorized |
| **Response** | User request rejected by system<br>System generates log |

| | |
|---|---|
| **Response measures** | System rejects illegal user request within 2s<br>System generates log instantly after rejecting request |

**Scenario 4: Invalid user input [Robustness]**

| Element | Possible values |
|---|---|
| **Source** | User |
| **Stimulus** | Invalid input from user |
| **Artifact** | Input validation module |
| **Environment** | System functioning properly |
| **Response** | System displays error information<br>System provides possible solutions |
| **Response measures** | System recognizes invalid input and responses correctly within 2s |

**Scenario 5: Adding new feature to system [Extensibility, Maintainability]**

| Element | Possible values |
|---|---|
| **Source** | Developer |
| **Stimulus** | New feature to be added to system |
| **Artifact** | Business computing module |
| **Environment** | System already released and functioning properly |
| **Response** | System releases new feature<br>Release process should be simple and easy |
| **Response measures** | Over 99% of users remain unaffected during system release<br>Release of new feature should be accomplished within 1h |

**Scenario 6: Changing current system function [Modifiability]**

| Element | Possible values |
|---|---|
| **Source** | Developer |
| **Stimulus** | Developer want to modify existent feature |
| **Artifact** | System |
| **Environment** | During development |
| **Response** | Implement necessary changes<br>Test modified code<br>Deploy modified system modules |
| **Response measures** | Changing one system function costs under 2 man-months<br>Modification costs over 80% less than rebuilding system |

**Scenario 7: Increasing/decreasing computing power [Scalability]**

| Element | Possible values |
|---|---|
| **Source** | Developer |
| **Stimulus** | Computing power needs to be increased or decreased for certain business |
| **Artifact** | Business computing module |
| **Environment** | System already released and functioning properly |

| | |
|---|---|
| **Response** | Computing power is increased or decreased correspondingly |
| **Response measures** | Change of computing power is accomplished within 1h<br>Over 99% of users remain unaffected during computing power increase/decrease |

**Scenario 8: Migrating system to another environment [Portability]**

| Element | Possible values |
|---|---|
| **Source** | Developer, maintainer |
| **Stimulus** | Migrating system to another environment |
| **Artifact** | System |
| **Environment** | During development, maintenance or configuration |
| **Response** | Finish necessary modifications for system migration<br>Test modified modules<br>Deploy system to new environment |
| **Response measures** | System migration costs under 2 man-months<br>Migration costs over 80% less than rebuilding system |

**Scenario 9: Server down [Availability]**

| Element | Possible values |
|---|---|
| **Source** | Maintainer |
| **Stimulus** | Server down for service |
| **Artifact** | Service cluster |
| **Environment** | Server functioning properly, under development or maintenance |
| **Response** | Identify server error<br>Restart server |
| **Response measures** | Server starts working normally within 1 minute |

**Scenario 10: Failed service discovery [Reliability, Availability]**

| Element | Possible values |
|---|---|
| **Source** | Maintainer |
| **Stimulus** | Certain service cannot be discovered |
| **Artifact** | Server, communication module, error handling module |
| **Environment** | System functioning properly or under test |
| **Response** | Check for connection failure, and restore connection if any<br>Check for server error, and resolve error if any |
| **Response measures** | Service discovery becomes available within 6h<br>Error checking and restoration cost under 2 man-months |

**Scenario 11: Failed service registration [Reliability, Availability]**

| Element | Possible values |
|---|---|
| **Source** | Developer |
| **Stimulus** | Service cannot be registered |
| **Artifact** | Communication module, service cluster module, error handling |

| | |
|---|---|
| | module |
| **Environment** | System functioning properly or under test |
| **Response** | Analyze cause of issue<br>Solve problems and restore service registration |
| **Response measures** | Service registration becomes available within 6h<br>Error checking and restoration cost under 2 man-months |

**Scenario 12: Database crash [Availability, Safety]**

| Element | Possible values |
|---|---|
| **Source** | Maintainer |
| **Stimulus** | Database crash |
| **Artifact** | Database system, error handling module |
| **Environment** | System functioning properly or under test |
| **Response** | Identify cause of crash<br>Restore database system |
| **Response measures** | Database becomes available within 6h<br>Error checking and restoration cost under 2 man-months |

**Scenario 13: Network outage [Reliability, Robustness]**

| Element | Possible values |
|---|---|
| **Source** | User, developer |
| **Stimulus** | Network connection failure |
| **Artifact** | Communication module, error handling module |
| **Environment** | System functioning properly or under test |
| **Response** | Check for network connection problem<br>Check for communication module malfunction<br>And restore connection |
| **Response measures** | Service registration becomes available within 6h<br>Error checking and restoration cost under 2 man-months |

**Scenario 14: Checking status information of service cluster [Reliability, Performance]**

| Element | Possible values |
|---|---|
| **Source** | Maintainer |
| **Stimulus** | Checking status information of service cluster |
| **Artifact** | Service cluster status log |
| **Environment** | System functioning properly |
| **Response** | System generates service cluster status log |
| **Response measures** | System can generate service cluster status log of any time period<br>Accuracy of service cluster status log is at least 99.9% |

### 3.1.2 Decomposed system components

Iteration 1 is for the overall architecture design. No system components are decomposed at this iteration.

### 3.1.3 Element view diagram

See also 2.1 Microservices architecture pattern.

## 3.2 Iteration 2

### 3.2.1 Requirements information

Requirements information is identical to Iteration 1.

### 3.2.2 Decomposed system components

The Service Registry component is decomposed at this iteration. Service Registry is responsible for service registering and discovering.

### 3.2.3 Component-responsible ASRs

| Architectural Driver | Importance | Difficulty |
|---|---|---|
| **Scenario 5: Adding new feature to system** | M | H |
| **Scenario 7: Increasing/decreasing computing power** | M | M |
| **Scenario 10: Failed service discovery** | M | M |
| **Scenario 11: Failed service registration** | M | M |

### 3.2.4 Designing for ASRs

#### 3.2.4.1 Design concerns

| Quality Attribute | Design Concern | Subordinate Concerns |
|---|---|---|
| **Availability, Performance** | Service registering and discovering | Synchronization between nodes |
| **Extensibility, Scalability** | Service addition and deletion | Construction of the registry |

#### 3.2.4.2 Alternative patterns for concerns

**1) Synchronization between nodes**

| # | Pattern | Availability | Performance | Cost |
|---|---|---|---|---|
| **1** | Use only one node for Service Registry | L | L | L |
| **2** | Consistency & Availability pattern | H | M | M |
| **3** | Availability & Partition tolerance pattern | H | H | M |
| **4** | Consistency & Partition tolerance pattern | L | M | M |

In theoretical computer science, the CAP theorem states that it is impossible for a distributed data store to simultaneously provide more than two out of the following three guarantees: Consistency, Availability and Partition tolerance.

Pattern #3 is selected. It provides both high availability and high performance at the same cost. ZooKeeper and its ZAB protocol, which is widely-used to build distributed data stores, can be used to achieve the goal of this pattern.

**2) Construction of the registry**

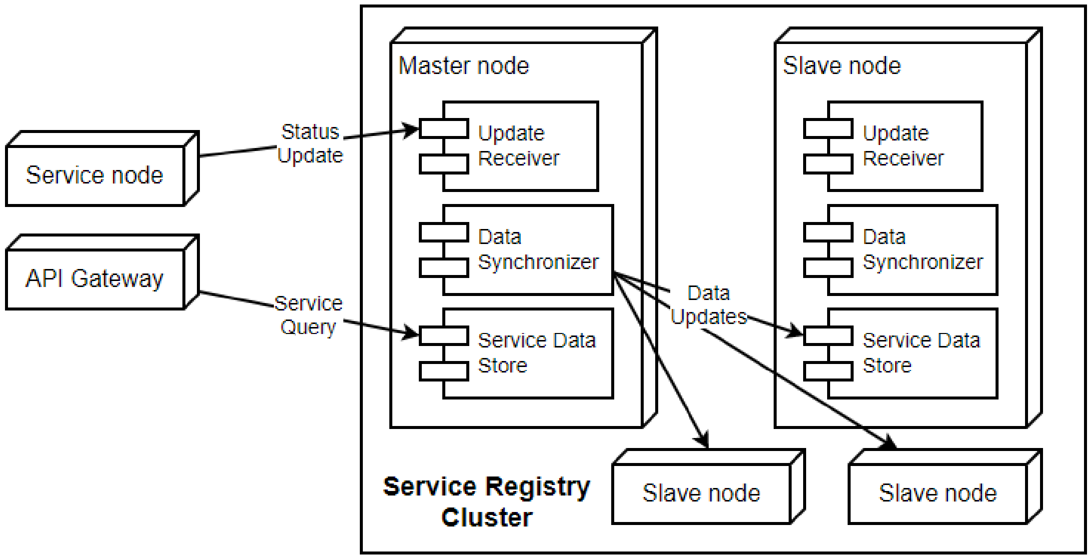
| # | Pattern | Availability | Performance | Cost |
|---|---|---|---|---|
| **1** | Services push updates to the registry | M | H | L |
| **2** | Service Registry pulls updates from services | H | L | M |

Pattern #1 is selected. Though pattern #2 can achieve higher availability, it consumes more resources (network, etc.) and cost more while developing. Pattern #2 can be selected in the Service Monitoring cluster, instead of the Service Registry.

