

Flexible Business Support System for Stock Index Futures Transaction

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Abstract—As an important financial derivative tool, SIF (stock index futures) gets an indispensable effect in the stock market for investors, including hedging, discovering price and resisting risk. The transaction mode and regulations of SIF are subject to change due to rapid financial products innovation, especially in an emerging market. Therefore, in SIF transaction, one of the essential requirements of business support system is flexibility.

After analyzing current transaction modes and business systems of world famous SIF markets, we present a new solution for flexible business support system with multi-layer architecture, object-oriented components and FIB (Futures Exchange Information Bus) router cloud in this paper. The system shows excellent performance in Shanghai Stock Exchange with the top 4 largest transactions in the world.

Index Terms—SIF (Stock Index Futures), business support system, flexible system

I. INTRODUCTION

SIF (Stock index futures) are futures contracts where the underlying object is stock price index [1]-[4]. As an innovative financial derivative tool, SIF plays a critical role in improving the risk-resisting ability for a country or region, and also satisfies investors' need of avoiding risk in stock market [5]-[7].

With the rapid innovation in financial products, the transaction modes for SIF are subject to change, especially in an emerging market such as in China [8]-[13]. These requirements related to the transaction process are complex and highly dependent on legal and specific regulations. Therefore, flexibility has become one of key requirements of business support system for SIF transactions [14]. Meanwhile, SIF should be in line with the trend of world future developing in electronic transaction, so it is necessary to employ advanced

architecture and techniques to design a business support system with high performance, stable structure and better security.

The development of computer and network technology has improved the ability of data collecting, storing, processing and distributing significantly, especially, the increasingly importance brought by internet in connecting people and market around the world. Based on advanced technology, the world famous systems to support SIF business can be found as follows in Fig. 1 [15]:

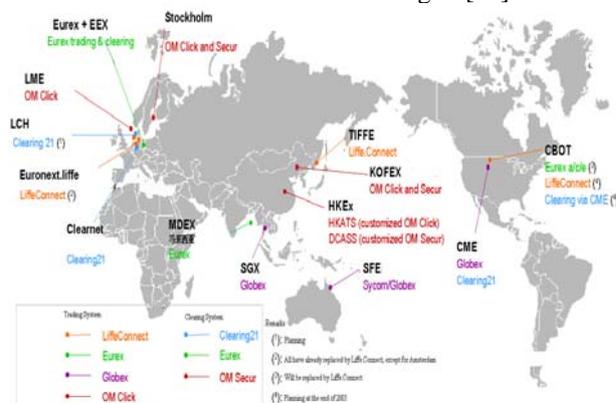


Figure1. Distributions of leading financial derivative trading and clearing system. Clearing21 is clearing platform of financial derivative used by CME and LCH.clearnet; Eurex transaction system is clearing platform of financial derivative used by European Exchange (Eurex);Globex is clearing platform of financial derivative used by Chicago Mercantile Exchange (CME)); LiffeConnect is clearing platform of financial derivative used by Euronext.Liffe; OM CLICK System is clearing platform of financial derivative used by Hong Kong Exchanges and Clearing Ltd. (HKEx) and Korean Options and Futures Exchange (KOFEX)); OM SECUR System is clearing platform of financial derivative used by Hong Kong Exchanges and Clearing Ltd. (HKEx) and Korean Options and Futures Exchange (KOFEX)).

Although some famous systems give reference solutions for the design of SIF systems in China [16]-[18], there are also a series of different characteristics and requirements to be considered, such as supporting multiply access modes including local area network, internet and mobile network, and connecting with more than 200 existing systems.

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Attempts to bridge business process and whole workflows are actually hard to find in practice. In so far our system is also a way of operationalizing so that it can be executed. The major objective of this paper is to present a new solution of flexible business support system for SIF transaction in emerging markets, especially in China [19]. The above aspects are discussed in detail below[20].

