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The X-DBaaS-Based Stock Trading System to Overcome Low Latency in Cloud Environment

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Abstract

In the latest stock systems, a variety of technologies have been introduced to minimize low latency and accelerate data processing, and a massive amount of stock information has become interoperable. Only with the support of expensive network equipment, however, it is limited to increase the speed. Besides, it is not very effective to induce such equipment. Also, such stock information is hard to be shared in cloud environment for many reasons due to the heterogeneity of metadata. This makes it harder to optimize the proper time of data among stock trading systems as well. This study is going to suggest a stock trading system using X-DBaaS (XMDR-Database as a Service) in cloud environment. The suggested system applies SPT (Safe Proper Time) which can satisfy the proper time of data transmission and also minimize the CPI (Cycle Per Instruction) in order to reduce the CPU overhead based on the understanding of kernels. Moreover, XMDR-DAI is utilized to solve the heterogeneity issues among metadata and schemata taking place in the interoperation of information among stock systems.

Keywords: *X-DBaaS-based, stock trading system, clouding*

1. Introduction

Nowadays many stock companies receive market price information from stock exchanges in cloud environment by using many kinds of equipment and then provide it to their users. That communication equipment used in cloud environment is highly influenced by the conditions of network circuits. Sometimes, this makes investors miss a right moment of trading due to the delay of trading or of market price information transmitted from stock exchanges, which affects their profit creation significantly. Also, to minimize information delay, stock companies invest much time and money for improving network environment in the section between stock companies and stock exchanges; however, they are facing limitations due to the physical restrictions present in increasing the speed. What stock companies intend to increase the speed for are HTS [1-2] and FEP (Front End Process) [3] inside stock companies. They are willing to induce expensive equipment (TOE (TCP/IP Offload Engine) [4,7], SDP (Socket Direct Protocol) [5]) to provide the fastest services to their investors, but in fact, its cost efficiency is rather low. Accordingly, this study is going to understand the characteristics of stock systems to solve the problems of low latency and also suggest a problem-solving mechanism from a viewpoint of software to overcome the limitations of low latency from a standpoint of hardware. Also, to satisfy the proper time of data, SPT (Safe Proper Time) is used for the optimal transmission rate and reliability. SPT is a way to improve the proper time and reliability of transmission in accordance with increase in the size of stock data, and it secures the transmission rate of a stock trading system. Also, this study is to suggest a stock trading system using X-DBaaS that can solve

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the problem of heterogeneity in metadata which takes place in the process of interoperating information during stock trading. It uses XMDR to solve various problems of heterogeneity that take place in the interoperability of massive data among stock trading systems in cloud environment. This study consists of six chapters. Chapter 2 reviews advanced research, and Chapter 3 describes the composition of the suggested system. Chapter 3 explains the stock schema-based XMDR, and Chapter 4 describes the SPT (Safe Proper Time) mechanism. Chapter 5 presents comparative analysis. Lastly, Chapter 6 provides conclusions and suggestions for follow-up research.

2. Literature Review

First, let's look into how stock systems transmit massive data. Generally, data are transmitted from a user's terminal. Through a stock application program, a stock company's system receives data transmitted to a stock exchange. Data go through a network and then are sent to a user's terminal system. This is the structure of data processing [6]. This data processing provides identical environment to all stock companies in cloud environment, and they come to order through the network. After the order is placed through HTS of a stock company, the information is supposed to be sent to the system in the stock exchange through FEP, a stock company's channel exclusive for external use. Particularly about the orders placed in the stock exchange's system, data packets are arranged by order of arrival. Therefore, after it is decided whether the trading is concluded or not, the result is delivered to each of the stock companies. After receiving the result from the FEP system, the stock company sends it to HTS, and the result is sent to the user through the network. This is how the ordering process is done.

