# Objectives

To implement a program which flows the approval requests from the ApprovalSource to the ApprovalDecisionService and then pass every returned ApprovalResponse on to the ApprovalResponseService as efficient as possible. There will be a large number of requests arriving at the ApprovalSource and they should be returned as quickly as possible to the ApprovalResponseService.

# Assumptions

1. Using ApprovalSource.getApprovalBatch () to get multiple requests is more efficient than getting one by one through separate getNextApproval(). It makes sense because generally single call should be more efficient than multiple separate calls. In this assignment, getApprovalBatch() is preferred if there are multiple items on the source.
2. Once the program gets any approval request(s) (either single or a batch) it will pass to the decision service as early as possible before getting other approval request(s).
3. The average processing time per response when calling ApprovalRespponseService.sendResponses(List<ApprovalResponse>) is less than ApprovalRespponseService.sendResponse(ApprovalResponse). In this case the program will group multiple approval responses in a single batch and then invoke sendResponses(responses), given that the approval responses are already available and without waiting.
4. Transaction number field is added to approval request. The main purpose is keep track of the request and response processing status in the output log.
5. java.util.logging is used in the program, although log4j has higher performance the Java Util log.
6. In order to simulate the real processing, I add extra delays on the Decision Service and Response Service

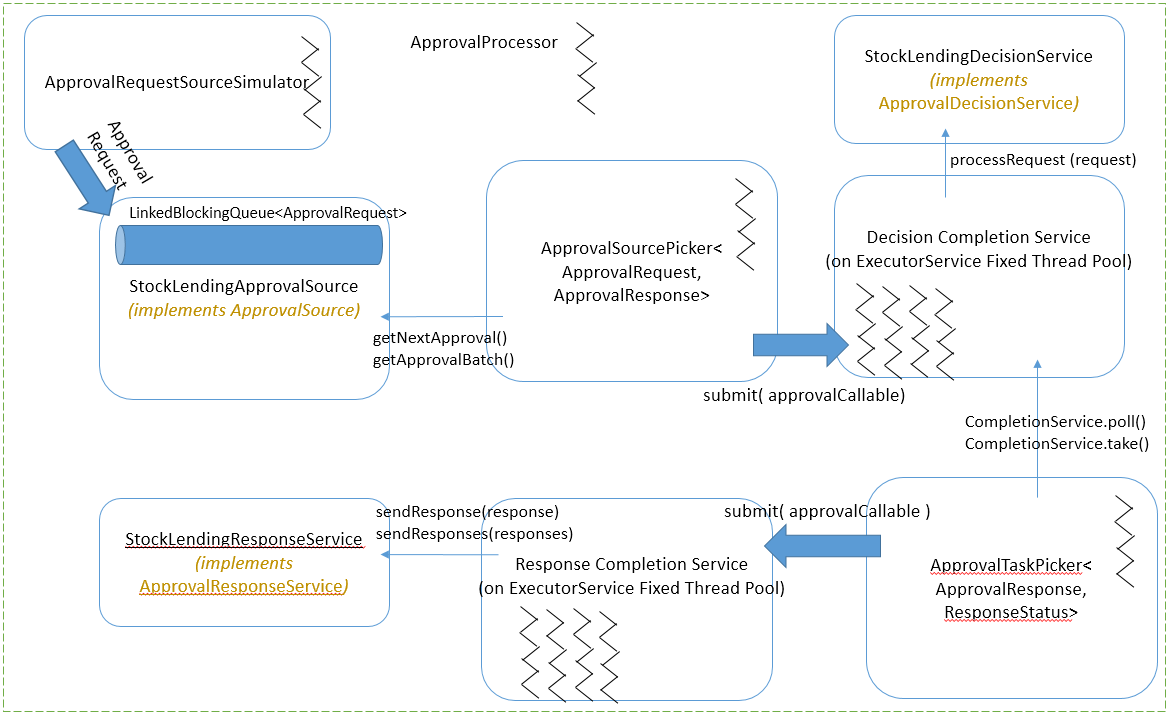
|  |  |
| --- | --- |
| ApprovalDecisionService processRequest(ApprovalRequest request) | (10+(long)(Math.random()\*10)) ms |
| ApprovalResponseService  sendResponse(ApprovalResponse response) | (15+(long)(Math.random() \* 10)) ms |
| ApprovalResponseService  sendResponses(List<ApprovalResponse> responses) | (12\*size of responses+(long)(Math.random() \* 20)) ms |