II. TRANSACTION MODE

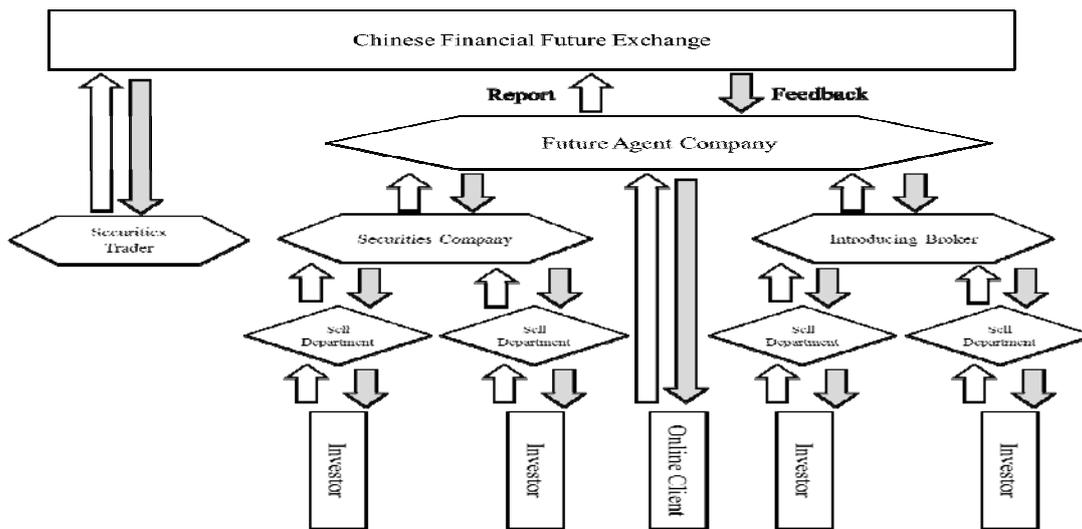


Figure 2. Main framework of SIF exchange

A. Financial Futures Exchange Station

Financial Futures Exchange station is certificated by the government and organized by membership where SIF and other financial derivatives are traded. Financial Futures Exchange station is the carrier of the SIF transaction support system on the exchange station end.

B. Member of Exchange Station

The member of exchange station is an individual or organization that is qualified to be the member of the exchange station and can do transactions directly in futures exchange station. The member of exchange station is also the carrier of the SIF transaction support system on the exchange station end.

Members can be classified into two groups. The first category includes the members who do hedging and speculation for themselves. The second category includes those futures brokerage firms that do futures brokerage business professionally.

C. Futures Trader

Futures traders are those who do hedging in order to avoid risks or those futures speculators who want to get speculating profits. They do futures trading in futures exchange station through futures agencies (or they are members of the futures exchange station) and they are the end users of the SIF transaction support system.

2.1. Main Framework

In order to build a system which is able to support the direct execution of arbitrary exchange tasks, a transaction-based approach is most appropriate: For each task we formulate a station of all the involved data objects, the process steps and the relevant regulation contexts. Then the system is compiled to process descriptions which run on top of the system components.

After analysis of current transaction modes and their business systems, we designed the framework of the SIF exchange as in Fig. 2.

D. Introducing Broker

Introducing brokers from securities companies can recommend their own investors to futures companies in the light of their experience based on the international situation in this field. Futures companies pay commissions to brokers, who are not qualified to be members. From the perspective of system designing, brokers work as the sales department of the futures agencies.

2.2. Transaction Process

Compared with the commodity futures Trading, SIF trading has features including electronic trading, large scale of traders and special operations functions (such as cash settlement, simpler delivery process compared with commodity futures', delivery through cash settlement, etc.). When designing system, demands should be fully considered.

The SIF transaction process with investors' participation is the fundamental basis of the demand analysis of the system, as shown in Fig. 3:

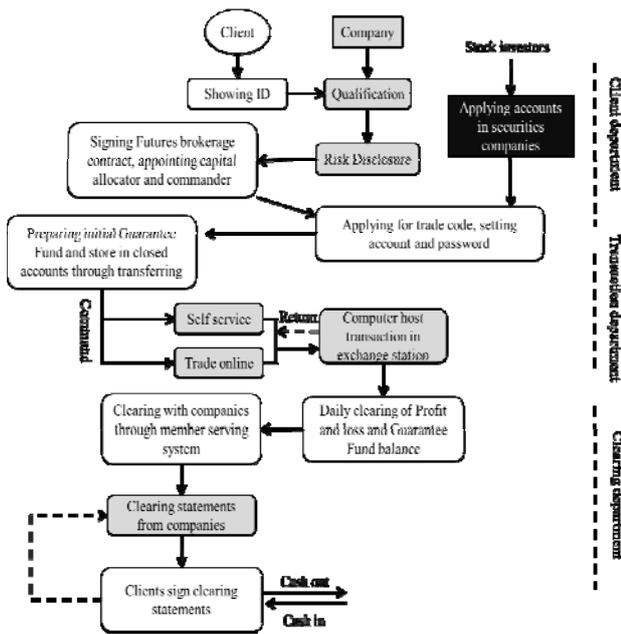


Figure 3. The SIF transaction process with participation of investors

A. Open Transaction Account

SIF transaction should happen in exchange station. Members include both futures brokerage firms and the self-assisted members. Ordinary investors should select an appropriate futures brokerage firm before stepping into the futures market. Futures brokerage firms can do the operations including opening users' accounts in users' end of the system for their clients.

B. Transaction Process

After paying the required margin, clients can deal with transaction, issue orders from the transaction system, and set the variety, quantity, and price of transaction contracts.

(1) Common transaction commands

The common international commands include transaction command, market price command, limit command, stop command and cancel command.

(2) Issuing transaction orders

A careful plan should be made before formal transaction. After that, the client can issue transaction orders according to the plan. Orders can be issued to the futures brokerage firm online.

(3) Bidding

Based on international experience, the contract price of SIF is generated by computer matching.

Computer matching is an automated trading method based on traditional auction, the process of matching transaction prices raised by buyers and sellers with computer. The transaction method has the features of accuracy, continuity, etc.

Daily opening price and closing price are all generated by call auction. The call auction is based on the principle of maximum trading volume, which means that the trading volume can be maximized in this price. Every buying request with the price higher than that generated by the call auction, and every selling request with the price lower than that generated by the call auction will be accepted. The acceptance price of buying or selling

request is equal to the price generated by the call auction will be decided by the volume of the request, the request with less volume will be granted.

