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♥♦ 01: 30+ Writing low latency applications in Java interview Q&As

Posted on November 25, 2014 by Arulkumaran Kumaraswamipillai — No Comments ↓

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Have you seen job advertisements requiring Java candidates to work in **real-time**, **low latency**, and **high throughput** systems? Wondering what questions you will be asked?

You will be quizzed on the low latency application you had recently worked on especially the outcomes in terms of the latencies, response times, and throughput along with the challenges you faced.

Q1. What do you understand by the terms **real-time application (RTA)**, **latency** & **throughput**?

A1. **Real-time application (aka RTA)** is an application

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where the content is pushed through “as it happens” within a specified time frame. These time frames are defined as SLAs (Service Level Agreements). For example, in a **Straight-Through Processing (STP)** solution, you have **real-time** trades flow between your front/middle office, and traders/stock exchange.

Real-time systems can be further divided into **1) Hard real-time** & **2) soft real-time**. **Hard real-time** is when an action is performed at the wrong time will have possibly no or negative effect. In other words, you must absolutely hit every deadline. It is not acceptable to say 90% of the time we hit the response time of 100ms. Only some systems have this requirement -> medical apps (e.g. pacemaker), defense systems, nuclear systems, avionics, etc.

Soft real-time is when an action is performed either too early or too late will still have a positive effect. If it had performed the task on time, it would have had greater value in terms of better customer experience, meeting the SLAs, etc. Soft real-time system can be a trading application with high through-put & low latency without any hard response time guarantees. No catastrophe happens when response times fail say 5% of time when 100K requests are sent. Most system fall into this category like financial applications (e.g. placing trades, matching trades, etc), event processing, telecom, etc.

Q. Can JVM be used for **real-time** applications in the sense that it's guaranteed to react within a certain amount of time?

A. The answer is no for the standard JVMs, but the special JVMs that support “**Real-Time Specification for Java (RTSJ)**” extensions can process in hard real-time. Standard JVMs achieve “**soft real-time**” mainly due to automatic garbage collection and GC pauses associated with it. The RTSJ provides a subclass of RTT (i.e. Real-Time-Thread) called NoHeapRealtimeThread (NHRT). Instances of this subclass are protected from GC induced pauses. NHRTs are NOT allowed to use the heap. NHRTs use the scoped memory and immortal memory features to allocate memory on a more predictable basis.

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Q. Do you favor hard or soft real-time Java development guidelines in general?

A. soft real-time is favored unless there is a specific need for hard real-time as soft real-time offers much better **developer productivity & application maintenance**.

Latency is the time required to perform some action or to produce some result. Latency is measured in units of time like seconds, milli seconds, micro seconds, nanoseconds, etc. What defines a “low” latency depends on the context – low latency over the internet might be 200ms whereas low latency in a trading application (e.g. pricing or order matching engines) using FIX or custom protocols over TCP/IP might be 2μs. Trading systems need to target 100 nano-seconds to 100 ms.

Throughput is the number of such actions executed or results produced per unit of time. This is measured in units of time like requests per second. The term “memory bandwidth” is sometimes used to specify the throughput of memory systems.

Hadoop Distributed File System (**HDFS**) & **Map-reduce** are about throughput. For example, processing a 100GB file across a 20 node cluster in 2 minutes or processing a 1TB file across a 100 node cluster in same 2 minutes to get the required **throughput**. HDFS **scales out** very well and uses cheaper commodity hardware. You can start with 20 nodes and then horizontally scale to 100+ nodes as higher throughput is required to analyze terabytes of data.

Q2. What is the difference between the terms **latency** and **response times**?”

A2. Latency is the time elapsed between when a request was sent to the server and when the first byte of the response has started to be received.

Response time is the time elapsed between when a request was sent to the server and when the response has been fully received. In a web application the browser needs to

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load the assets like the DOM tree, images, CSS, and the JavaScript scripts.

So, the response time will always be \geq latency. In other words,

```
1
2 response time = latency + processing time (e.g. r
3
```

Low latency is a sum of many things, and two most important ones are 1. **Network Latency**, which is the time taken on the network to send/receive a message/event & 2. **Processing Latency**, which is the time taken by your application to act on a message/event.

If you are building a “trade order matching” engine in Java, the “**network latency**” is the time taken in say micro seconds to receive an order matching request to the engine from a client app plus the time taken for the client app to receive the first byte of the response message from the engine. The “**processing latency**” is the time elapsed in micro or milli seconds for the engine to match the order and build the response to be sent back to the client app.

Q3. Is a latency of over 20ms seconds considered fast or slow in HFT (High Frequency Trading) application?”

A3. Anything over 20ms will be considered slow. The HFT trades are conducted using algorithms to buy, sell, and match huge volume of trades. These are ultra low latency applications once used to be written in “C”, and now a days increasingly being written in Java.

Q4. What throughput will you be aiming for in HFT (High Frequency Trading) applications?”