1. The program is a multi-thread programs (See below figure)

|  |  |
| --- | --- |
| Components | Number of threads used |
| Main thread ( Approval Processor) | 1 |
| ApprovalSourcePicker | 1 |
| Decision Completion Service | 4 |
| ApprovalTaskPicker | 1 |
| Response Completion Service | 4 |

1. The simulator is generating at a rate of 100 requests/second. To simulate a higher throughput, user can changes to a higher value. If the approval requests rate is low compared to the processing power of the running platform, ApprovalResponseService.sendResponses(responses) may not be invoked.
2. To stop the simulator, please type letter x and ENTER on the console. All the threads and executor services will shut down gracefully.

# High Level Approval Flow



1. Approval Requests are generated from the ApprovalRequestSourceSimulator. The new approval requests are put in the StockLeingApprovalSource’s LinkedBlockingQueue.
2. ApprovalSourcePicker runs on a separate thread will keep getting the approval requests from StockLeingApprovalSource. Once it gets any approval request(s), it will submit the callable to decision completion service which in turns call processRequest(request) on the thread pool.
3. Similarly ApprovalTaskPicker runs on a separate thread will keep getting the approval response from decision completion service. Once it gets any approval response, it will submit the callable to response completion service which in turns call sendResponse(response) or sendResponses(responses) on the thread pool.

# Summary of Classes Descriptions

Below are the summary of classes. Please check the sources for detail comments.

|  |  |
| --- | --- |
| Class Name |  |
| AbstractApprovalServiceFactory | AbstractApprovalServiceFactory is an abstract class to get factories for  ApprovalDecisionService and ApprovalResponseService |
| ApprovalCallable<T,R> | ApprovalCallable is a class implements the Callable interface which  override the Callable's call() method   1. takes an object (type T) as an input 2. invokes the Function<T, R> 3. and returns the result object (type R) |
| ApprovalCode | Approval code is the approval response status from Approval Decision Service |
| ApprovalDecisionService | Interface that takes the approval requests and return approval response |
| ApprovalDecisionServiceFactory | ApprovalDecisionServiceFactory is the factory to instantiate concrete class that implements AbstractApprovalService |
| ApprovalExercise | The ApprovalExercise is the main class to get started the approval processing flow. |
| ApprovalProcessor | Class ApprovalProcessor that takes instances of the interfaces (ApprovalSource, ApprovalDecisionService and ApprovalResponseService).  ApprovalProcessor controls the flow of approval request taken from the ApprovalSource, passing to ApprovalDecisionService which will return an ApprovalResponse, and finally every ApprovalResponse must be passed on to the ApprovalResponseService |
| ApprovalRequest | Approval Request is a security lending request. It consists of client, security and security quantity information. |
| ApprovalRequestSourceSimulator | ApprovalRequestSourceSimulator is a simulator that generates a series of approval requests (which follows Poisson distribution) to the approval source. ApprovalRequestSourceSimulator is mainly used for simulation purpose in this assignment |
| ApprovalResponse | Approval Response is the response on the approval request after being processed by ApprovalDecisionService. The response is comprised of original request, approved quantity and approval response code. |
| ApprovalResponseService | ApprovalResponseService is to process the approval request coming from ApprovalDecisionService |
| ApprovalResponseServiceFactory | ApprovalResponseServiceFactory is the factory pattern to generate concrete class that implements ApprovalResponseService. In this assignment it will create an instance of StockLendingResponseService |
| ApprovalServiceFactory | ApprovalServiceFactory implements the abstract factory pattern to create the approval service factory. In this assignment, it will generate ApprovalDecisionServiceFactory and ApprovalResponseServiceFactory |
| ApprovalServiceType | Approval Service Type is type of abstract service factory |
| ApprovalSource | Approval Source provides the interfaces the get the approval requests |
| ApprovalSourceException | ApprovalSourceException is the runtime exception (unchecked exception) and indicates the exception occurred during process of getting approval request from the approval source. |
| ApprovalSourcePicker | The ApprovalSourcePicker implements the Runnable interface which   1. takes approval request from ApprovalSource interface 2. creates a ApprovalCallable which takes a Function<ApprovalRequest, ApprovalResponse> which applies approval processing function on an approval request and returns an approval response; 3. submits the ApprovalCallable to the 'sink' completion service and then executor executes the callable. |
| ApprovalTaskPicker<T,R> | The ApprovalTaskPicker implements the runnable interface which   1. takes source object (generic type T) from 'source' completion service 2. creates a ApprovalCallable takes a Function<> which applies   single or batch processing function on source object (generic type T or List<T>) and returns a result object (generic type R)   1. submits the ApprovalCallable to the 'sink' completion service and then executor executes the callable. |
| StockLendingApprovalSource | The StockLendingApprovalSource class is the class to implement ApprovalSource interface and provides implementation of interface methods getNextApproval() and getApprovalBatch(). |
| StockLendingDecisionService | The StockLendingDecisionService class is the class to implement ApprovalDecisionService interface and provides implementation of  Interface method processRequest(). |
| StockLendingResponseService | The StockLendingResponseService class is the class to implement ApprovalResponseService interface and provides implementation of interface methods sendResponse() and sendResponses().  Assumption: When sending responses in batch, the average processing time is less than sending individually. In my example, sending one approval response takes a minimum of 50 ms but sending multiple responses (at least 2) takes a minimum of 70 ms. |