(4) Feedback and confirmation of transactions

The feedback of transactions will be received automatically by the transaction system from the exchange station and shown to the user end. The transaction price, volume and return time will be included in transaction feedbacks.

C. Clearing and Cash Delivery

Clearing means the process of calculating and allocating margin, gain and loss, commission charge, delivery payment and other costs, which are generated in the transaction process based on related regulations and transaction results. Clearing includes the clearing towards members operated by exchange station and clearing towards clients operated by futures brokerage firm. The calculated results will be recorded in clients' margin accounts.

The transaction of SIF takes the form of cash delivery. When the contract of future matures, the occupation right is transferred from seller to buyer through cash delivery.

III. REQUIREMENTS OF BUSINESS SUPPORT SYSTEM

3.1. Difference in System Design between SIF and Commodity Future

In stock index futures market, futures companies play the key role but securities companies play the role as introducing brokers. Different from those previous used systems by futures companies, the stock index futures system can not only satisfy the requirements such as electronic transactions, customer management, capital management, clearing, risk control, and declaration management, but also take possible transaction size of securities companies into consideration in the system. Table I shows the main differences of these two futures from system design perspective.

TABLE I. DIFFERENCES BETWEEN STOCK INDEX FUTURES SYSTEM AND COMMODITY FUTURE SYSTEM

System's index	Stock index futures	Commodity futures
Burden on exchange station side	3-5 million	160 thousand
Member size	100,000	10,000
Accessing of investors	Internet mostly	Internet and LAN
Speed of declaration on members' side	200 declarations per second	10 declarations per second
Bandwidth	2M or above	64-128 K

3.2. System's Requirements

A. Functional Requirement

The SIF transaction support system should support the clearing of stock index futures' transactions and other financial derivatives' transactions. Besides, the interfaces that connect domestic commodity futures transaction should be reserved in order to expand business.

The design of system’s functions should apply in accordance with previous analysis of the business process and features. The main functions are categorized as follows:

- a. Basic data management: the management of members’ information, clients’ information, authority, clearing accounts, public parameters, etc.
- b. Transaction: the management of transaction participants, the products, risk control parameters, the configuration and management of transaction models and other elements, match processing of commission and bidding certification, management of transaction process and risk control.
- c. Clearing and risk management: the accounts’ structure of clearing participants, cash management, calculation of settlement price, calculation of profit and loss, calculation of margin and commission charge.
- d. Information management and publish: capture data from multiple information sources. Providing value-added services based on the received data. The data will be transferred into required output format and published to different users.
- e. Member service include: public service, business notification, daily reports, data queries, customer registration, and authority control.
- f. Delivery: cash delivery happens on the contract’s effective date. The value of effective contract will be calculated and both profit and loss will be recorded into clients’ accounts.

B. Non-functional Requirements

Non-functional requirements include: have standard interfaces, possess high availability, maintainability, efficiency and expansibility, and also achieve good security, scalability, and operability.

C. System’s Technical Requirements

(1) Exchange station’s systematical requirements

a. System capacity

The size that users could tolerate is at least 5 million, and the average daily transaction could be as many as 2.5 million.

b. Transaction system’s access capability

The transaction system should support as many as 800 access points’ connection, and load balance should be applied to improve system’s accessing ability.

(2) Member-end’s performance requirements

a. System capacity

The size that users could tolerate is at least 100,000, and the average daily transaction could be as many as 50,000.

b. Transaction system’s access capability

The transaction system should support as many as 2000 access points’ connection, and the load balance should be applied to improve system’s accessing ability.

c. Transaction system’s processing capability

1. The system should be able to transfer 150 declaration confirmation messages per second. This requirement is limited to the throttle mechanism and declaration response time.

2. The system should be able to transfer 140 transaction feedback messages. This requirement is based on the assumption that every declaration generates 0.46 transactions and every transaction affects both buyer and seller. This requirement is also limited to the throttle mechanism and declaration response time. 3. 90% of the declaration s’ response time should not exceed 1 second.

3. Parallel processing should be considered when design the system to achieve high performance. System should be able to provide current quotations to participants, and can check members’ capital condition and holding position.

Besides, there are also specific requirements towards system’s availability, security and manageability.

IV. DESIGN OF BUSINESS SUPPORT SYSTEM

4.1. Principle of System Design

This research is trying to integrate the key applications into the stock index futures transaction support system. The technology is object oriented and based on the “plug and play” function. We apply the “small core, big expansion” principle in the designing process. The total system will be separated into a group of subsystems to achieve the system’s flexibility, extensibility, maintainability, and openness.

4.2. System’s Architecture

Similar with commodity futures, SIF transaction support system includes exchange station end system and member end system. We will design those two systems separately.

4.2.1 Exchange Station end System

A. Analysis of main system architecture

Fig. 4 shows the composition of the exchange station end system. It reflects the logical relationships between different components.

B. Analysis of subsystem architecture

Transaction subsystems can be classified into three categories based on its technological features, as in Table II:

TABLE II
TRANSACTION SUBSYSTEMS

Category	Subsystem	Perfor mance	Reliabi lity	Scala bility	Expans ibility
Real-time transactio n	Trading system, Risk monitoring system	High	High	High	Mediu m
Database applicatio n	Trading management system, Clearing system, Delivery system	Mediu m	Mediu m	Mediu m	High
Web	Members service system	Mediu m	Mediu m	High	High

We use different technological architectures to design different subsystems based on their different technological features.