A4. 50k to 200k orders or transactions per second. You will have multiple servers to process the requests. The architecture needs to be **scalable** to cater for growing demands. You can learn more at [Scalability interview questions & answers](#)

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Q5. What latency will you be targeting for your applications?

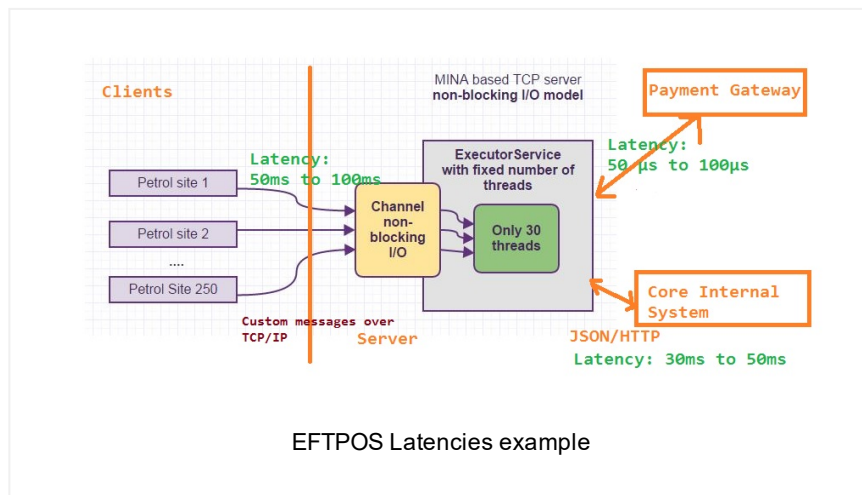
A5 It depends on the context of the application. For example,

#1. Trading system placing buy/sell equity or FX orders to the market will target a latency of under 20ms.

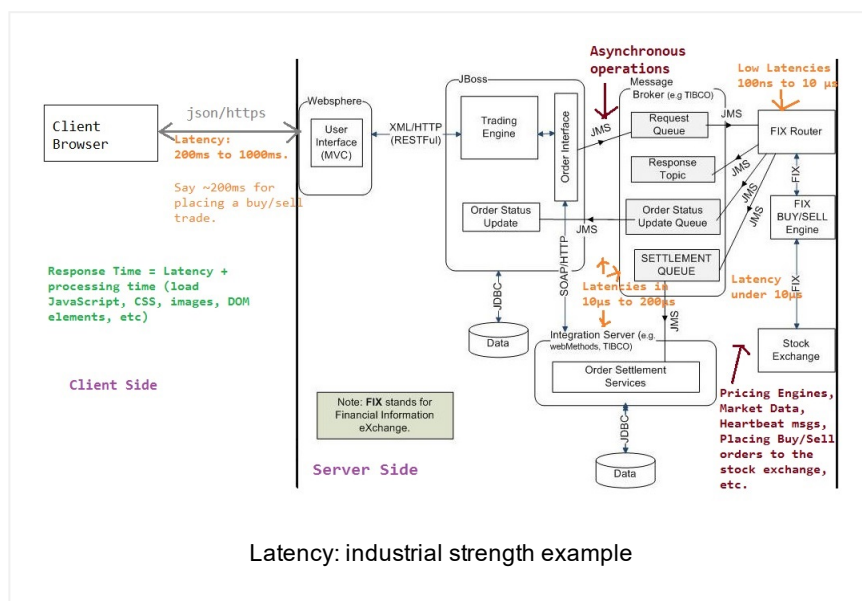
#2. A standard web application will target a latency of 200ms to 800ms.

#3. A gaming application or a more complex web application will target a latency of 500ms to 1000ms.

Example 1: An EFTPOS system



Example 2: An Online Trading System



Q6. How will you go about improving the latency for a more complex web site?

A6.

#1. Processing the requests asynchronously by submitting to a queue and getting the results later on via a client pull or server push.

#2. Reducing the complexity of the page by dividing the tasks with the view of better user experience. This also means smaller payloads transferred between the clients & the servers for better network latency.

#3 Producing less garbage by violating the OO concepts by favoring primitive data types, and applying the flyweight design pattern to improve reuse.

#4. Profiling the application with the tools like **VisualVM** to identify and improve the bottlenecks in terms of CPU, memory usage, Garbage Collection pauses, etc.

#5. [13 tips in detail to write low latency applications in Java.](#)

Q7. What do you understand by the terms real-time systems, latency, and scalability?