Output log

May 28, 2017 10:06:40 PM com.morganstanley.stocklending.approval.StockLendingDecisionService processRequest

INFO: Decision Service Done: Approval Response: [ Approval Request #1795: { Client: JPM Security: HSBC00005 Quantity: 6500 } Approved Quantity: 6500 Status Code: APPROVED ]

May 28, 2017 10:06:40 PM com.morganstanley.stocklending.approval.StockLendingResponseService sendResponse

INFO: Single Approval Response Processing:

Approval Response: [ Approval Request #1795: { Client: JPM Security: HSBC00005 Quantity: 6500 } Approved Quantity: 6500 Status Code: APPROVED ]

May 28, 2017 10:06:40 PM com.morganstanley.stocklending.approval.StockLendingDecisionService processRequest

INFO: Decision Service Done: Approval Response: [ Approval Request #1796: { Client: GS Security: CCB00939 Quantity: 6500 } Approved Quantity: 4550 Status Code: APPROVED ]

May 28, 2017 10:06:40 PM com.morganstanley.stocklending.approval.StockLendingResponseService sendResponse

INFO: Single Approval Response Processing:

Approval Response: [ Approval Request #1796: { Client: GS Security: CCB00939 Quantity: 6500 } Approved Quantity: 4550 Status Code: APPROVED ]

May 28, 2017 10:06:40 PM com.morganstanley.stocklending.approval.StockLendingDecisionService processRequest

INFO: Decision Service Done: Approval Response: [ Approval Request #1798: { Client: GS Security: HKEX00388 Quantity: 6000 } Approved Quantity: 2700 Status Code: APPROVED ]

May 28, 2017 10:06:40 PM com.morganstanley.stocklending.approval.StockLendingDecisionService processRequest

INFO: Decision Service Done: Approval Response: [ Approval Request #1797: { Client: GS Security: TENCENT00700 Quantity: 2500 } Approved Quantity: 1500 Status Code: APPROVED ]

May 28, 2017 10:06:40 PM com.morganstanley.stocklending.approval.StockLendingResponseService sendResponse

INFO: Single Approval Response Processing:

Approval Response: [ Approval Request #1798: { Client: GS Security: HKEX00388 Quantity: 6000 } Approved Quantity: 2700 Status Code: APPROVED ]