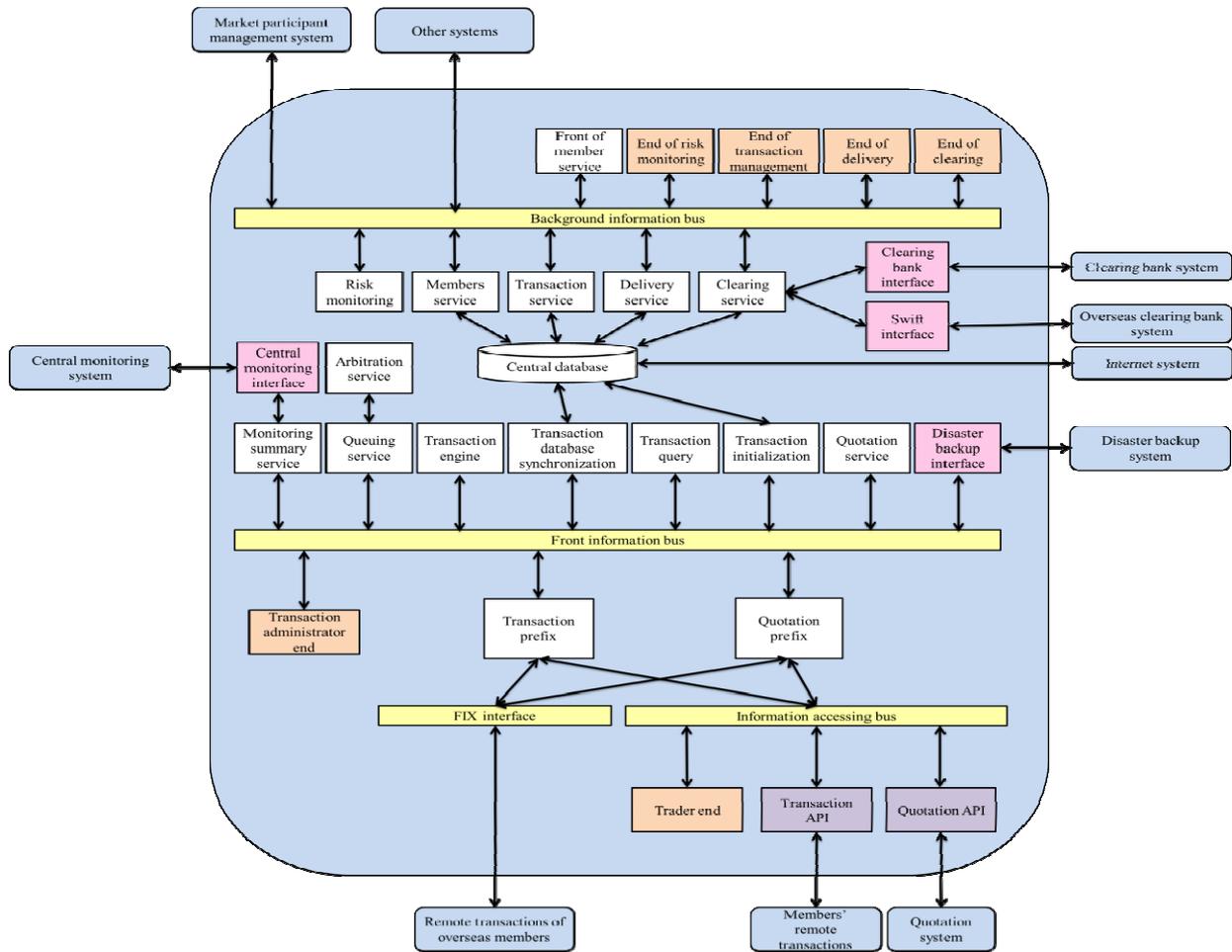


Figure 4. System architecture on exchange station end

B. Analysis of subsystem architecture

Transaction subsystems can be classified into three categories based on its technological features, as in Table II:

TABLE II
TRANSACTION SUBSYSTEMS

Category	Subsystem	Performance	Reliability	Scalability	Expansibility
Real-time transaction	Trading system, Risk monitoring system	High	High	High	Medium
Database application	Trading management system, Clearing system, Delivery system	Medium	Medium	Medium	High
Web	Members service system	Medium	Medium	High	High

We use different technological architectures to design different subsystems based on their different technological features.

4.2.2. Member end System

A. Multi-layer Structure of System

The SIF system on member end is based on MVC structure. We design 5 layers structure based on the business requirements of the member end, as shown in Fig. 5.