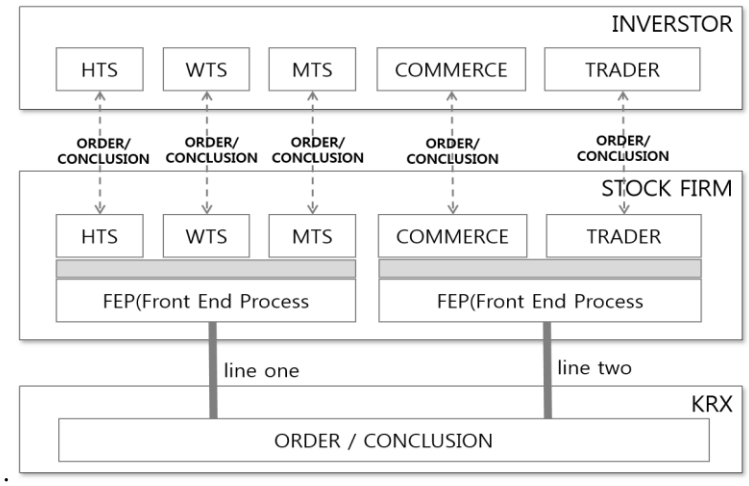

Figure 1. The Environment of the Stock System

Figure 1 shows the section where ordering/concluding data are sent between the investor's HTS and the stock company's HTS. Regarding the transmission rate of ordering/concluding data, this section cannot provide any service for trading rate improvement by any means. To increase the service speed of the section in the FEP system in a stock company's HTS (Home Trading System), many stock companies induce RDMA (Remote Direct Memory Access)-based low latency technology like SDP, TOE, iWARP [8], or Infiniband; however, they are facing the limitations of speed improvement in the area of hardware, too. It is mainly because they cannot overcome the limitations of physical accessibility. The limitations of the section to improve the physical speed show us the limitations of speed improvement in the section from the stock company's internal system up to the stock exchange receiving data after ordering/concluding data are received through

an internet network. For this, stock companies try to induce and apply RDMA-related technology internally; however, it is true that the expensive equipment has low cost efficiency.

3. The Stock Trading System Using X-DBaaS

The diagram of the system suggested in this study is presented in Figure 2. It employs XMDR for stock information data transmitted by stock exchanges in cloud environment and supports interoperability among the systems. This solves the problems of metadata's heterogeneity that takes places in processing data transmitted between stock exchanges and stock trading systems. To improve transmission rate, with the data sent through XMDR, orders are checked through HTS, WTS, and MTS from the time market price is received, and then, SPT is utilized to overcome the low delay of transmission rate in the section that the order is placed through FEP and the response is gained for conclusion.

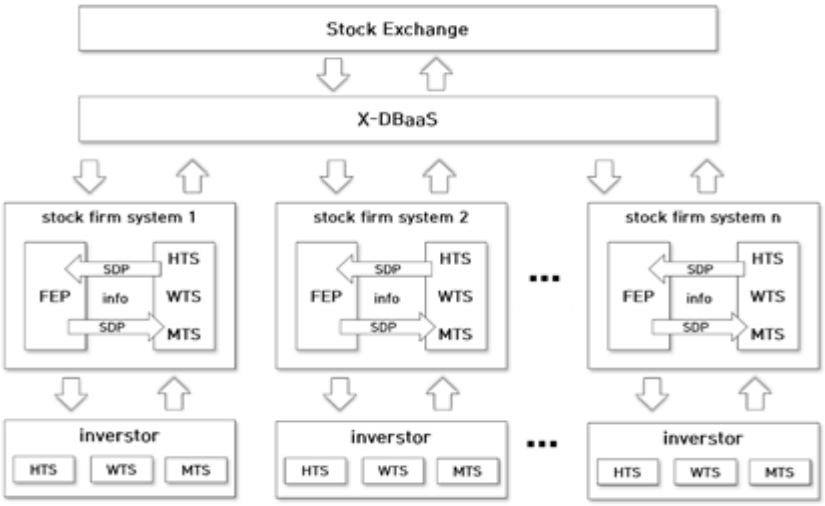

Figure 2. The X-DBaaS-Based Stock Trading System

4. Stock Scheme-Based XMDR

This study uses XMDR to support interoperability in processing data transmitted by stock exchanges in cloud environment Figure 3. The definitions and elements are as shown below:

① Meta-Semantic Ontology (MSO): MSO makes the schema information of local database metadata in a stock trading system into a thesaurus. This has been defined to do mapping of stock-related metadata schemas designated as a standard and increase relevance among data and solve the problem of collisions resulted from heterogeneity. Also, MSO is information needed for mapping to convert global metadata schemas as a standard of schemas into local metadata schemas.

