Chapter 11
Java Network Programming

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https://wdsseu.github.io/java/

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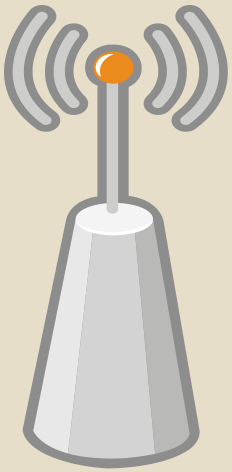


Content

- Identification of Machine
- Client and Server
- Port
- Java Socket Programming Primer (C/S Programming on TCP)
- Java Web Enlightenment

Identification of Machine

- IP address - Internet Protocol
  - Domain name or host name: cose.seu.edu.cn
  - Four fragments： 58.192.114.215
- IPv4
  - A figure in 32-bits
  - Almost 4,000,000,000 IPs
- IPv6
  - A figure in 128-bits
  - Guess how many IPs?

Identification of Machine

- IP
  - 58.192.112.11
  - Identical in WAN or in LAN
- Hostname
  - Spark-pc
  - Identical in LAN
- Domain Name
  - www.seu.edu.cn
  - Translated into IP by using DNS

Java Internet IP

```
public void getIP(){
        try{
            //得到InetAddress
            InetAddress iAddress = InetAddress.getLocalHost();
            //获得本机IP
            String localIP = iAddress.getHostAddress().toString();
            //获得本机名称
            String hostName=iAddress.getHostName().toString();
            System.out.println("您的IP为：" + localIP);
            System.out.println("您的主机名为：" + hostName);
        }catch(UnknownHostException e){
            e.printStackTrace();
        }catch(Exception e){
            e.printStackTrace();
        }
}
```

Getting IP of Multiple Network Adaptor

```
/* 通过本机的主机名获取所有IP */
public ArrayList<String> getAllIP(){
    ArrayList<String> allIP = new ArrayList<String>();
    try{
        String hostName = InetAddress.getLocalHost().getHostName();
        if(hostName.length()>0){
            InetAddress[] addresses = InetAddress.getAllByName(hostName);
            for(int i=0; i<addresses.length; i++){
                allIP.add(addresses[i].getHostAddress().toString());
            }
        }
        return allIP;
    }catch(Exception e){
        e.printStackTrace();
        return allIP;
    }
}
```

InetAddress Class

- Constructor localhost InetAddress

```
InetAddress addr = InetAddress.getByName(null);
InetAddress addr = InetAddress.getByName("127.0.0.1");
InetAddress addr = InetAddress.getByName("localhost");
InetAddress addr = InetAddress.getLocalHost();

byte[] ip = {127,0,0,1};
InetAddress addr = InetAddress.getByAddress(ip);
```

- Construct InetAddress of other machine

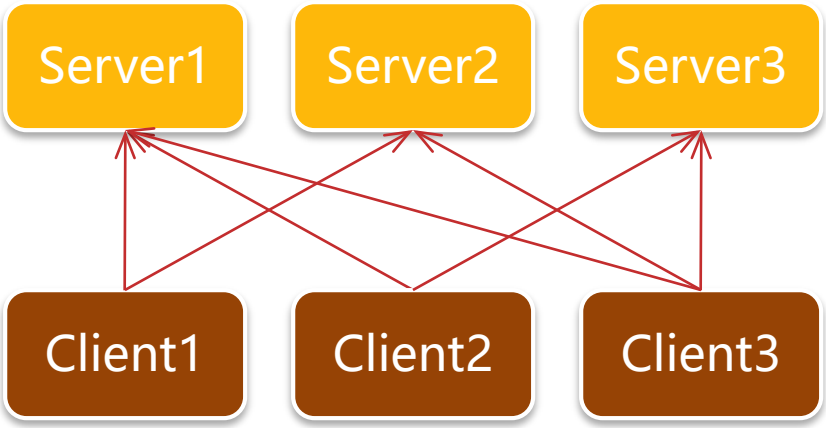
```
InetAddress addr = InetAddress.getByName("cose.seu.edu.cn");

byte[] ip = {(byte)58,(byte)192,(byte)114,(byte)215};
InetAddress addr = InetAddress.getByAddress(ip);
```

Ping

```
private static final int TIMEOUT = 5000;
public void ping(InetAddress addr){
    try{
        String hostName = addr.getHostName();
        while(true){
            if(addr.isReachable(TIMEOUT)){
            System.out.println("Reply from "
                    + hostName + " within " + TIMEOUT + "ms.");
            }
            Thread.sleep(1000);
        }
    }catch(Exception e){e.printStackTrace();}
}
```

Client and Server

- Server
  - Response passively, intercepting requests
- Client
  - Request actively