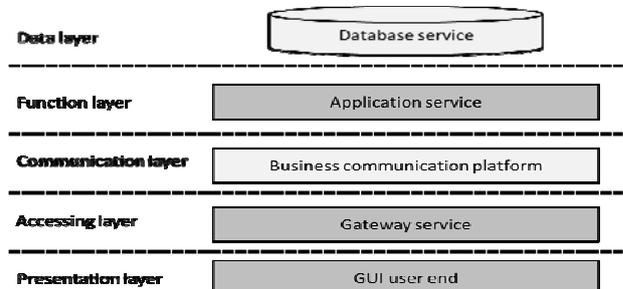


Figure 5. System architecture

The concrete framework of the SIF transaction support system on the member end, based on the 5 layers architecture is shown in Fig. 6:

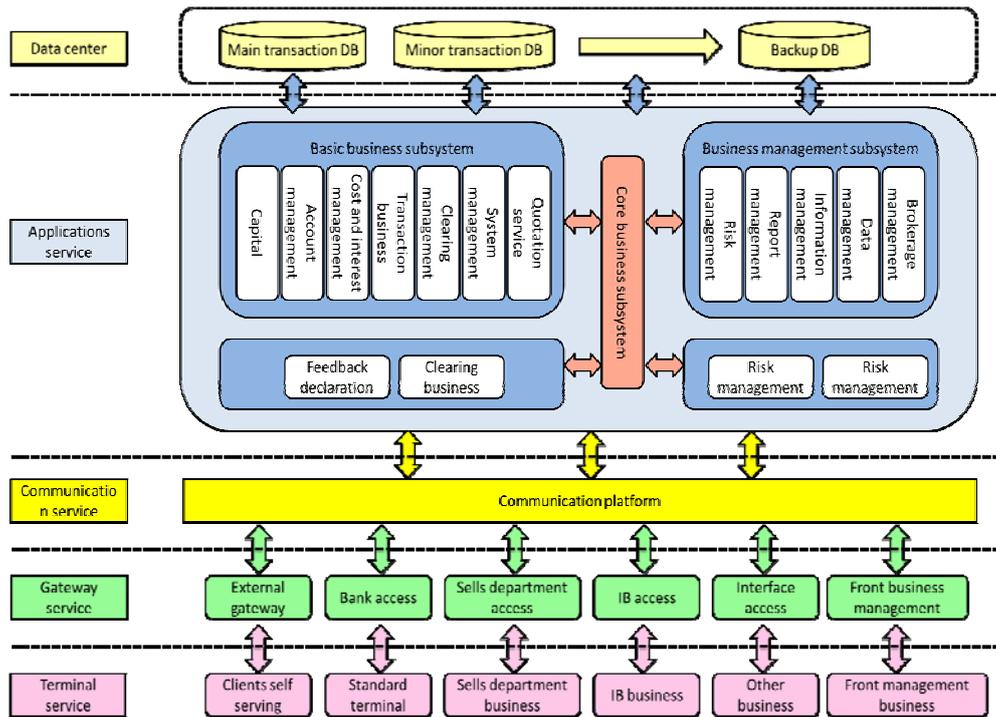


Figure6. Architecture of member end system

4.3. Design of System’s Functions

4.3.1. System on Exchange Station End

The basic data system includes the following subsystem: member management, internal management and system maintenance. The basic business system includes transaction, transaction management, clearing, delivery subsystems, which are all basic services provided to members and clients. The external business system includes statistical inquiry, quotation data, risk monitoring, and other subsystems, where process data are on the basis of business system and provide more advanced analysis and value added services.

4.3.2. System on Member End

System on member end can be separated into core subsystem, basic business subsystem, auxiliary services subsystem and external business subsystem.

Core subsystem contains customer management, institution management, and system maintenance. Basic business subsystem includes transaction business, risk control, and capital management. Every business subsystem is based on the core subsystem, but they are all independent with each other. This layer will be expanded to other financial derivatives’ business. The clearing subsystem is used to finish the process of delivery and accounting of SIF capital and holding position. On the one hand, clearing system is separated from its corresponding business system; on the other hand, different clearing systems are aimed at different independent business. This subsystem is used to satisfy the requirements from business processing and daily maintenance, including internal management subsystem, risk management subsystem, offering subsystem, bank

subsystem, marketing (agent) subsystem, declaration subsystem, etc.

The member end systems that support the commodity futures business are all operated in futures companies, whose scales and technical investments are limited and hardware devices, communication networks and technology management are relatively backward. Because the high technological requirements of SIF, a new theory of “transaction trusteeship” mechanism is proposed. SIF trusteeship means that the “SIF trusteeship center” that provides sites and transaction connection routes. Futures brokerage firms rent devices from the center (they can also buy devices themselves based on related regulations) and build communication with the “SIF trusteeship center” and then install their transaction system on the rented servers. Members can use local or remote operation to finish capital management, customer management, money transferring, etc., with the support of counter software.

Transaction trusteeship has the advantages like saving members’ investment (resource sharing), professional service management, high speed trusteeship service, high level trusteeship center, complete trusteeship system, etc.

V. KEY TECHNOLOGIES

Based on SIF business’ features, the system’s performance and high availability are the most important requirements for the transaction system. Here we focus on the main technologies as shown in Fig. 7 including futures exchange memory database (FEMDB), futures exchange information bus (FIB) and principle and subordinate fault-tolerant mechanism and try to find an efficient solution that can be applied to real business environment.