May 28, 2017 10:06:40 PM com.morganstanley.stocklending.approval.StockLendingResponseService sendResponse

INFO: Single Approval Response Processing:

Approval Response: [ Approval Request #1797: { Client: GS Security: TENCENT00700 Quantity: 2500 } Approved Quantity: 1500 Status Code: APPROVED ]

May 28, 2017 10:06:40 PM com.morganstanley.stocklending.approval.StockLendingDecisionService processRequest

INFO: Decision Service Done: Approval Response: [ Approval Request #1800: { Client: CLSA Security: CCB00939 Quantity: 5000 } Approved Quantity: 3000 Status Code: APPROVED ]

May 28, 2017 10:06:40 PM com.morganstanley.stocklending.approval.StockLendingDecisionService processRequest

INFO: Decision Service Done: Approval Response: [ Approval Request #1799: { Client: JPM Security: HSBC00005 Quantity: 5500 } Approved Quantity: 5500 Status Code: APPROVED ]

May 28, 2017 10:06:40 PM com.morganstanley.stocklending.approval.StockLendingResponseService sendResponse

INFO: Batch Approval Response Processing:

Approval Response: [ Approval Request #1800: { Client: CLSA Security: CCB00939 Quantity: 5000 } Approved Quantity: 3000 Status Code: APPROVED ]

Approval Response: [ Approval Request #1799: { Client: JPM Security: HSBC00005 Quantity: 5500 } Approved Quantity: 5500 Status Code: APPROVED ]

May 28, 2017 10:06:40 PM com.morganstanley.stocklending.approval.StockLendingDecisionService processRequest

INFO: Decision Service Done: Approval Response: [ Approval Request #1801: { Client: UBS Security: CCB00939 Quantity: 6000 } Approved Quantity: 6000 Status Code: APPROVED ]

May 28, 2017 10:06:40 PM com.morganstanley.stocklending.approval.StockLendingResponseService sendResponse

INFO: Single Approval Response Processing:

Approval Response: [ Approval Request #1801: { Client: UBS Security: CCB00939 Quantity: 6000 } Approved Quantity: 6000 Status Code: APPROVED ]

May 28, 2017 10:06:41 PM com.morganstanley.stocklending.approval.StockLendingDecisionService processRequest

INFO: Decision Service Done: Approval Response: [ Approval Request #1802: { Client: CLSA Security: CCB00939 Quantity: 4000 } Approved Quantity: 2400 Status Code: APPROVED ]

May 28, 2017 10:06:41 PM com.morganstanley.stocklending.approval.StockLendingResponseService sendResponse

INFO: Single Approval Response Processing:

Approval Response: [ Approval Request #1802: { Client: CLSA Security: CCB00939 Quantity: 4000 } Approved Quantity: 2400 Status Code: APPROVED ]

May 28, 2017 10:06:41 PM com.morganstanley.stocklending.approval.StockLendingDecisionService processRequest

INFO: Decision Service Done: Approval Response: [ Approval Request #1803: { Client: UBS Security: HKEX00388 Quantity: 6500 } Approved Quantity: 0 Status Code: REJECTED ]

May 28, 2017 10:06:41 PM com.morganstanley.stocklending.approval.StockLendingResponseService sendResponse

INFO: Single Approval Response Processing:

Approval Response: [ Approval Request #1803: { Client: UBS Security: HKEX00388 Quantity: 6500 } Approved Quantity: 0 Status Code: REJECTED ]

May 28, 2017 10:06:41 PM com.morganstanley.stocklending.approval.StockLendingDecisionService processRequest

INFO: Decision Service Done: Approval Response: [ Approval Request #1804: { Client: GS Security: HKEX00388 Quantity: 3500 } Approved Quantity: 1575 Status Code: APPROVED ]

May 28, 2017 10:06:41 PM com.morganstanley.stocklending.approval.StockLendingResponseService sendResponse

INFO: Single Approval Response Processing:

Approval Response: [ Approval Request #1804: { Client: GS Security: HKEX00388 Quantity: 3500 } Approved Quantity: 1575 Status Code: APPROVED ]

May 28, 2017 10:06:41 PM com.morganstanley.stocklending.approval.StockLendingDecisionService processRequest

INFO: Decision Service Done: Approval Response: [ Approval Request #1806: { Client: CLSA Security: HKEX00388 Quantity: 6000 } Approved Quantity: 6000 Status Code: APPROVED ]

May 28, 2017 10:06:41 PM com.morganstanley.stocklending.approval.StockLendingResponseService sendResponse

INFO: Single Approval Response Processing:

Approval Response: [ Approval Request #1806: { Client: CLSA Security: HKEX00388 Quantity: 6000 } Approved Quantity: 6000 Status Code: APPROVED ]

May 28, 2017 10:06:41 PM com.morganstanley.stocklending.approval.StockLendingDecisionService processRequest

INFO: Decision Service Done: Approval Response: [ Approval Request #1805: { Client: CLSA Security: HKEX00388 Quantity: 3500 } Approved Quantity: 3500 Status Code: APPROVED ]

May 28, 2017 10:06:41 PM com.morganstanley.stocklending.approval.StockLendingResponseService sendResponse

INFO: Single Approval Response Processing:

Approval Response: [ Approval Request #1805: { Client: CLSA Security: HKEX00388 Quantity: 3500 } Approved Quantity: 3500 Status Code: APPROVED ]

May 28, 2017 10:06:41 PM com.morganstanley.stocklending.approval.StockLendingDecisionService processRequest

INFO: Decision Service Done: Approval Response: [ Approval Request #1807: { Client: CLSA Security: HKEX00388 Quantity: 4500 } Approved Quantity: 4500 Status Code: APPROVED ]

May 28, 2017 10:06:41 PM com.morganstanley.stocklending.approval.StockLendingResponseService sendResponse

INFO: Single Approval Response Processing:

Approval Response: [ Approval Request #1807: { Client: CLSA Security: HKEX00388 Quantity: 4500 } Approved Quantity: 4500 Status Code: APPROVED ]

May 28, 2017 10:06:41 PM com.morganstanley.stocklending.approval.StockLendingDecisionService processRequest

INFO: Decision Service Done: Approval Response: [ Approval Request #1808: { Client: CLSA Security: HSBC00005 Quantity: 3500 } Approved Quantity: 0 Status Code: REJECTED ]

May 28, 2017 10:06:41 PM com.morganstanley.stocklending.approval.StockLendingResponseService sendResponse

INFO: Single Approval Response Processing:

Approval Response: [ Approval Request #1808: { Client: CLSA Security: HSBC00005 Quantity: 3500 } Approved Quantity: 0 Status Code: REJECTED ]

May 28, 2017 10:06:41 PM com.morganstanley.stocklending.approval.StockLendingDecisionService processRequest

INFO: Decision Service Done: Approval Response: [ Approval Request #1809: { Client: GS Security: TENCENT00700 Quantity: 3000 } Approved Quantity: 1800 Status Code: APPROVED ]

May 28, 2017 10:06:41 PM com.morganstanley.stocklending.approval.StockLendingResponseService sendResponse

INFO: Single Approval Response Processing:

Approval Response: [ Approval Request #1809: { Client: GS Security: TENCENT00700 Quantity: 3000 } Approved Quantity: 1800 Status Code: APPROVED ]

May 28, 2017 10:06:41 PM com.morganstanley.stocklending.approval.StockLendingDecisionService processRequest

INFO: Decision Service Done: Approval Response: [ Approval Request #1810: { Client: UBS Security: CCB00939 Quantity: 3000 } Approved Quantity: 3000 Status Code: APPROVED ]

May 28, 2017 10:06:41 PM com.morganstanley.stocklending.approval.StockLendingResponseService sendResponse

INFO: Single Approval Response Processing:

Approval Response: [ Approval Request #1810: { Client: UBS Security: CCB00939 Quantity: 3000 } Approved Quantity: 3000 Status Code: APPROVED ]