#### 3.2.4.3 Corresponding ASRs of selected patterns

| Concern | Selected Pattern | Architectural Drivers |
|---|---|---|
| **Synchronization between nodes** | Availability & Partition tolerance pattern | Scenario 7, Scenario 9, Scenario 10 |
| **Construction of the registry** | Services push updates to the registry | Scenario 5, Scenario 11 |

### 3.2.5 Element view diagram




### 3.2.6 Evaluation

No conflicts were found during the evaluation of this iteration.

## 3.3 Iteration 3

### 3.3.1 Requirements information

Requirements information is identical to Iteration 1.

### 3.3.2 Decomposed system components

The Service Monitor component is decomposed at this iteration. Service Monitor is responsible for monitoring service availability and apply failover mechanism when service unavailability is detected. It ensures the performance, availability and reliability of services, which is significant to the operation of the whole system.

### 3.3.3 Component-responsible ASRs

| Architectural Driver | Importance | Difficulty |
|---|---|---|
| **Scenario 1: >1000 users trading at the same time** | H | H |
| **Scenario 9: Server down** | H | M |
| **Scenario 13: Network outage** | M | M |
| **Scenario 14: Checking status information of service cluster** | M | M |

### 3.3.4 Designing for ASRs

#### 3.3.4.1 Design concerns

| Quality Attribute | Design Concern | Subordinate Concerns |
|---|---|---|
| **Availability** | Service availability monitoring | Service status monitoring |
| **Availability** | Service unavailability handling | Unavailability handling method |
| **Performance** | Service performance monitoring | Response time measure,<br>Service invocation counting |

#### 3.3.4.2 Alternative patterns for concerns

**1) Service status monitoring**

| # | Pattern | Availability | Service Cost | Monitor Cost |
|---|---|---|---|---|
| **1** | Heartbeat | H | H | M |
| **2** | Ping/echo | H | M | H |

Pattern #1 is selected. It lightens the stress of services, which is vital to the whole system.

**2) Unavailability handling method**

| # | Pattern | Availability | Success Rate | Cost |
|---|---|---|---|---|
| **1** | Report and try automatic reboot | H | M | L |
| **2** | Record and wait for manual reboot | L | H | M |

Pattern #1 is selected. Automatic reboot pattern reduces manpower consumption and saves cost of the system. Manual reboot is still considered, but is only needed when automatic reboot is not working.

**3) Response time measure**

| # | Pattern | Accuracy | Performance |
|---|---|---|---|
| **1** | Measure response time of each request | H | M |
| **2** | Measure response time of random requests | M | H |

Pattern #2 is selected. Measuring each request consumes much more system resources and may affect normal operations. Measuring random requests consumes less resources, and its accuracy depends on the algorithm to select requests randomly.

**4) Service invocation counting**

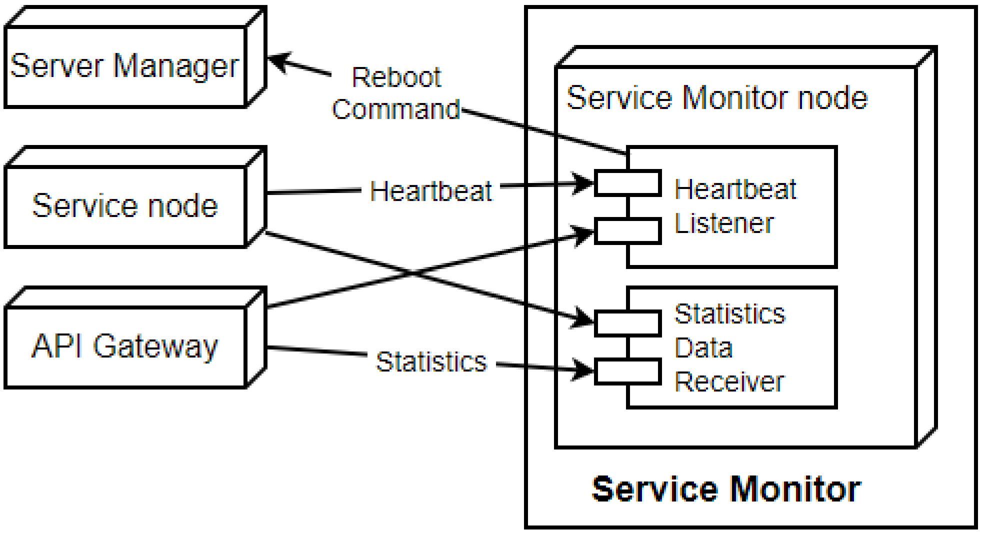
| # | Pattern | Accuracy | Performance |
|---|---|---|---|
| **1** | Count on each invocation | H | M |
| **2** | Count on a regular interval | M | H |
| **3** | Count on a regular amount of invocations | M | H |

Pattern #2 is selected. Counting on each invocation consumes lots of system resources, while the rest patterns cost less. Counting on a regular amount of invocations may lead to accuracy decrement if the service is invocated irregularly. Counting on a regular interval ensures the data collected regularly.

#### 3.3.4.3 Corresponding ASRs of selected patterns

| Concern | Selected Pattern | Architectural Drivers |
|---|---|---|
| **Service status monitoring** | Heartbeat | Scenario 1, Scenario 9, Scenario 13 |
| **Unavailability handling method** | Report and try automatic reboot | Scenario 1, Scenario 9, Scenario 13 |
| **Response time measure** | Measure response time of random requests | Scenario 14 |
| **Service invocation counting** | Count on a regular interval | Scenario 14 |

### 3.3.5 Element view diagram




### 3.3.6 Evaluation

No conflicts were found during the evaluation of this iteration.

## 3.4 Iteration 4

### 3.4.1 Requirements information

Requirements information is identical to Iteration 1.

### 3.4.2 Decomposed system components

The API Gateway component is decomposed at this iteration. API Gateway receives HTTP requests from users' browsers, then forwards them to the Service Cluster by Remote Procedure Calls (RPCs). It is also a vital part of the whole system.

### 3.4.3 Component-responsible ASRs

| Architectural Driver | Importance | Difficulty |
|---|---|---|
| **Scenario 1: >1000 users trading at the same time** | H | H |
| **Scenario 2: Normal trade operation by user** | H | M |
| **Scenario 9: Server down** | M | M |
| **Scenario 10: Failed service discovery** | M | M |

### 3.4.4 Designing for ASRs

#### 3.4.4.1 Design concerns

| Quality Attribute | Design Concern | Subordinate Concerns |
|---|---|---|
| **Availability** | Failover mechanism | Service unavailability discovery, Service unavailability handling |
| **Availability** | Service discovery | Maintain connection with Service Registry |
| **Performance** | Service load balancing | Load balancing pattern |
| **Performance** | Caching | Caching method |

#### 3.4.4.2 Alternative patterns for concerns

**1) Service unavailability discovery**

| # | Pattern | Availability | Response Time |
|---|---|---|---|
| **1** | Service unavailable if an amount of requests failed | H | M |
| **2** | Service unavailable if no success requests in an amount of time | H | L |

Pattern #1 is selected. In a real environment, the frequency of requests is hard to predict. Therefore, Pattern #2 can easily cause false alarms, though its low response time.

**2) Service unavailability handling**

| # | Pattern | Availability | Response Time |
|---|---|---|---|
| **1** | Return cached result or error message immediately (fail-fast) | H | L |
| **2** | Retry until service is available again (fail-back) | M | H |
| **3** | Return cached result or error message after an amount of retries (fail-over) | H | M |

Pattern #3 is selected. In this pattern, both retrying and response time is considered. Limiting the amount of retries makes the response time more predictable.

**3) Maintain connection with Service Registry**

| # | Pattern | Availability | Cost |
|---|---|---|---|
| **1** | Use persistence connection and heartbeat | H | H |
| **2** | Ping Service Registry when requests arrive | M | M |

Pattern #1 is selected. Though its high cost, it effectively ensures high availability.

**4) Load balancing pattern**

| # | Pattern | Performance | Cost |
|---|---|---|---|
| **1** | Weighted round robin | M | L |
| **2** | Least response time | H | M |
| **3** | Consistent hashing | M | L |
| **4** | Random | L | L |

Pattern #2 is selected. In a trading system, response time is significant. However, random method can be used in other systems. “Scientific research shows that random often creates miracles.” said Tongwei Ren, associate professor at Software Institute, Nanjing University.

**5) Caching method**

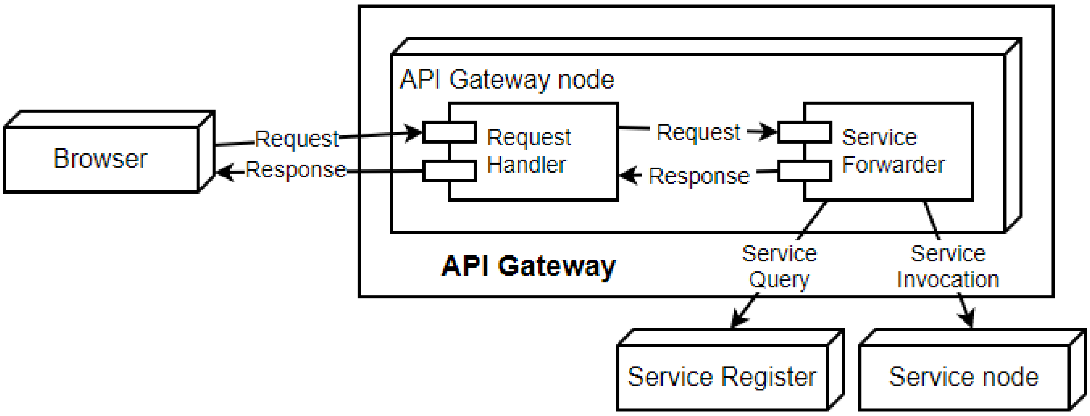
| # | Pattern | Availability | Performance | Cost |
|---|---|---|---|---|
| **1** | In-memory caching | M | H | L |
| **2** | Dedicated caching server (Redis, Memcached, …) | H | M | M |

Pattern #2 is selected. In-memory caching is not robust and often causes data loss, thus a dedicated caching server is needed for high availability.