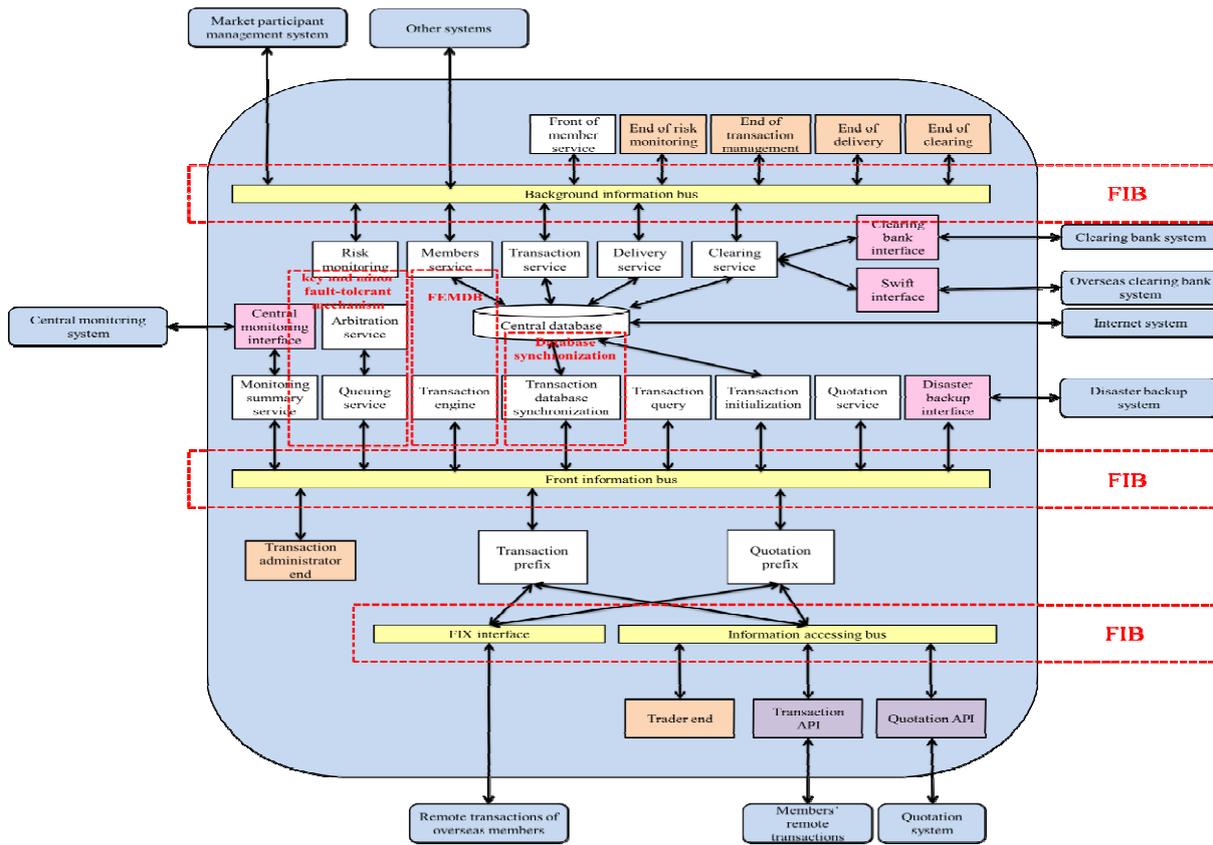


Figure 7. Application of FIB, FEMDB and fault-tolerant mechanism in the SIF transaction support system

5.1. FEMDB

5.1.1. Memory Database

Memory database stores data in the physical memory in order to achieve high access speed and concurrent access ability. We design an object oriented futures exchange memory database (FEMDM) to satisfy system's requirement that supports data table, index, foreign key, transaction process and trigger. All the core data (includes declarations, bargain information, etc.) generated from business transactions will not be stored in the hard disk memory, but in the memory database. Besides, the system also contains a mechanism of synchronization between memory database and real database, which includes the input of initial daily data, data's bidirectional and dynamical synchronization in the middle of the day, etc. Those mechanisms help to achieve data operations that are similar with those in the real database but still keep high speed of processing in the memory database.

5.1.2. Transaction Engine

Transaction engine is the key part of the whole system. Transaction engine is responsible for the verification and matching of declarations and generate bargains.

The structure of the transaction engine contains the following parts, shows in Fig. 8. It includes memory database, match engine, regulation engine, and communication module.

The memory database stores transaction data, including all the required and generated data in the whole transaction process. The memory database realizes the transaction processing mechanism and guarantees the security and stability of the transaction mechanism. The high performance of the system is on the basis of memory database. Match engine matches the declarations and the matching is based on the principle of price and time priority. Regulation engine stores the transaction rules including client holding position rule, member holding position rule, margin rule, etc.

Communication module controls the interaction between the transaction engine and the outside.

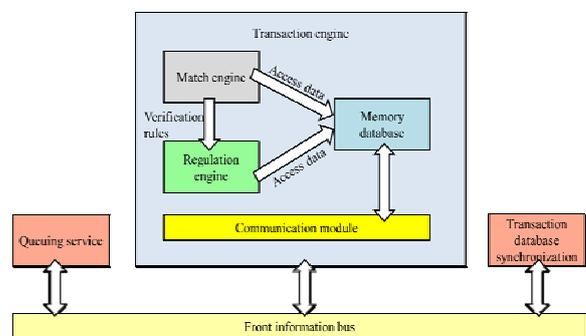


Figure 8. Structure of the transaction engine

5.2. FIB

Information bus is the collection of information passages (also named queues or subjects) and the common configuration is the request-reply passage pair. Each pair of passage represents an available service. The

request side puts the request into the requests queue and listens to the reply in the reply queue asynchronously.