② Meta-Location (MLoc): MLoc registers the physical location of a stock trading system's local database and information about right to access, and so on in connection with MSO. This has been defined to deliver stock trading process messages to proper locations in data transfer and transaction processes needed for interoperability during data access and integration.

③ Instance-Semantic Ontology (InSo): InSo does mapping of association information among instance values, the actual stock data, and makes it into a thesaurus. It has been defined in consideration of meaningfulness, similarity, and effectiveness among instance values. In other words, it has been defined by classifying the information of heterogeneous collisions between units or formats (ex: \ -> $, mm/dd/yy -> yy-mm-dd).

④ MetaData Registry (MDR): MDR registers and manages the individual schemas of local database metadata in a stock trading system. MDR is composed of global schema area and local schema area.

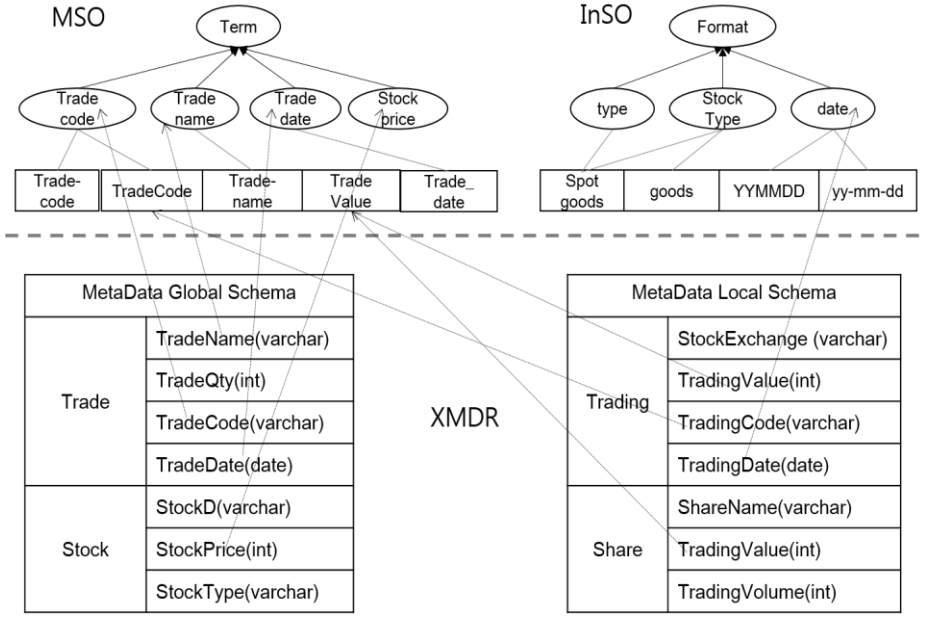

Figure 3. The Stock Information-Based XMDR-DAI Model

Global Schema: Global schemas consist of the standard schemas of local schemas in each of the stock trading systems and organize them appropriately for the cooperation of stock trading processes.

Local Schema: Local schemas register the schemas of a local database in a stock trading system participating in the cooperation of stock trading processes.

The elements of XMDR defined above are based on the list of data attributes described in ISO/IEC 11179-3. The basic attributes of data include identify attributes, define attributes, associate attributes, and presentation attributes, and the details are defined as below:

- Identify attribute: Attributes for identifying data elements
- Define attribute: Attributes with the meanings of data elements
- Presentation attribute: Attributes for the presentation of data elements

5. The SPT (Safe Proper Time) Mechanism

This study selects SPT as a transmission method according to the data size of stock information so that an optimal transmission method for data transmission is selectively processed. Generally, the sequence transmission method is preferred to prevent the block state that may occur in processing data. When the data size is small as less than 100 bytes, this method consumes only tens of micro-seconds for data processing. But as the data size increases, the frequency of using the CPU increases rapidly, and accordingly, the rate delay of data transmission increases, too. The method to transmit data with a lower frequency of using the CPU is batch processing transmission. This method processes data all at once when the data size reaches a certain point, which lowers the frequency of using the CPU; however, as the amount of its kernel buffer determines the state of transmission, in the block state, it shows low reliability in data transmission.