### 3.4.4.3 Corresponding ASRs of selected patterns

| Concern | Selected Pattern | Architectural Drivers |
|---|---|---|
| **Service unavailability discovery** | Service unavailable if an amount of requests failed | Scenario 1, Scenario 9 |
| **Service unavailability handling** | Return cached result or error message after an amount of retries (fail-over) | Scenario 1, Scenario 9 |
| **Maintain connection with Service Registry** | Use persistence connection and heartbeat | Scenario 10 |
| **Load balancing pattern** | Least response time | Scenario 1 |
| **Caching method** | Dedicated caching server (Redis, Memcached, …) | Scenario 1, Scenario 2 |

### 3.4.5 Element view diagram




### 3.4.6 Evaluation

No conflicts were found during the evaluation of this iteration.

## 3.5 Iteration 5

### 3.5.1 Requirements information

Requirements information is identical to Iteration 1.

### 3.5.2 Decomposed system components

The Service Cluster component is decomposed at this iteration. Service Cluster handles service invocations by Remote Procedure Calls (RPCs).

### 3.5.3 Component-responsible ASRs

| Architectural Driver | Importance | Difficulty |
|---|---|---|
| **Scenario 1: >1000 users trading at the same time** | H | H |
| **Scenario 2: Normal trade operation by user** | H | M |
| **Scenario 8: Migrating system to another environment** | L | H |

### 3.5.4 Designing for ASRs

#### 3.5.4.1 Design concerns

| Quality Attribute | Design Concern | Subordinate Concerns |
|---|---|---|
| **Performance, Portability** | Data transferring protocol | Network protocol,<br>Data serialization method,<br>Data compression method |

#### 3.5.4.2 Alternative patterns for concerns

**1) Network protocol**

| # | Pattern | Performance | Portability | Difficulty |
|---|---|---|---|---|

| | | | | |
|---|---|---|---|---|
| **1** | Use HTTP protocol for data transferring | H | H | L |
| **2** | Use custom TCP protocol for data transferring | H | L | H |

Pattern #1 is selected. HTTP is a widely-used and mature protocol for data transferring. It can handle both short connections and persistence connections. Custom TCP protocol cost time for developing, and it needs to be ported to new environment when the system is being migrated to another environment.

**2) Data serialization method**

| # | Pattern | Performance | Portability | Difficulty |
|---|---|---|---|---|
| **1** | Use JSON serialization | M | H | M |
| **2** | Use cross-language binary serialization (Hession, Protostuff, …) | H | M | L |
| **3** | Use Java-only binary serialization (JVM, Kryo, …) | H | L | L |

Pattern #2 is selected. Cross-language binary serialization methods achieve balance of performance, portability and difficulty. It is fast, easy to use, and needs less time when migrating to another environment.

**3) Data compression method**

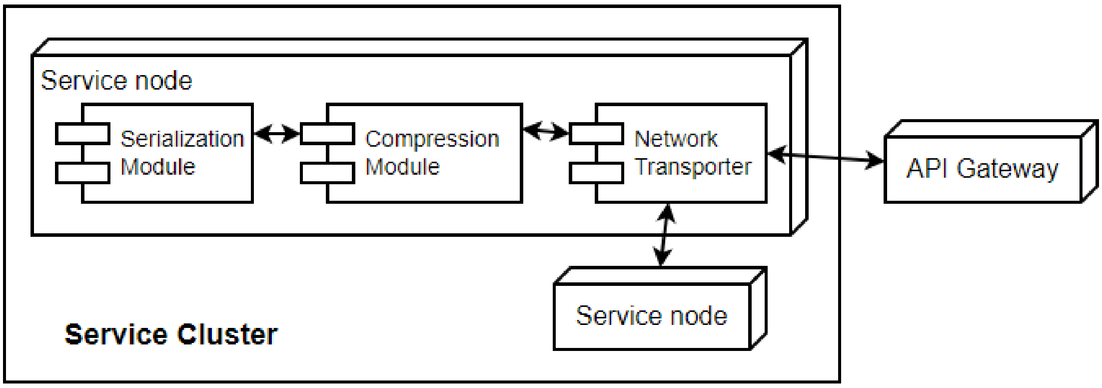
| # | Pattern | Performance | Portability | Difficulty |
|---|---|---|---|---|
| **1** | No data compression | M | H | L |
| **2** | Compress all data | M | M | L |
| **3** | Compress data larger than specific size | H | M | M |

Pattern #3 is selected. If no data is compressed, large packets needs more time to be transferred on the network. If all data is compressed, more system resources are consumed for small packets. In a real environment, most of RPC requests are small packets, thus pattern #3 achieves high performance for both small and large packets.

### 3.5.4.3 Corresponding ASRs of selected patterns

| Concern | Selected Pattern | Architectural Drivers |
|---|---|---|
| **Network protocol** | Use HTTP protocol for data transferring | Scenario 1, Scenario 2, Scenario 8 |
| **Data serialization method** | Use cross-language binary serialization (Hession, Protostuff, …) | Scenario 1, Scenario 2, Scenario 8 |
| **Data compression method** | Compress data larger than specific size | Scenario 1, Scenario 2, Scenario 8 |

### 3.5.5 Element view diagram




### 3.5.6 Evaluation

No conflicts were found during the evaluation of this iteration.

## 3.6 Iteration 6

### 3.6.1 Requirements information

Requirements information is identical to Iteration 1.

### 3.6.2 Decomposed system components

The Security component is decomposed at this iteration. This component is responsible for user permission verification and input data filtering.

### 3.6.3 Component-responsible ASRs

| Architectural Driver | Importance | Difficulty |
|---|---|---|
| **Scenario 3: Trade operation by unauthorized user** | H | M |
| **Scenario 4: Invalid user input** | H | M |
| **Scenario 12: Database crash** | H | H |

### 3.6.4 Designing for ASRs

#### 3.6.4.1 Design concerns

| Quality Attribute | Design Concern | Subordinate Concerns |
|---|---|---|
| **Security** | Attack prevention | User authentication,<br>Input data validation |
| **Security** | Network transport security | Encryption method |
| **Safety** | Attack recovery | Data loss protection |

#### 3.6.4.2 Alternative patterns for concerns

**1) User authentication**

| # | Pattern | Performance | Security | Difficulty |
|---|---|---|---|---|

| | | | | |
|---|---|---|---|---|
| **1** | Use session for authentication | M | H | H |
| **2** | Use token for authentication | H | H | L |

Pattern #2 is selected. In a distributed system, sessions need to be stored on server-side, and synchronization between server nodes is necessary, which brings excessive performance overhead and consistency problem. Tokens, like JWTs(JSON Web Tokens), are more suitable for distributed systems.

**2) Input data validation**

| # | Pattern | Performance | Security | Difficulty |
|---|---|---|---|---|
| **1** | Validate data in front-end | H | L | M |
| **2** | Validate data in back-end | M | H | M |
| **3** | Validate data in both front-end and back-end | M | H | H |

Pattern #3 is selected. Validation in front-end can not ensure security at all. However, validation only in back-end leads to excessive requests and high latency, which affects user experience.

**3) Encryption method**

| # | Pattern | Performance | Security | Difficulty |
|---|---|---|---|---|
| **1** | Use HTTPS (SSL/TLS) for encryption | M | H | L |
| **2** | Use custom encryption protocol | M | H | H |

Pattern #1 is selected. HTTPS is widely-used for data encryption, and it ensures transportation layer security. HTTPS is supported by most of browsers, and cost less effort into developing.

**4) Data loss protection**

| # | Pattern | Safety | Cost | Difficulty |
|---|---|---|---|---|
| **1** | Backup database regularly | H | M | L |
| **2** | Add another database server for real-time copying | H | H | M |

Pattern #2 is selected. Pattern #2 is almost real-time, and uses incremental copying method, which brings high performance and high data safety.