We design a communication middleware between different procedures based on the information bus to achieve high performance and stability in the transaction process, named futures exchange information bus (FIB for short), which provides a simple, consistent, flexible environment for distributed business processing communications. Application modules can communicate with each other through FIB with high speed, reliability and security. These procedures belong to single computer, LAN or WAN.

The design principle of FIB is that each application module can communicate with one another through standard interfaces. With FIB, the front-ends and terminals of different application modules can connect with the information bus to expand the system.

5.2.1. Structure of FIB

The FIB contains two parts including FIB Router and FIB Terminal, as shown in Fig. 9.

FIB Router is an independent information router procedure, which provides reliable publish/subscribe communication model and request/reply communication model. Multiple FIB Routers can operate simultaneously to form a FIB Router Cloud, which can improve the system’s reliability, performance and access capability.

FIB Terminal API is a group of C++ programming interfaces that interact with FIB Router. FIB Terminal is an application which uses the FIB Terminal API and it’s also a procedure.

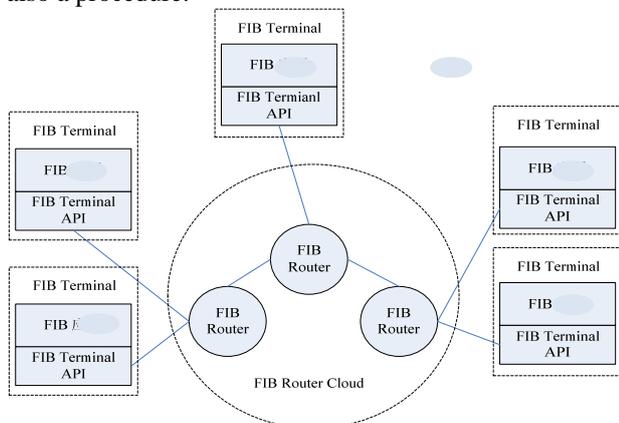


Figure 9. Structure of FIB

5.2.2. Special Design of FIB

We give some special designs to the FIB to meet the requirements of transaction system:

- a. Dynamical information router
- b. Supports publish/subscribe communication model
- c. Supports request/reply communication model
- d. High fault-tolerate capacity
- e. High security
- f. Open and standard interface

(1) Dynamical information router

The disadvantage of traditional information bus is that it is not self-described and users are not easy to find the most proper passage. With FIB Router, every message can find the best transferring route and deliver the

message to its destiny efficiently. The key mechanism of FIB Router is that the router stores a routing table contain all kinds of transferring routes for choosing.

The dynamic routing table is the table that will be modified by the FIB Router based on the network condition automatically. The FIB Router can learn and memorize the operating condition of the network and calculate the best transferring route if necessary.

The routing table is generated based on the link-state routing protocol. The FIB Router collects information from its connected FIB Router and FIB Terminal. FIB Router exchanges its own saved network linking information with adjacent FIB Routers in order to grasp the whole network topology and calculates routes independently.

(2) Publish/subscribe model

Publish/subscribe model is a model of transfer message asynchronously. The message queue can be seen as the medium of transferring. The publisher publishes the message to the subject and the subscriber subscribes message from the subject. The message queue keeps publisher and subscriber independent from each other and the messages can be transferred without contact.

FIB provides a reliable publish/subscribe model, in which messages can be received by subscriber consequently even when the subscriber is off line.

(3) Request/reply model

Request/reply model is another common communication model. Client generates a request and sends it to the server, who will process the request and send the processing result back to client.

Service is an independent unit which provides specific business functions to the outside. One application can provide one or more service. Every service has a service port used to identify from each other.

(4) High security

FIB has many methods to improve security. It adopts end to end encryption, which is supported in data exchange between any two nodes in the network. Using asymmetric (public) key algorithm to exchange keys, symmetric encryption algorithm is used to encrypt data. Sequence number and check code protection protocol protect the system against attacks by timestamp. For each method, the verification can be completed by asymmetric or symmetric encryption algorithm.

Besides, the FIB controls the access authority of each node, which controls the granted operations of each node.

(5) Open and standard interface

A communication platform with open structure is important to satisfy market’s requirement of innovation and expand existing system flexibly. Through the FIB bus, every front or terminal of application module can achieve the expansion of “plug and play”. Such a structure guarantees the system’s modularization, openness and easy scalability.

5.3. Fault-tolerant Mechanism

As the transaction system has to continuously working and trouble-free, the system’s availability should be high. Some key components such as the queuing service must provide sequence service, which makes it difficult to

adopt the cluster mechanism, so the special fault tolerance mechanisms should be designed to guarantee the system's availability.