May 28, 2017 10:06:41 PM com.morganstanley.stocklending.approval.StockLendingDecisionService processRequest

INFO: Decision Service Done: Approval Response: [ Approval Request #1813: { Client: GS Security: TENCENT00700 Quantity: 3500 } Approved Quantity: 2100 Status Code: APPROVED ]

May 28, 2017 10:06:41 PM com.morganstanley.stocklending.approval.StockLendingResponseService sendResponse

INFO: Single Approval Response Processing:

Approval Response: [ Approval Request #1813: { Client: GS Security: TENCENT00700 Quantity: 3500 } Approved Quantity: 2100 Status Code: APPROVED ]

May 28, 2017 10:06:41 PM com.morganstanley.stocklending.approval.StockLendingDecisionService processRequest

INFO: Decision Service Done: Approval Response: [ Approval Request #1811: { Client: CLSA Security: HKEX00388 Quantity: 4500 } Approved Quantity: 4500 Status Code: APPROVED ]

May 28, 2017 10:06:41 PM com.morganstanley.stocklending.approval.StockLendingResponseService sendResponse

INFO: Single Approval Response Processing:

Approval Response: [ Approval Request #1811: { Client: CLSA Security: HKEX00388 Quantity: 4500 } Approved Quantity: 4500 Status Code: APPROVED ]

May 28, 2017 10:06:41 PM com.morganstanley.stocklending.approval.StockLendingDecisionService processRequest

INFO: Decision Service Done: Approval Response: [ Approval Request #1812: { Client: CLSA Security: CCB00939 Quantity: 4000 } Approved Quantity: 2400 Status Code: APPROVED ]

May 28, 2017 10:06:41 PM com.morganstanley.stocklending.approval.StockLendingResponseService sendResponse

INFO: Single Approval Response Processing:

Approval Response: [ Approval Request #1812: { Client: CLSA Security: CCB00939 Quantity: 4000 } Approved Quantity: 2400 Status Code: APPROVED ]

May 28, 2017 10:06:41 PM com.morganstanley.stocklending.approval.StockLendingDecisionService processRequest

INFO: Decision Service Done: Approval Response: [ Approval Request #1814: { Client: GS Security: TENCENT00700 Quantity: 5000 } Approved Quantity: 3000 Status Code: APPROVED ]

May 28, 2017 10:06:41 PM com.morganstanley.stocklending.approval.StockLendingResponseService sendResponse

INFO: Single Approval Response Processing:

Approval Response: [ Approval Request #1814: { Client: GS Security: TENCENT00700 Quantity: 5000 } Approved Quantity: 3000 Status Code: APPROVED ]

May 28, 2017 10:06:41 PM com.morganstanley.stocklending.approval.StockLendingDecisionService processRequest

INFO: Decision Service Done: Approval Response: [ Approval Request #1815: { Client: GS Security: HKEX00388 Quantity: 6000 } Approved Quantity: 2700 Status Code: APPROVED ]

May 28, 2017 10:06:41 PM com.morganstanley.stocklending.approval.StockLendingResponseService sendResponse

INFO: Single Approval Response Processing:

Approval Response: [ Approval Request #1815: { Client: GS Security: HKEX00388 Quantity: 6000 } Approved Quantity: 2700 Status Code: APPROVED ]

May 28, 2017 10:06:41 PM com.morganstanley.stocklending.approval.StockLendingDecisionService processRequest

INFO: Decision Service Done: Approval Response: [ Approval Request #1816: { Client: GS Security: HKEX00388 Quantity: 6500 } Approved Quantity: 2925 Status Code: APPROVED ]

May 28, 2017 10:06:41 PM com.morganstanley.stocklending.approval.StockLendingResponseService sendResponse

INFO: Single Approval Response Processing:

Approval Response: [ Approval Request #1816: { Client: GS Security: HKEX00388 Quantity: 6500 } Approved Quantity: 2925 Status Code: APPROVED ]

SOURCE:

GitHub: https://github.com/richardwkwu/ms\_interview

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Test:

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