#### 3.6.4.3 Corresponding ASRs of selected patterns

| Concern | Selected Pattern | Architectural Drivers |
|---|---|---|
| **User authentication** | Use token for authentication | Scenario 3 |
| **Input data validation** | Validate data in both front-end and back-end | Scenario 4 |
| **Encryption method** | Use HTTPS (SSL/TLS) for encryption | Scenario 4 |
| **Data loss protection** | Add another database server for real-time copying | Scenario 12 |

### 3.6.5 Element view diagram

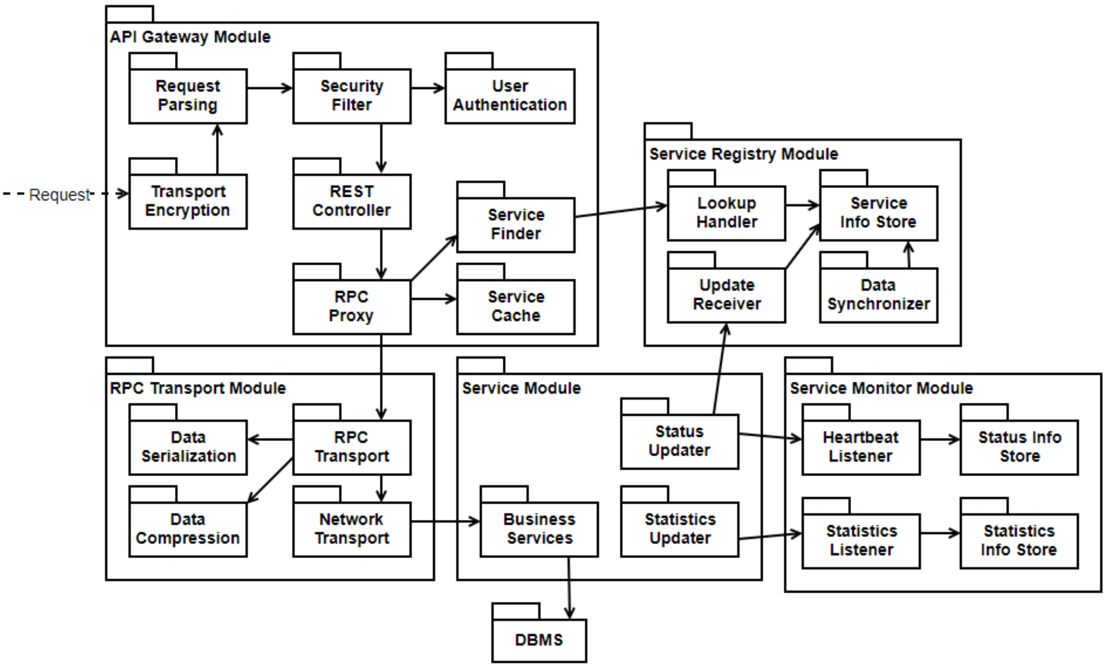
Features of this component are implemented in other modules.
See also 3.4.5 API Gateway element view diagram.

### 3.6.6 Evaluation

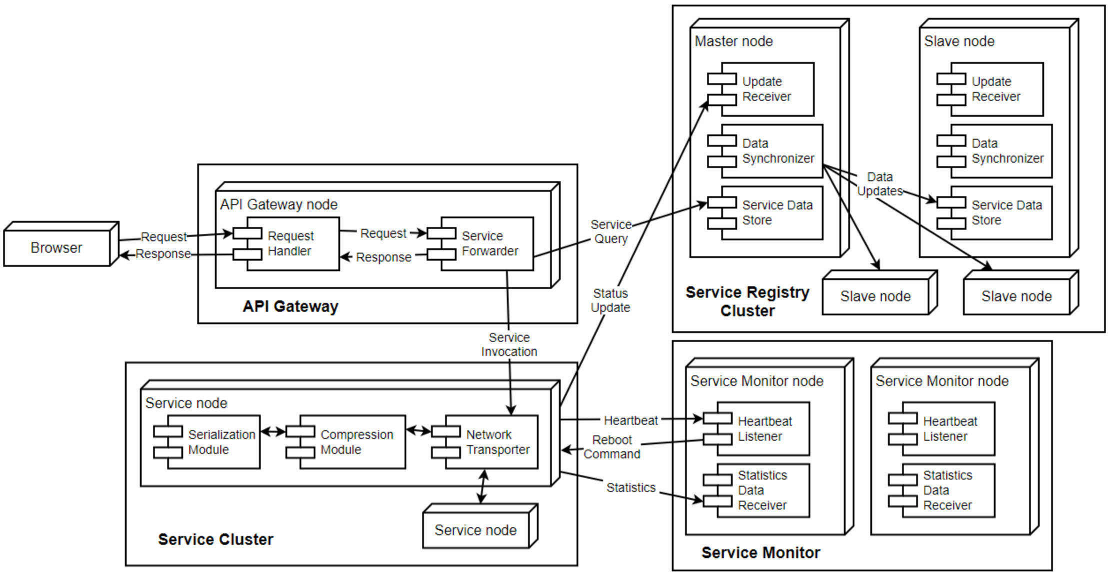
No conflicts were found during the evaluation of this iteration.

## 3.7 Final architectural views

### 3.7.1 Module view




### 3.7.2 Component-Connector view



# 4. ADD Procedures for MVC Pattern

## 4.1 Iteration 1

### 4.1.1 Requirements information

See also 3.1 Iteration 1.

### 4.1.2 Decomposed system components

Iteration 1 is for the overall architecture design. No system components are decomposed at this iteration.

### 4.1.3 Element view diagram

See also 2.2 MVC architecture pattern.

## 4.2 Iteration 2

### 4.2.1 Requirements information

Requirements information is identical to Iteration 1.

### 4.2.2 Decomposed system components

The trading module is decomposed at this iteration. This module processes users' orders, matches buy orders and sell orders based on their prices.

### 4.2.3 Component-responsible ASRs

| Architectural Driver | Importance | Difficulty |
|---|---|---|
| **Scenario 1: >1000 users trading at the same time** | H | H |
| **Scenario 2: Normal trade operation by user** | H | M |
| **Scenario 7: Increasing/decreasing computing power** | M | M |
| **Scenario 9: Server down** | H | H |
| **Scenario 13: Network outage** | M | H |

### 4.2.4 Designing for ASRs

#### 4.2.4.1 Design concerns

| Quality Attribute | Design Concern | Subordinate Concerns |
|---|---|---|
| **Performance** | Trade processing speed | Order processing speed |
| **Scalability** | Increasing/decreasing trade request processing power | Increasing/decreasing computing power |
| **Reliability** | Concurrent operations | Concurrent computing |
| **Reliability** | Network outage | Network status checking,<br>Network outage handling |

#### 4.2.4.2 Alternative patterns for concerns

**1) Order processing speed**

| # | Pattern | Extensibility | Throughput | Performance | Cost |
|---|---|---|---|---|---|
| **1** | Use queue for order processing | H | H | M | M |
| **2** | Upgrade server hardware | M | M | H | H |

Pattern #1 is selected. Although pattern #2 improves performance dramatically, it is not a cost-effective solution. Besides, high throughput is more important than performance of a single order in high concurrency situations.

**2) Increasing/decreasing computing power**

| # | Pattern | Impacts | Difficulty | Cost |
|---|---|---|---|---|
| **1** | Increase or decrease the count of servers | L | M | M |
| **2** | Upgrade server hardware | H | L | H |

Pattern #1 is selected. When the hardware of a server is being upgraded, the server must go down first, which will impact existing services.

**3) Concurrent computing**

| # | Pattern | Extensibility | Concurrency | Performance | Cost |
|---|---|---|---|---|---|
| **1** | Add more servers, use load balancing | H | H | H | H |
| **2** | Upgrade server hardware | M | L | H | H |

Pattern #1 is selected. Concurrency problem is significantly vital in trading systems. These systems must achieve very high concurrency. If we only upgrade server hardware, it is more likely for us to face concurrency bottlenecks. Therefore, pattern #1 is selected though its high cost.

**4) Network status checking**

| # | Pattern | Performance | Time Cost |
|---|---|---|---|
| **1** | Network outage if not receiving response in a regular interval | H | H |
| **2** | Use persistence connection and heartbeat checking | M | L |

Pattern #1 is selected. In MVC architecture pattern, it is difficult to maintain persistence connections between servers, and they will consume more system resources. Pattern #1 only needs to handle network outage if responses are not received in a regular interval, thus it consumes less system resources.

**5) Network outage handling**

| # | Pattern | Server Performance | Client Performance |
|---|---|---|---|
| **1** | Clients retry requests | H | M |
| **2** | Clients send acknowledgement | M | M |

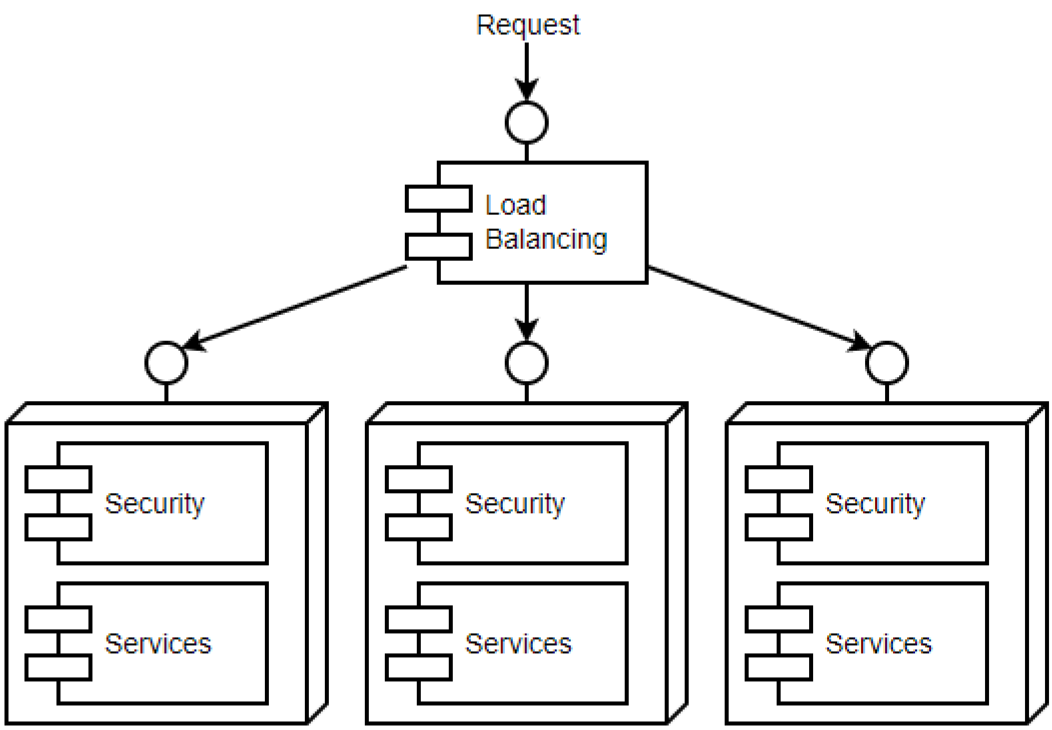
Pattern #1 is selected. Sending acknowledgement consumes more resources on both client side and server side, which also affects performance of other clients.