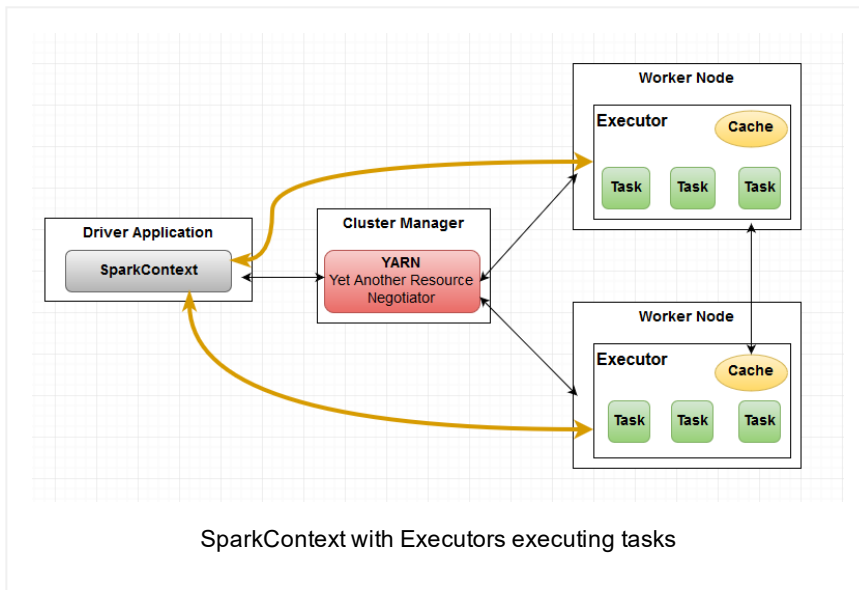
A7. Real-time and **low-latency** are distinctly separate subjects although often related. Real-time is about being more predictable than fast. Low latency systems need to be fast to meet SLAs (Service Level Acceptances) in sub milliseconds (e.g. micro seconds).

Scalability means the ability of the system to handle growing demands by adding more CPUs, memory, nodes, servers, etc. [Scalability interview questions & answers](#)

Q8. What are some of the considerations in writing low latency applications in Java?

A8.

- 1) Writing concurrent programs with Java multi-threading features such as executors, futures, completable futures, fork/join, concurrent data structures, etc.
- 2) Understanding the Java memory model & tuning memory & garbage collection in Java.
- 3) Using event based and non-blocking paradigms. For example, using frameworks like Apache **MINA**, **Netty**, Grizzly, and **Akka**.
- 4) MINA & Netty are lower level frameworks than Akka, and have NIO (New Java IO) as its core. NIO is an event driven non blocking paradigm.
- 5) Akka is a higher level general purpose framework compared to MINA & Netty for building event-driven, scalable, and fault-tolerant applications. Akka is written in Scala, with language bindings provided for both Scala and Java. Akka uses the **Actor model** to hide all the thread-related code and gives you really simple and helpful interfaces to easily implement a scalable and fault-tolerant system.
- 6) Even though you need to have a good handle on writing concurrent programs in Java & interviewers like to quiz/test you on it, favor a framework like Akka as writing complex concurrent programs is not a trivial task, and you need to deal with threads, locks, race conditions & debugging. Writing concurrent programs without frameworks can be error-prone and can lead to code that is difficult to read, test, and maintain.
- 7) If you are working in the BigData space, have a look at Apache Spark, which is based on Scala & **Akka Toolkit**. Here is an example of a Spark master “Driver Application” creating tasks & scheduling them to be run on the “Spark Executors”. Only two executors are shown here, but typical clusters will have 100+ nodes & executors.



Executors are worker nodes' processes in charge of running individual tasks in a given Spark job. Spark Executors are launched at the beginning of a Spark application and typically run for the entire lifetime of an application. Once they have finished running the tasks they send the results to the "Driver Application". "**Spark Executors**" also provide in-memory storage for RDDs that are cached.

Q9. What is an **actor model** in Akka toolset, which is also known as the **reactor design pattern**?

A9. "actor model" is a design pattern for writing concurrent and scalable code that runs on distributed systems. This is an **even driven** (i.e. message passing) model that involves sending & receiving events among actors.

1) Instead of invoking an object directly, you construct a message and send it to a destination object called an **actor**.

2) Each thread is an actor with a specific job to do. The actor engine stores the message in a queue.

3) When a thread becomes available, the actor engine running the actor delivers that message to its destination actor object.

4) When the actor completes its task, it sends a message back to the originating object, which is also considered an actor.

5) You can orchestrate which messages get passed to which actors under what conditions.

The **akka-camel** module allows “Untyped Actors” to receive and send messages over a great variety of protocols such as HTTP, SOAP, TCP, FTP, SMTP or JMS and APIs such as java & Scala .

Wondering what to learn or brush up on?

You need to have a good grasp of multi-threading, Java Memory Model, GC, Profiling, Non-blocking I/O (aka NIO), Big-O notation, lock free data structures like concurrent lists/maps, and strategies to produce less garbage. Here are tutorials & Q&As to build your skills to develop **LOW LATENCY** applications in Java.

1. [Simple Akka tutorial in Java step by step.](#)
2. [13 tips to write low latency applications in Java.](#)
3. [Reactive Programming \(RP\) in Java Interview Q&A.](#)
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