We design three kinds of fault tolerance mechanisms to meet the expected target:

- a. Principle and subordinate fault tolerance mechanism
- b. Dual-computer hot backup mechanism
- c. Multi-computer cluster mechanism

We will take a deep look at the fault tolerance mechanism in some key components including FIB, queuing system, transaction engine and front-end system.

5.3.1 Fault Tolerance of FIB

FIB Cloud is the information bus of the transaction system and its connectivity should be guaranteed. No cut vertex appears in the topology of FIB Cloud and the cut vertex must be the single point of failure of the information bus, as shown in Fig. 10. In this model, if a FIB Router fails, only its adjacent FIB Clients will be affected and other nodes can keep communicating.

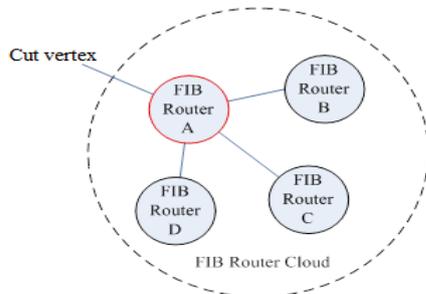


Figure 10. FIB Cloud with cut vertex. If IB Router A fails, communication in the information bus will stop.

5.3.2 Fault Tolerance of Queuing System

The main task of queuing system is to serialize transaction requests and publish the transaction sequence as the basis for transaction core to process data. The queuing service will be categorized into two procedures: principle service and subordinate service. The principle service will queue transaction requests and release them after the verification of subordinate service. When principle service breaks down, its job will be taken over by subordinate service. The switching between principle service and subordinate service is determined by the arbitration service.

Messages' reliable and sequential transmission is the basis of business fault tolerance in transaction system. Messages' perfect ordered transmission is guaranteed by the mechanism that the queuing system provides global clock signals and gives global timestamps to messages from different sources. Message's duplication and loss can be checked by the serial number mechanism in the message source and those retransmitted messages will be buffered in order to achieve message forwarding. The queuing system adopts the Dual-computer hot backup mechanism to avoid single point of failure.

5.3.3 Fault Tolerance of Transaction Engine

The fault tolerance in transaction engine is realized by the parallel working of dual or multiple computers. Two or more transaction engines can be deployed in the

transaction system and those engines will be synchronized by the fault-tolerant communication platform. Any transaction engine's failure won't affect the transition process, as shown in Fig. 11.

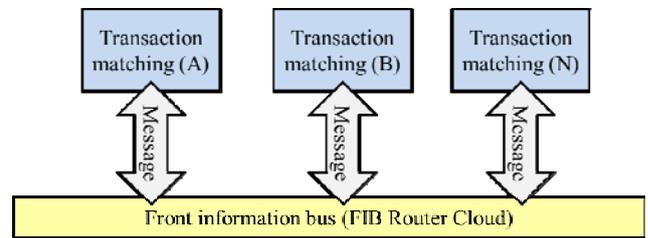


Figure 11. Fault tolerance of transaction engine

We don't have to consider the fault tolerance mechanism during the development period with the same working state of multiple transaction engines and what we are care about is the achievement of business functions, which improves the reliability and extension ability of business achievements.

The sequence of transaction processing in every transaction engine should be unified in order to achieve the same working state. The queuing system can provides the same transaction sequence.

If all the transaction engines break down simultaneously, the pre-fault state should be recovered after repairing and restarting to avoid the following transactions can be processed.

5.3.4 Fault Tolerance of Front-end System

The fault tolerance in front-end system adopts multi-computer cluster mechanism. Multiple front-end systems can be deployed in the transaction system and those front-end systems contain the same data with the help of FIB and queuing system. If one front-end system fails, with which members are connected will switch to other normal front-ends and continuously working. As shown in Fig. 12.

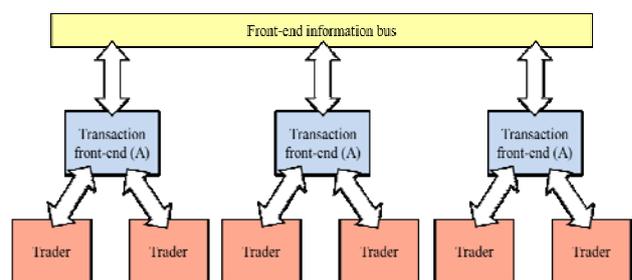


Figure 12. Fault tolerance in front-end system

When front-end system breaks down, restarting will happens right after repairing and appropriate redundancy will be maintained.

VI. DISCUSSION AND CONCLUSION

This paper focus on SIF transaction model and its business support system. On the business process level, the overall concept and framework are put forward. On the technology level, the key components of the system, including the construction of platform, application

software, are studied and the initial test of the result through simulation of the transaction system.

However, because of the complexity of stock index futures transaction model, the construction of its business support system is a large engineering. With the continuous growing of SIF business, the transaction process will be improved. Future's searches and studies will focus on two aspects, the business model aspect and technology aspect. From the business model aspect, operation rules have to be unveiled because of the huge difference in the key processes like clearing and risk control between SIF transaction and traditional commodity transaction. As for the technology aspect, the future research will be the improvement on the technology of memory database, the process of futures exchange information bus and other key technologies to establish a perfect and unified transaction system. Besides, the academic research results still need to be testified in real business environment.

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