#### 4.2.4.3 Corresponding ASRs of selected patterns

| Concern | Selected Pattern | Architectural Drivers |
|---|---|---|

| | | |
|---|---|---|
| **Order processing speed** | Use pipeline for order processing | Scenario 1, Scenario 2 |
| **Increasing/decreasing computing power** | Increase or decrease the count of servers | Scenario 7 |
| **Concurrent computing** | Add more servers, use load balancing | Scenario 1, Scenario 2 |
| **Network status checking** | Network outage if not receiving response in a regular interval | Scenario 9 |
| **Network outage handling** | Clients retry requests | Scenario 13 |

### 4.2.5 Element view diagram




### 4.2.6 Evaluation

No conflicts were found during the evaluation of this iteration.

## 4.3 Iteration 3

### 4.3.1 Requirements information

Requirements information is identical to Iteration 1.

### 4.3.2 Decomposed system components

The market information module is decomposed at this iteration. This module is responsible for showing the latest market information to users.

### 4.3.3 Component-responsible ASRs

| Architectural Driver | Importance | Difficulty |
|---|---|---|
| **Scenario 2: Normal trade operation by user** | H | H |
| **Scenario 9: Server down** | M | L |

### 4.3.4 Designing for ASRs

#### 4.3.4.1 Design concerns

| Quality Attribute | Subordinate Concerns |
|---|---|
| **Usability** | Clear visualization, easy to use |
| **Portability** | Compatible with desktop and mobile browsers |
| **Availability** | Show notice when server down |

#### 4.3.4.2 Alternative patterns for concerns

**1) Clear visualization, easy to use**

| # | Pattern | Usability | Difficulty |
|---|---|---|---|
| **1** | Use chart to show prices | H | M |
| **2** | Use list to show prices | M | L |

Pattern #1 is selected. Charts are the best way to show price trends in a time period, hence the usability of system is higher.

**2) Compatible with desktop and mobile browsers**

| # | Pattern | Portability | Difficulty |
|---|---|---|---|
| **1** | Use different layouts on desktop and mobile browsers | H | H |
| **2** | Use responsive layouts | H | L |

Pattern #2 is selected. Responsive layouts can easily fit in different browser sizes without the need to develop more than once.

**3) Show notice when server down**

| # | Pattern | Cost | Difficulty |
|---|---|---|---|
| **1** | Show notice if not receiving server responses | L | L |
| **2** | Actively monitor server status | H | H |

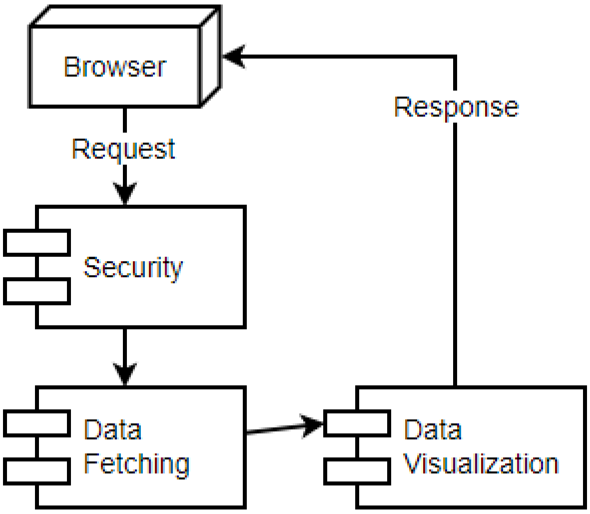
Pattern #1 is selected. In MVC architecture pattern, it will cost much resources for browsers to actively monitor the status of server. Pattern #1 uses passive monitoring, allowing users to know the status of servers without additional overhead.

#### 4.3.4.3 Corresponding ASRs of selected patterns

| Concern | Selected Pattern | Architectural Drivers |
|---|---|---|
| **Clear visualization, easy to use** | Use chart to show prices | Scenario 2 |
| **Compatible with desktop and mobile browsers** | Use responsive layouts | Scenario 2 |
| **Show notice when server down** | Show notice if not receiving | Scenario 9 |

| | | |
|---|---|---|
| | server responses | |

### 4.3.5 Element view diagram




### 4.3.6 Evaluation

No conflicts were found during the evaluation of this iteration.

## 4.4 Iteration 4

### 4.4.1 Requirements information

Requirements information is identical to Iteration 1.

### 4.4.2 Decomposed system components

The data management module is decomposed at this iteration. This module is responsible for insertion, deletion and modification operations of market, order, inventory, and wallet data.

### 4.4.3 Component-responsible ASRs

| Architectural Driver | Importance | Difficulty |
|---|---|---|
| **Scenario 2: Normal trade operation by user** | H | M |

### 4.4.4 Designing for ASRs

#### 4.4.4.1 Design concerns

| Quality Attribute | Subordinate Concerns |
|---|---|
| **Usability** | Easy to use with clear visualization |

#### 4.4.4.2 Alternative patterns for concerns

**1) Easy to use with clear visualization**

| # | Pattern | Usability | Cost |
|---|---|---|---|
| **1** | Provide all users with a universal set of user interface for buying and | H | M |

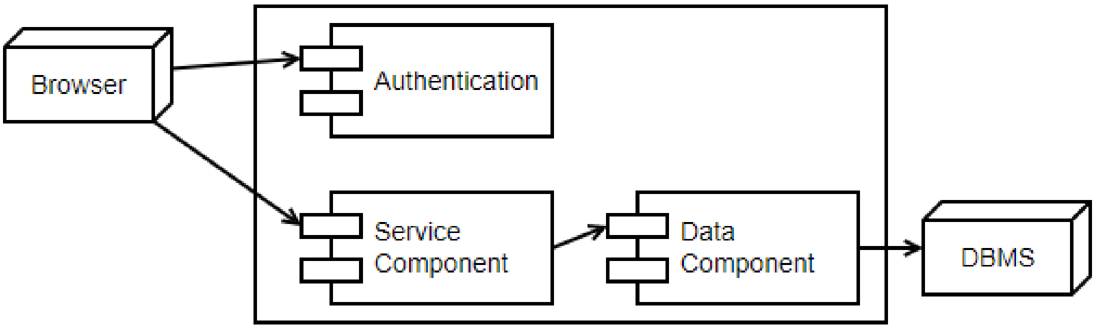
| | | | |
|---|---|---|---|
| | selling | | |

Pattern #1 is selected. All users have an identical set of permissions and functions including buying and selling items, since the role of seller in traditional trade model is taken by every user in this system. Therefore, providing universal user interface is the most reasonable solution.

#### 4.4.4.3 Corresponding ASRs of selected patterns

| Concern | Selected Pattern | Architectural Drivers |
|---|---|---|
| **Easy to use with clear visualization** | Provide all users with a universal set of user interface for buying and selling | Scenario 2 |

### 4.4.5 Element view diagram




### 4.4.6 Evaluation

No conflicts were found during the evaluation of this iteration.

## 4.5 Iteration 5

### 4.5.1 Requirements information

Requirements information is identical to Iteration 1.

### 4.5.2 Decomposed system components

The security component is decomposed at this iteration. Architectural design of this component is identical to the security component in Microservices pattern.

### 4.5.3 Component-responsible ASRs

See also 3.6.3 Component-responsible ASRs.

### 4.5.4 Designing for ASRs

See also 3.6.4 Designing for ASRs.

### 4.5.5 Element view diagram

Features of this component are implemented in other modules.