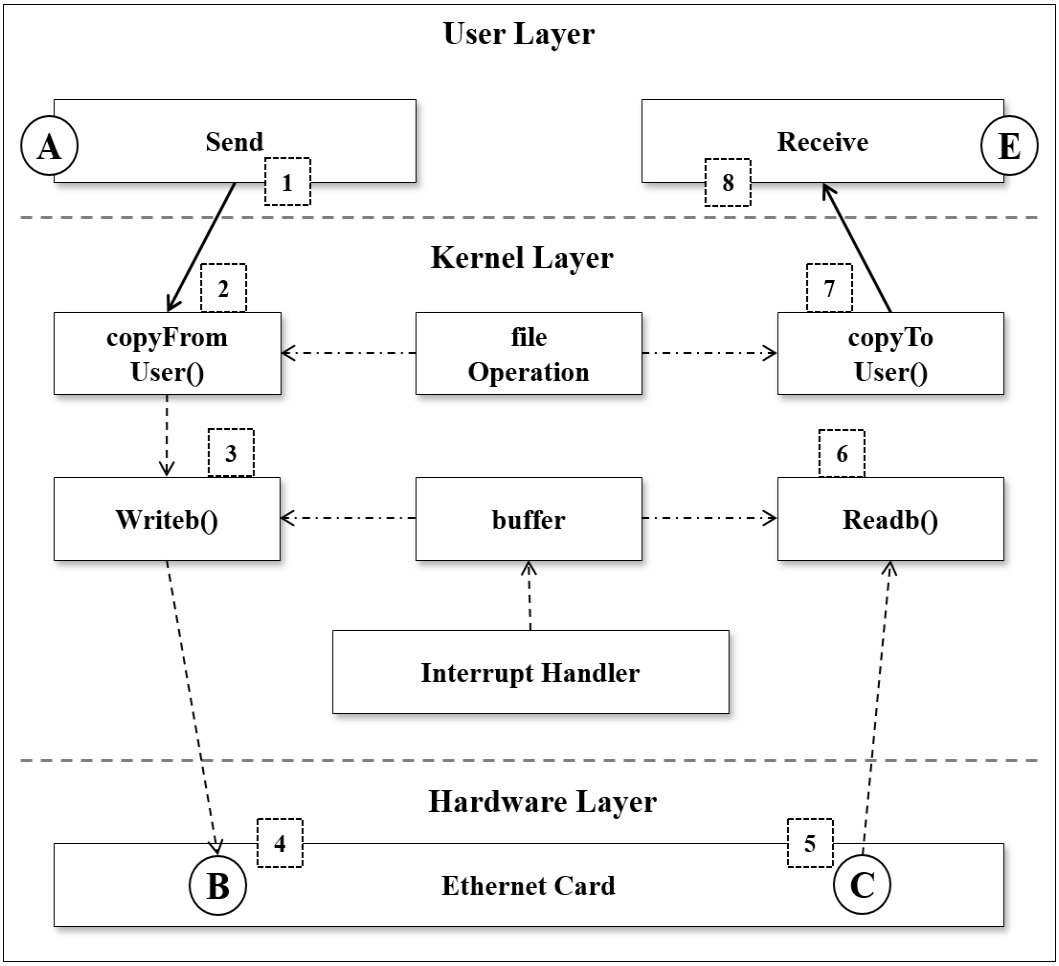

Figure 4. The Concept Map Showing the Flow of Data in the User Layer and Kernel Layer

Figure 4 conceptualizes the flow of the process to send and receive data in the section of the kernel stratum in the user area. This concept map illustrates that the batch processing method performs 1-cycle processing while the sequence method does it repeatedly according to the data size.

