Java Development: Do’s and Don’ts
Overview

- Asynchronous networking
- Data copies
- Connection management
- Logging
Middleware provides multiple replication schemes
Sets and Deletes are handled by an asynchronous thread (one for each server)
Gets are handled by a synchronous reader thread pool
What is wrong with this code?
public class ReadHandler implements Runnable {
    [...]
    public ReadHandler(BlockingQueue<Request> queue, InetSocketAddress serverAddr){
        this.queue = queue;
        server = SocketChannel.open();
        server.connect(serverAddr);
        server.configureBlocking(false);
    }

    public void run(){
        while(true){
            Request request = queue.take();
            ByteBuffer command = ByteBuffer.wrap(request.getCommand());
            server.write(command);
            command.clear();

            ByteBuffer buf_header = ByteBuffer.allocate(message_size);
            int bytesRead = 0;
            do{
                bytesRead = server.read(buf_header);
            } while(bytesRead == 0);
            [...]
        }
    }
}}
public class ReadHandler implements Runnable {
    [...]  
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    }
    [...]
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            int bytesRead = 0;
            do {
                bytesRead = server.read(buf_header);
            } while (bytesRead == 0);
        }
    }

    [...]}

What is wrong with this code?

Socket is non-blocking. What are the implications?

How about a read with timeout? Can lead to increasing and unpredictable response time.

Read will return instantly.

Hot loop! Consumes CPU.
How much difference can this change make?

Figure 4: The throughput during the one-hour experiment. The mean is 1966.6 and the standard deviation is 19.2.

2.000 req/sec
How much difference can this change make?

Figure 3: The throughput during the 10-minute trace. The error bars represent the 95% confidence intervals.

Figure 4: The throughput during the one-hour experiment. The standard deviation is 100 req/sec.

2.000 req/sec

17.000 req/sec
How about different message sizes?

Student A

Student B
How about different message sizes?

Student A: Is this network bound?
How about different message sizes?

Student A

Is this network bound?
No. Sending data to 7 servers is not 2x slower than 3 servers. Required bandwidth << network bw.
How about different message sizes?

Student A:

Large messages should have a higher latency.

Student B:

Is this network bound? No. Sending data to 7 servers is not 2x slower than 3 servers. Required bandwidth << network bw.
How about different message sizes?

Large messages should have a higher latency. Yes, but multiple threads will hide that latency and sustain the throughput.

Is this network bound? No. Sending data to 7 servers is not 2x slower than 3 servers. Required bandwidth << network bw.
How about different message sizes?

Student A

Data is copied across buffers!
String s1 = “request”;
String s2 = new String(s1);

Large messages should have a higher latency.
Yes, but multiple threads will hide that latency and sustain the throughput.

Is this network bound?
No. Sending data to 7 servers is not 2x slower than 3 servers. Required bandwidth << network bw.
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Network Microbenchmark: Echo server

- Client connects to server and sends message
- Server reads message and sends it back
- Client reads message
What is wrong with this code?

Client Code:

```java
long startTime = System.nanoTime();

for (int i = 0; i < 100000; ++i) {
    Socket socket = new Socket(hostName, portNumber);
    PrintWriter out = new PrintWriter(socket.getOutputStream());
    BufferedReader in = new BufferedReader(new InputStreamReader(socket.getInputStream()));

    out.println(m);
    out.flush();
    String t = in.readLine();

    out.close();
    in.close();
    socket.close();
}

long stopTime = System.nanoTime();
System.out.println("It took "+ (stopTime-startTime) + "ns");
```
What is wrong with this code?

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    out.close();
    in.close();
    socket.close();
}

long stopTime = System.nanoTime();
System.out.println("It took " + (stopTime-startTime) + " ns");
```

You measure how fast the OS can open and close connections.
Keep connections open

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    String t = in.readLine();
    out.close();
    in.close();
    socket.close();
}
long stopTime = System.nanoTime();
System.out.println("It took "+(stopTime-startTime)+"ns");
```

Open the connection once and reuse it

Client Code:

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Socket socket = new Socket(hostName, portNumber);
PrintWriter out = new PrintWriter(socket.getOutputStream());
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for (int i = 0; i < 100000; ++i) {
    out.println(m);
    out.flush();
    String t = in.readLine();
    out.close();
    in.close();
    socket.close();
}
long stopTime = System.nanoTime();
System.out.println("It took "+(stopTime-startTime)+"ns");
```
What is the impact?

2-3x difference
What is the impact?

Larger difference for smaller messages

2-3x difference

![Bar chart comparing Single Connection and Open/Close for 128 bytes and 1024 bytes messages.]
What is the impact?
What is the impact?

Single client (1 thread). Lower latency results in higher throughput.
What is the impact?

Opening/closing connections is the bottleneck of this system.
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Logging to files vs main memory

for (int i = 0; i < 1000000; ++i) {
    int keyHash = hashFunction(keys[i]);
    logging.println("Key " + keys[i] + " hashes to "+ keyHash);
    logging.flush();
}
...
Avoid excessive logging/flushing in critical sections
Logging to files vs main memory

... for (int i = 0; i < 1000000; ++i) {
    int keyHash = hashFunction(keys[i]);
    logging.println("Key " + keys[i] + " hashes to " + keyHash);
    logging.flush();
}
...

Avoid excessive logging/flushing in critical sections

... for (int i = 0; i < 1000000; ++i) {
    values[i] = hashFunction(keys[i]);
}
... for (int i = 0; i < 1000000; ++i) {
    logging.println("Key " + keys[i] + " hashes to " + values[i]);
}
logging.flush();
logging.close();
...
Logging to files vs main memory

...for (int i = 0; i < 1000000; ++i) {
    int keyHash = hashFunction(keys[i]);
    logging.println("Key "+ keys[i] + " hashes to " + keyHash);
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Avoid excessive logging/flushing in critical sections

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...for (int i = 0; i < 1000000; ++i) {
    logging.println("Key " + keys[i] + " hashes to " + values[i]);
}
logging.flush();
logging.close();
...
Recurring questions about threads/queues
Recurring questions about **threads**

How many net threads are allowed? / Can I use helper threads? / Can I deviate from the thread design in the figure?

It is OK to use helper thread(s), but the fundamental operations (data receiving and sending, request decoding) has to happen as shown in the figure. Points of measurement should be equivalent to the given design also!
Recurring questions about queues

What type of objects are enqueued in the queue? / Where should I parse the requests?

Logically, each element in the queue must correspond to a single request. The exact implementation is up to you, but in the report you must explain why the implementation fulfills this condition. Work division between the different types of threads is up to you, but the measurement points must also correspond to the description.
Take-away message: Be careful with ...

- Non-blocking and asynchronous I/O
- Copying of large data buffers
- Opening and closing connections
- Flushing your data to disk in hot loops