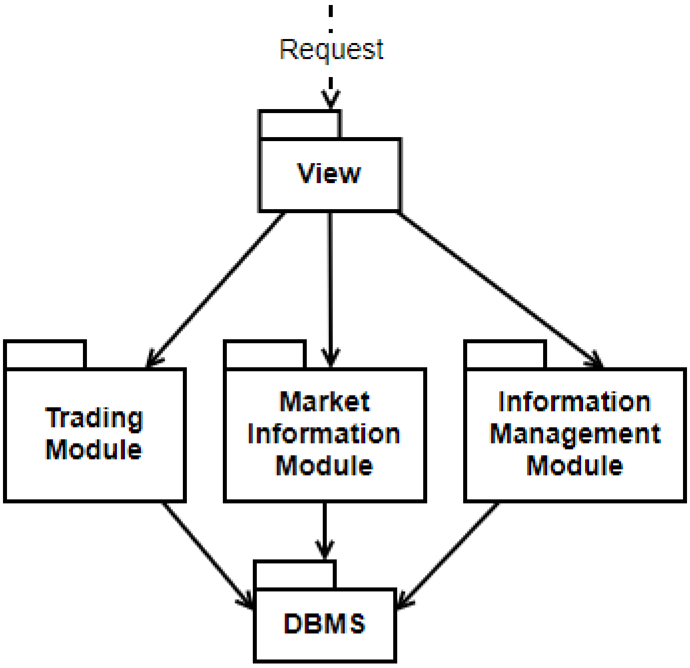
See also 4.2.5 Element view diagram and 4.3.5 Element view diagram.

### 4.5.6 Evaluation

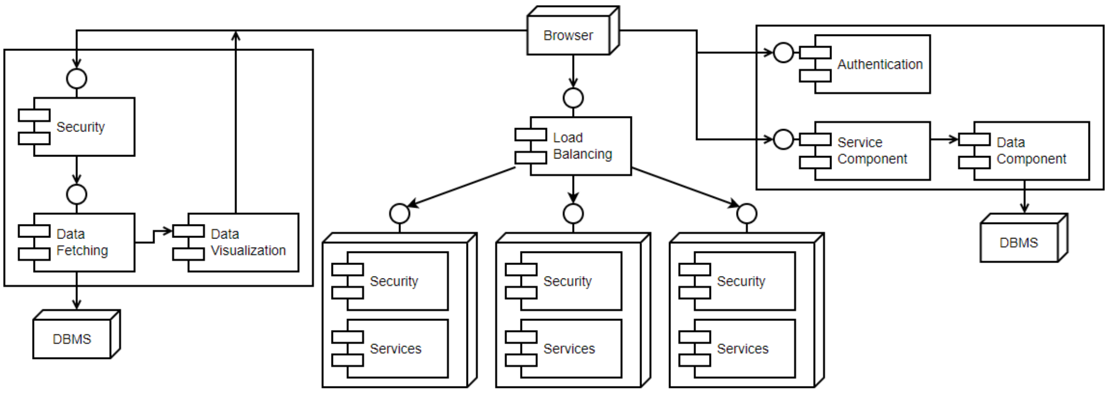
No conflicts were found during the evaluation of this iteration.

## 4.6 Final architectural views

### 4.6.1 Module view




### 4.6.2 Component-Connector view



# 5. Architecture Patterns Comparison

## 5.1 Overview

MVC architecture is more favorable for development of small system, providing high performance for low-concurrency scenario, while Microservices architecture shows advantage in high-concurrency scenario and excellent availability. Besides, MVC architecture also allows quicker development, and requires lower costs.

System that employs MVC architecture can be easily maintained and extended. In Microservices architecture, services are deployed independently, which makes it possible for maintainers to add and remove services dynamically, thereby enhancing the scalability and extensibility.

| MVC | Microservices |
|---|---|
| ● Friendly to small system development<br>● High performance at low-concurrency scenario<br>● Easy to maintain and extend<br>● Quick development & lower costs | ● Excellent at high-concurrency scenario<br>● Independent service deployment<br>● Adding/removing services dynamically<br>● Great extensibility and scalability<br>● High availability |

## 5.2 Performance

| MVC | Microservices |
|---|---|
| ● Stable service in low-concurrency and low-traffic environment<br>● High-concurrency performance restrained by data storage and processing capability of a single server | ● Lower speed in low-concurrency scenario due to communication among modules<br>● Quick access in high-concurrency scenario |

## 5.3 Availability

| MVC | Microservices |
|---|---|
| ● Whole system down whenever one server is down | ● Normally one down server won't affect the whole system |

## 5.4 Security

| MVC | Microservices |
|---|---|
| ● Single-direction and highly concentrated data and control flow, easier to ensure security<br>● Attacking one server undermines function of the whole system | ● Great security due to independence of modules and other security measures<br>● Normally attacking one server won't affect the whole system |

### 5.5 Cost

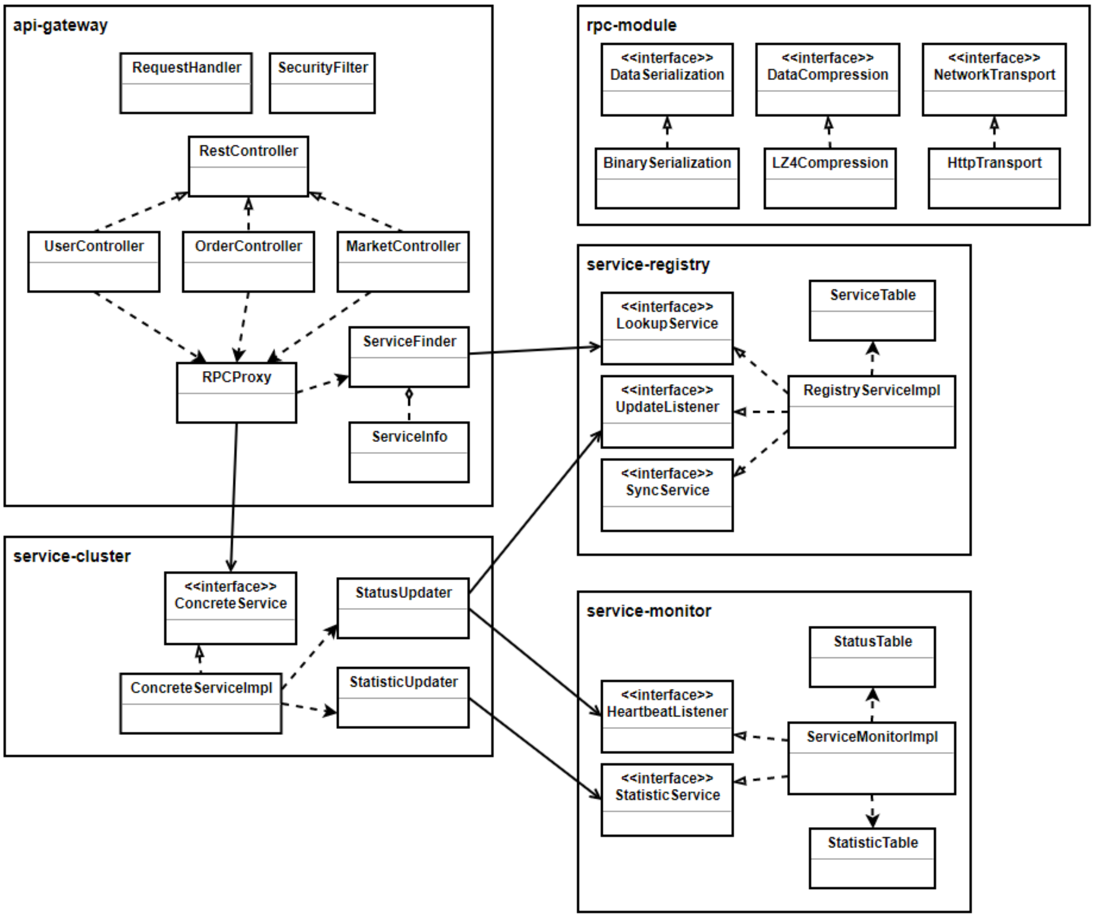
| MVC | Microservices |
|---|---|
| • Less servers required, thus lower hardware costs<br>• Lower system complexity, thus lower development costs<br>• Low maintenance costs | • More servers required, thus higher hardware costs<br>• Large data storage necessitated by data backup<br>• Higher system complexity, thus higher development costs<br>• Higher maintenance costs |

### 5.6 Conclusion

Considering the requirement of high concurrency and scalability in this particular system, Microservices pattern is finally chosen.