SPT does not apply the aspects of transmission for massive stock information data but performs its processing variably according to the data size; therefore, even when massive data are entered, it guarantees the optimal rate. Concerning the characteristics of a stock ordering system, what should be guaranteed first is the proper timing of data processing. As shown in Figure 5, in the process of SPT, the data transmission broker calculates the optimal transmission size of data, and according to the optimized size of data, when the data size are smaller than the optimal transmission size of data, the sequence method is chosen, and when it is larger than the optimized data size, the batch processing method comes to be selected. After then, the accumulated average rate of data processing is calculated, which selects the next data processing method adaptively

```
Algorithm: Convergence(sequence/batch)  Processing
Input: stock data
Ouput: stock contract data
Begin
    Convergence transfer start {
       var dataTrans:  //send data
       …
       transfer(dataTrans) // send start
            resSEQ = seqProc(dataTrans); // sequence processing
            resBAT = batProc(dataTrans); // batch processing

            IF runtime(resSEQ ? resBAT) THEN  //excute time/choice method
               optimumMethod (resSEQ / resBAT); //excute
            END If;
        …
   }
End
```

Figure 5. The SPT-Based Process

6. Comparison and Analysis

This study has comparatively analyzed the performances to overcome the low latency of data transmission on the stock conclusion system in cloud environment applying the SPT mechanism. Table 1 presents how the general transmission of stock/conclusion data is different from the SPT transmission suggested in this paper.

Table 1. Differences between General Transmission and SPT Transmission of Data

Division	Sending/receiving 100 bytes	Efficiency rate
General transmission	Sending (User: 100, Kernel: 200) Receiving (User: 100, Kernel: 200) Total: 600 times of repetition	N = the frequency of system calls, General rate: (6/600)*100=0.99%
Suggested transmission (SPT)	Sending (User: 1, Kernel: 2) Receiving (User: 1, Kernel: 2) Total: 6 times of repetition	SPT rate: (600/606)*100=99.00%

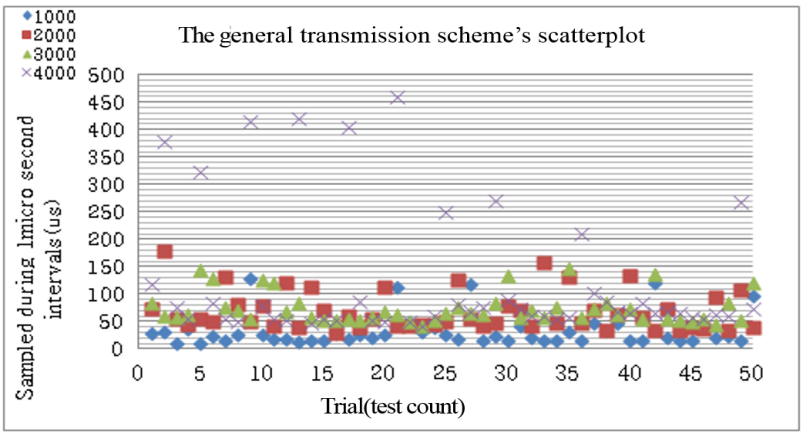

Figure 6. The General Transmission Scheme's Scatterplot

Figure 6 shows the general transmission scheme's scatterplot to process data according to the file size. Transmitting 1,000, 2,000, 3,000, and 4,000 bytes, this researcher measured the time. According to the result, as the data size gets larger, the proper time to process data becomes lower. In 4,000 bytes, it takes from 80 up to 450 microseconds. Even though the data size is the same, the time to process the data differs considerably. This means it cannot guarantee the proper time of transmission.