## 6. UML Class Diagram and Mapping

### 6.1 Class Diagram



### 6.2 Class Mapping

| Module | Component | Class |
|---|---|---|
| **API Gateway** | Request handling | RequestHandler, RestController |
| | Security filtering | SecurityFilter |
| | Service lookup | ServiceFinder |
| | Service info cache | ServiceFinder, ServiceInfo |
| | Service forwarding | RPCProxy |
| | Load balancing | RPCProxy |
| **Service Registry** | Service addition and removal | UpdateListener |
| | Service lookup handling | LookupService |
| | Service info store | ServiceTable |
| | Synchronization between nodes | SyncService |
| **Service Monitor** | Heartbeat receiving | HeartbeatListener |
| | Statistics data receiving | StatisticService |
| | Statistics data querying | StatisticService |
| | Service status store | StatusTable |
| | Service statistics store | StatisticTable |
| **Service Cluster** | Status reporting | StatusUpdater |
| | Statistics reporting | StatisticUpdater |
| | Business logic | ConcreteService, ConcreteServiceImpl |
| **RPC** | Network transport | NetworkTransport |
| | Data serialization | DataSerialization |
| | Data compression | DataCompression |

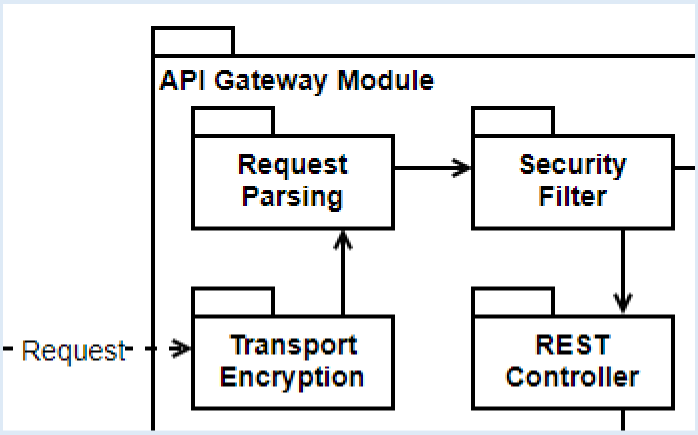
## 7. ATAM Procedures for Microservices Pattern

### 7.1 Quality Attribute Utility Tree

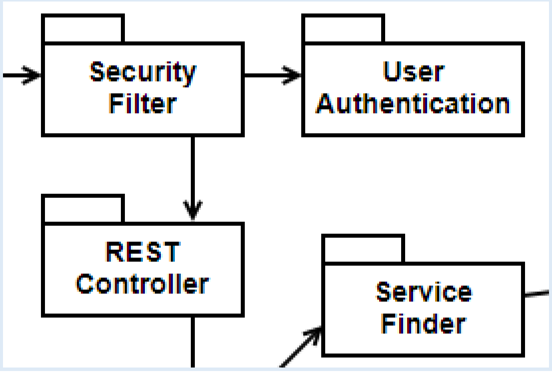
| Quality Attribute | Concrete Attribute | Scenario |
|---|---|---|
| **Security** | Data encryption | A1: Network traffic wire-tappers cannot decrypt sensitive information [H,L] |
| | User authentication | A2: System rejects unauthorized requests within 2s [H,M] |
| **Availability** | Service availability | A3: Service unavailable time less than 10 minutes per day [H,H] |
| | Failure detection | A4: Service failures can be detected within 30s [H,H] |
| | Failure recovery | A5: Recover from failures within 10 minutes [H,M] |
| **Performance** | Response time | A6: When 1000 users are trading simultaneously, over 85% requests finish within 1s [H,H] |
| | Load and capacity | A7: System can handle 1000 simultaneous users [H,H] |

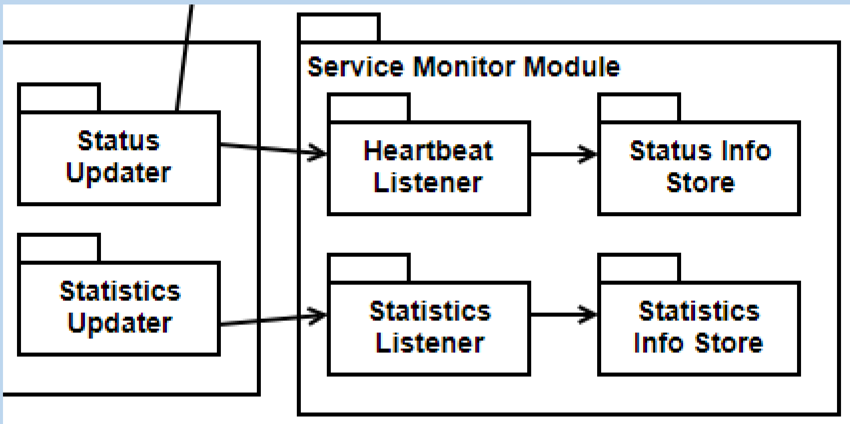
| | | |
|---|---|---|
| **Robustness** | Input validation | A8: System rejects invalid input within 2s [H,M] |
| | Error fallback | A9: When error occurs, system responses with fallback data or error message [M,L] |
| **Extensibility** | Feature extension | A10: New features or modifications can be deployed within 1h [M,M] |
| **Scalability** | System power scaling | A11: Change of computing power is accomplished within 1h [L,M] |
| **Portability** | System migration | A12: System migration costs under 2 man-months [L,M] |

## 7.2 ATAM Analysis

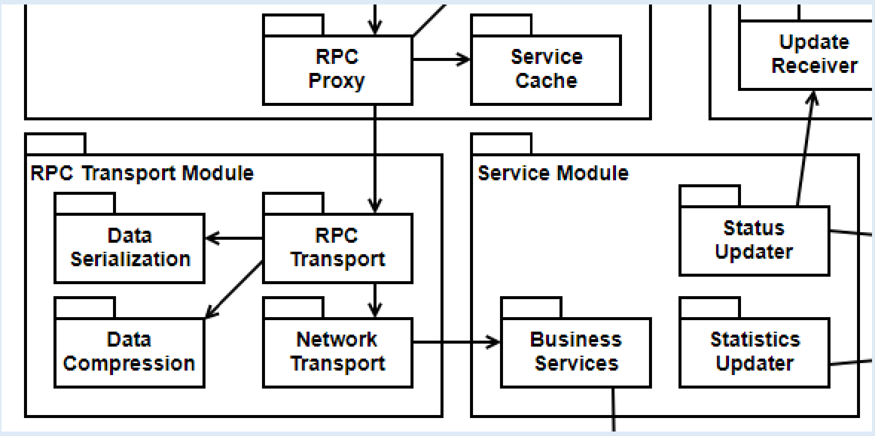
| **Scenario A1: Network traffic wire-tappers cannot decrypt sensitive information** | | | | |
|---|---|---|---|---|
| **Attribute** | Security | | | |
| **Environment** | System functioning properly | | | |
| **Stimulus** | External network wire-tapping | | | |
| **Response** | Network traffic wire-tappers fail to decrypt sensitive information | | | |
| **Architectural decisions** | **Sensitivity** | **Tradeoff** | **Risk** | **Non-risk** |
| Use HTTPS for encryption | S1 | T1 | | N1 |
| **Reasoning** | This particular system is related to real and virtual properties, thus security is important requirement. Wire-tappers may monitor network traffic, which may lead to sensitive information leakage. Encryption is an effective way to prevent these attacks, though it may slightly affect performance. | | | |
| **Related Architecture Diagram** |  | | | |

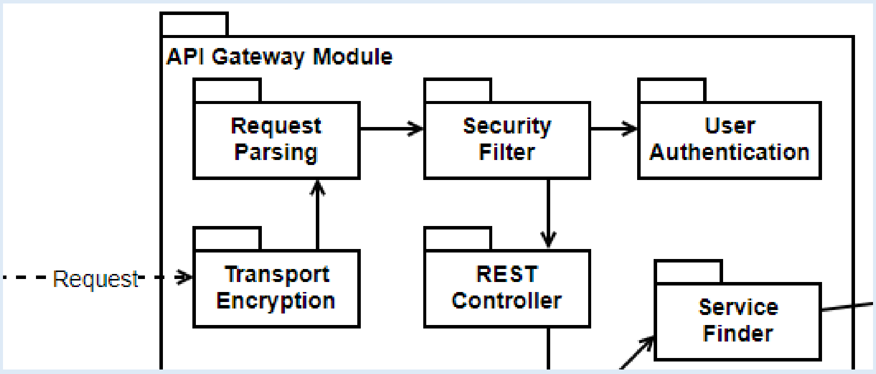
| **Scenario A2: System rejects unauthorized requests within 2s** | | | | |
|---|---|---|---|---|
| **Attribute** | Security | | | |
| **Environment** | System functioning properly | | | |
| **Stimulus** | Unauthorized user sends a request | | | |
| **Response** | System rejects the request within 2s | | | |
| **Architectural decisions** | **Sensitivity** | **Tradeoff** | **Risk** | **Non-risk** |
| Use token for authentication | S2 | | R1 | N2 |
| **Reasoning** | This particular system is related to real and virtual properties, thus security is important requirement. All trading should be operated by authorized users, | | | |

| | |
|---|---|
| | token authentication solves this problem effectively without performance impacts. |
| **Related Architecture Diagram** |  |

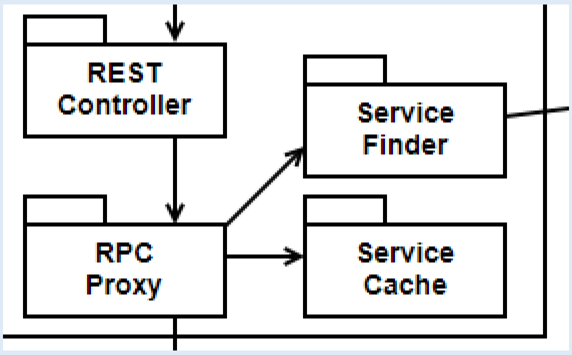
| **Scenario A3: Service unavailable time less than 10 minutes per day**<br>**Scenario A4: Service failures can be detected within 30s**<br>**Scenario A5: Recover from failures within 10 minutes** | | | | |
|---|---|---|---|---|
| **Attribute** | Availability | | | |
| **Environment** | System functioning properly | | | |
| **Stimulus** | A service node is down | | | |
| **Response** | System detects failure within 30s and recover within 10 minutes | | | |
| **Architectural decisions** | **Sensitivity** | **Tradeoff** | **Risk** | **Non-risk** |
| Heartbeat monitoring | S3 | T2 | R2 | N3 |
| Try automatic reboot | S4 | | R3 | |
| **Reasoning** | Heartbeat monitoring detects service failure faster. Automatic reboot reduces manpower cost and allows quicker recovery. | | | |
| **Related Architecture Diagram** |  | | | |

| **Scenario A6: When 1000 users are trading simultaneously, over 85% requests finish within 1s**<br>**Scenario A7: System can handle 1000 simultaneous users** | |
|---|---|
| **Attribute** | Performance |
| **Environment** | System functioning properly |
| **Stimulus** | >1000 users trading at the same time |
| **Response** | System executes trade operations by users normally<br>Server delivers large-scale requests to computational nodes<br>Data stored in database are modified normally |

| Architectural decisions | Sensitivity | Tradeoff | Risk | Non-risk |
|---|---|---|---|---|
| Least response time load balancing | S5 | | | N4 |
| Measure response time of random requests | S5 | | R4 | |
| Dedicated caching server | S6 | T3 | R5 | N5 |
| Use cross-language binary serialization | S7 | T4 | | N6 |
| Compress data larger than specific size | S7 | T4 | | N6 |
| **Reasoning** | Performance is also significant in distributed high-concurrency trading systems. Performance is considered and optimized in both API Gateway, RPC protocol and Service Monitor. | | | |
| **Related Architecture Diagram** |   | | | |

| Scenario A8: System rejects invalid input within 2s | | | | |
|---|---|---|---|---|
| **Attribute** | Robustness | | | |
| **Environment** | System functioning properly | | | |
| **Stimulus** | User sends a request with invalid input data | | | |
| **Response** | System rejects the request within 2s | | | |
| **Architectural decisions** | **Sensitivity** | **Tradeoff** | **Risk** | **Non-risk** |
| Validate data in both front-end and back-end | S8 | T5 | R6 | |
| **Reasoning** | Data validation rejects invalid data, which ensures robustness of the whole system. | | | |
| **Related Architecture Diagram** |   | | | |

| Scenario A9: When error occurs, system responses with fallback data or error message | |
|---|---|
| **Attribute** | Robustness |
| **Environment** | System functioning properly |

| | | | | |
|---|---|---|---|---|
| **Stimulus** | An error occurred | | | |
| **Response** | System responses with fallback data or error message | | | |
| **Architectural decisions** | **Sensitivity** | **Tradeoff** | **Risk** | **Non-risk** |
| Return cached result or error message after an amount of retries (fail-over) | S9 | | R7 | |
| **Reasoning** | Fail-over mechanism handles error in a way that does not affect user experience. | | | |
| **Related Architecture Diagram** |  | | | |



| | | | | |
|---|---|---|---|---|
| **Scenario A10: New features or modifications can be deployed within 1h**<br>**Scenario A11: Change of computing power is accomplished within 1h**<br>**Scenario A12: System migration costs under 2 man-months** | | | | |
| **Attribute** | Extensibility, Scalability, Portability | | | |
| **Environment** | System functioning properly | | | |
| **Stimulus** | System functions need to be extended, changed or migrated. | | | |
| **Response** | New features or modifications can be deployed within 1h<br>Change of computing power is accomplished within 1h<br>System migration costs under 2 man-months | | | |
| **Architectural decisions** | **Sensitivity** | **Tradeoff** | **Risk** | **Non-risk** |
| Microservices architecture pattern | S10 | T6 | | N7 |
| **Reasoning** | This particular system is related to real and virtual properties, thus security is important requirement. Wire-tappers may monitor network traffic, which may lead to sensitive information leakage. Encryption is an effective way to prevent these attacks, though it may slightly affect performance. | | | |
| **Related Architecture Diagram** | See also 2.1 Microservices architecture pattern. | | | |

### 7.3 Sensitivity points

| # | Architectural decision | Reasoning |
|---|---|---|
| **S1** | Use HTTPS for encryption | Sensitivity point for security and performance. Effectively ensures users' information security, but brings performance overhead. |
| **S2** | Use token for authentication | Sensitivity point for security and performance. Effectively prevents unauthorized operations. |

| | | |
|---|---|---|
| **S3** | Heartbeat monitoring | Sensitivity point for availability and performance. Detects service failure faster, but increases network and system resource usage. |
| **S4** | Try automatic reboot | Sensitivity point for availability. Allows recovering from service failure faster. |
| **S5** | Least response time load balancing<br>Measure response time of random requests | Sensitivity point for performance. Load balancing significantly improves overall performance, while measuring response time slightly affects performance. |
| **S6** | Dedicated caching server | Sensitivity point for performance and portability. Caching improves performance, but dedicated caching servers are more difficult to migrate. |
| **S7** | Use cross-language binary serialization<br>Compress data larger than specific size | Sensitivity point for performance and portability. Serialization and compression methods have different impacts on performance and different difficulties when migrating. |
| **S8** | Validate data in both front-end and back-end | Sensitivity point for robustness and performance. Data validation improves robustness but slightly affects performance on server-side. |
| **S9** | Return cached result or error message after an amount of retries (fail-over) | Sensitivity point for robustness. Fail-over mechanism improves robustness of the whole system. |
| **S10** | Microservices architecture | Sensitivity point for extensibility, scalability, portability. Services are easy to scale and migrate, but difficult to extend or modify. |

## 7.4 Tradeoff points

| # | Architectural decision | Reasoning |
|---|---|---|
| **T1** | Use HTTPS for encryption | Tradeoff point for security and performance. Improves security but decreases performance. |
| **T2** | Heartbeat monitoring | Tradeoff point for availability and performance. Improves availability but decreases performance. |
| **T3** | Dedicated caching server | Tradeoff point for performance and portability. Improves performance but affects portability. Needs specific operations when migrating. |
| **T4** | Use cross-language binary serialization<br>Compress data larger than specific size | Tradeoff point for performance and portability. Improves performance but affects portability. |
| **T5** | Validate data in both front-end and back-end | Tradeoff point for robustness and performance. Improves robustness but slightly affects performance. |
| **T6** | Microservices architecture | Tradeoff point for extensibility, scalability, portability. Easy to scale and migrate, but difficult to extend or modify. |

### 7.5 Risk

| # | Architectural decision | Reasoning |
|---|---|---|
| **R1** | Use token for authentication | Tokens revocation takes more time to become effective than using session for authentication. |
| **R2** | Heartbeat monitoring | If network is congested, heartbeat monitoring may be affected. |
| **R3** | Try automatic reboot | Requires additional hardware manager support. |
| **R4** | Measure response time of random requests | If measurement is not accurate, server usages may be non-uniform. |
| **R5** | Dedicated caching server | System performance may be affected when caching server is down |
| **R6** | Validate data in both front-end and back-end | User experience may be affected if validation rules are not consistent. |
| **R7** | Return cached result or error message after an amount of retries | Cached result may be outdated. The success rate of retrying is often low. |

### 7.6 Non-risk

| # | Architectural decision | Reasoning |
|---|---|---|
| **N1** | Use HTTPS for encryption | HTTPS is supported by most web servers and browsers. |
| **N2** | Use token for authentication | Mature solutions like JSON Web Token. |
| **N3** | Heartbeat monitoring | Heartbeat monitoring is widely-used in distributed systems. |
| **N4** | Least response time load balancing | Load balancing is widely-used in distributed systems. |
| **N5** | Dedicated caching server | Mature solutions like Memcached, Redis, ... |
| **N6** | Use cross-language binary serialization<br>Compress data larger than specific size | Cross-platform methods (e.g. Hessian) are widely-used. |
| **N7** | Microservices architecture pattern | Microservices architecture pattern is widely-used and proven practicable. |

# 8. Summary

## 8.1 Challenges and experience

At the beginning of this project, our group members generally had little understanding of distributed system architecture. Therefore, we encountered many problems when designing, such as the synchronization methods between different nodes. With the help of various reference materials as well as existing distributed systems, we are finally able to analyze different patterns for distributed system architecture.

While designing, we placed great emphasis on ADD methods. ADD focuses on quality attributes, and is totally different from conventional designing methods focusing on system functions. It helps us find a balance among many quality attributes by comparing different patterns with ASRs.

As a group of 8 students, we are divided into 3 subgroups: 2 students work on Microservices pattern, 4 of us work on MVC pattern and others evaluate the design. This division allows us to work more efficiently.

## 8.2 Individual's contributions

| Name and ID | Contributions |
|---|---|
| **梁家铭(151250091)** | Designing Microservices architectural pattern (Iteration 2, 3, 4, 5)<br>Project presentation and demo developing<br>Document integration and translation |
| **李一然(151250087)** | Identifying ASRs and scenarios of the project<br>Comparing two architectural patterns<br>Document integration and translation |
| **倪辰皓(141250096)** | Designing MVC architectural pattern (Iteration 1, 2) |
| **曹鸿荣(151250006)** | Designing MVC architectural pattern (Iteration 3) |
| **常德隆(151250011)** | Designing MVC architectural pattern (Iteration 3, 4)<br>Drawing view diagrams |
| **陈进(151250013)** | Designing Microservices architectural pattern (Iteration 6)<br>Comparing two architectural patterns |
| **陈淼(151250015)** | Searching and reading related materials<br>Evaluating Microservices architectural pattern using ATAM methods |
| **陈锐(151250016)** | Searching and reading related materials<br>Evaluating Microservices architectural pattern using ATAM methods |