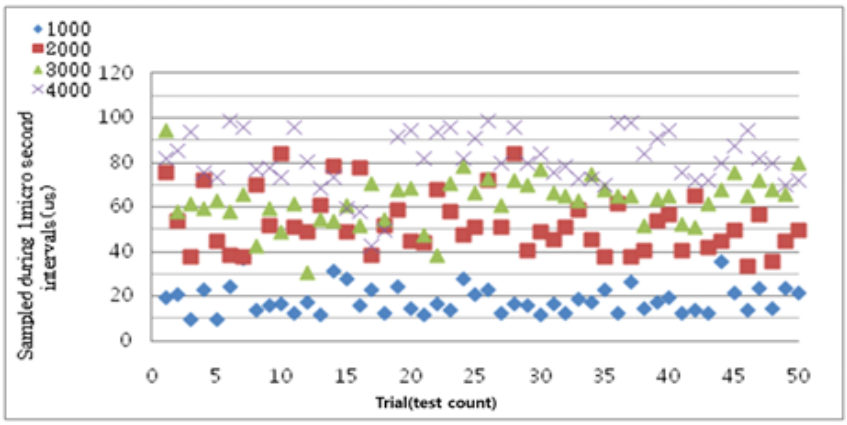

Figure 7. The SPT Transmission Scheme's Scatterplot

Figure 7 shows the SPT (Safe Proper Time) transmission scheme's scatterplot to process data according to the file size. Transmitting 1,000, 2,000, 3,000, and 4,000 bytes, this researcher measured the time. According to the result, as the data size gets larger, the proper time to process data can be guaranteed. In 4,000 bytes, it takes from 60 up to 100 microseconds. This means that it takes relatively less time to process data of the same size.

Figure 8 shows that as the data size increases, the SPT (Safe Proper Time) scheme is more efficient than the general one. In general transmission, it takes up to 121.2 microseconds to process 4,000 bytes. But in SPT transmission, it takes only 81.24 microseconds at the maximum. The time to process data differs significantly between them. When calculated by percentage, 1,000 bytes indicated 63.90%, 2,000 bytes 56.17%, 3,000 bytes 53.98%, and 4,000 bytes 59.87%. With this result, we can conclude that the SPT scheme's appropriate transmission size is 1,000 bytes.

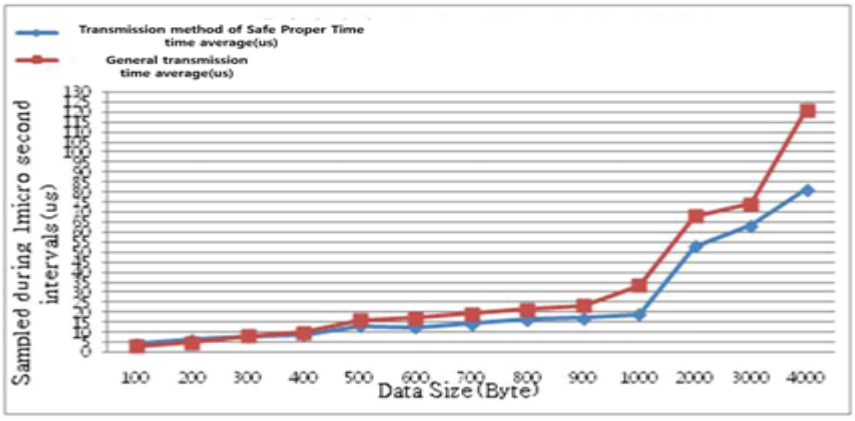

Figure 8. Comparison on Data Processing between General/SPT Transmission

7. Conclusions

This study suggests the stock trading system using X-DBaaS to solve the problem of metadata's heterogeneity that takes place in the process of interoperating information in stock trading. Also, it suggests SPT to realize the optimal transmission rate and proper timing of data. With it, this study has solved the problem of low interoperability among massive stock-related data resulted from the diversification of users' contacting points in cloud environment and also settled down one of the latest problems of transmission delay of market price information being received from stock exchanges. This author has realized the necessity to improve a stock company's internal system so that it can secure the proper time of trading, one of the characteristics of a stock trading system, and have better performances as a stock system. To accelerate the data processing of the internet network characterized as cloud environment, we need more than just replacing equipment in the aspects of hardware. Only with this, we cannot guarantee differentiated rate any longer. This is why this researcher has examined how to improve the rate in the aspects of software. After finding out the problem of low latency in general transmission we have used, this author has tried to improve it effectively. Adopting Safe Proper Time [1] transmission equipped with proper time and high data transmission rate, this researcher conducted an experiment. As a result, data transmission rate improved 64% in 1,000 bytes and over 57% in 2,000 bytes. This means that it can guarantee high trading conclusion rate, one of the characteristics of a stock trading system, as well as high profit rate from trading. Follow-up research will have to calculate the maximum transmission bandwidth according to the environment of network composition and devise ways to process data produced with that at a high late. In order to solve security problems in cloud environment, it is needed to study data transmission delay that might take place while data packets are encoded, analyze problems resulted from data encoding and find solutions for them, and also investigate how to minimize encoding packet delay afterwards.

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