Port

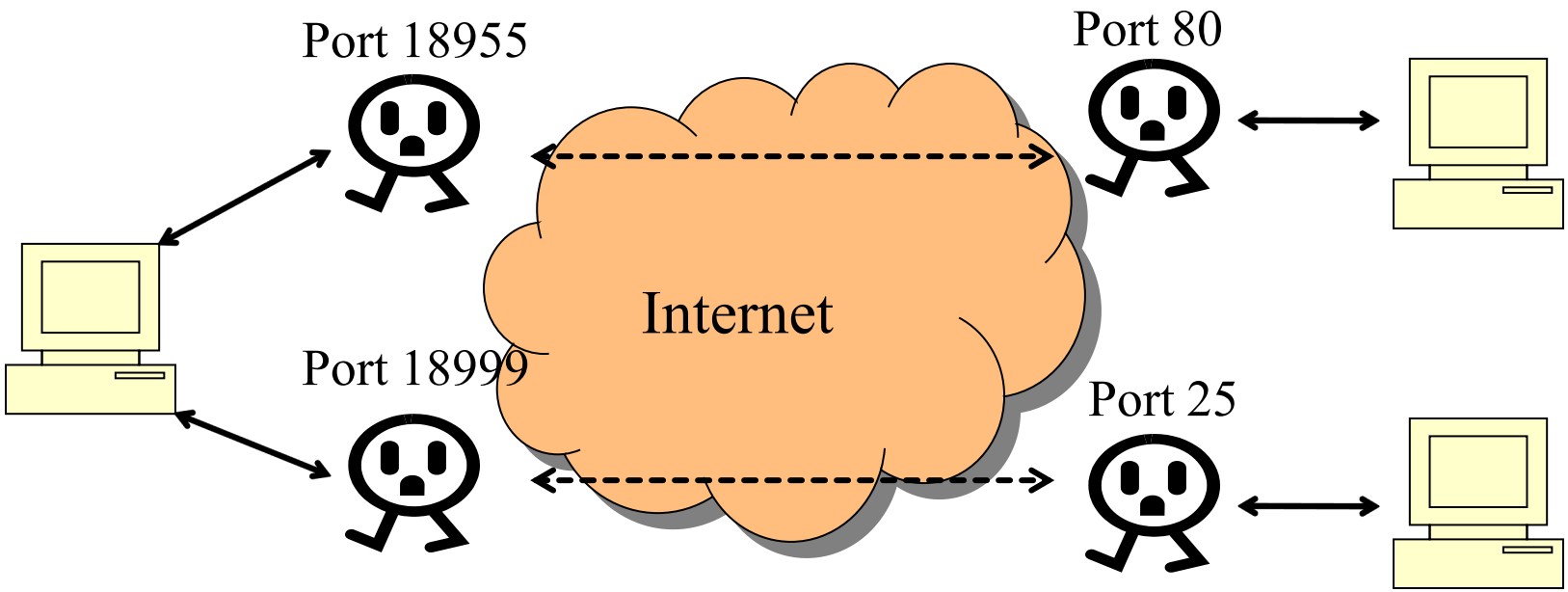
- IP identifies machines, but cannot identify apps
- Considering our server:
  - Web server http://cose.seu.edu.cn
  - FTP server ftp://cose.seu.edu.cn
  - Mail server smtp://mail.seu.edu.cn
- IP – House number; Port – Room number
- Client communicates with a port on server
- Port 1-1024 is occupied

Occupied Port

Port	Service
21	FTP
23	TELNET
25	SMTP
53	DNS
80	HTTP
110	POP3
1080	SOCK

Socket

- A virtual terminal between two machines for a connection
- Data flows from one Socket to the other



Socket

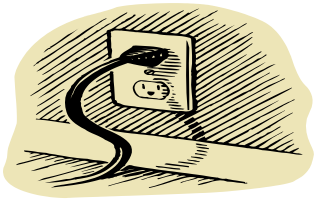
- Client create a Socket to connection to server

```
//通过host name来构建客户端Socket
Socket client = new Socket("cose.seu.edu.cn", 8080);
//或者通过InetAddress来构建客户端Socket
InetAddress address = InetAddress.getByName("cose.seu.edu.cn");
Socket client = new Socket(address, 8080);
```

- Server create a ServerSocket to intercept request

```
//创建服务端的ServerSocket监听客户端请求
ServerSocket server = new ServerSocket(8080);
//当没有客户端请求时，服务器端阻塞，
//当客户端请求到来时，accept()方法将创建一个服务器端Socket
Socket serverSocket = server.accept();
```

Socket



- Socket – read and write
  - Client write data to Socket by OutputStream
  - Server read date from Socket by InputStream

```
Socket client = new Socket("cose.seu.edu.cn", 8080);
InputStream is = socket.getInputStream();
OutputStream os = socket.getOutputStream();
```

  - Remember to close input and output stream, and the Socket itself, after communication.

A Simple Server

```
ServerSocket server = new ServerSocket(8088);
System.out.println("服务器已经启动.");
Socket socket = server.accept();
try{
    BufferedReader in = new BufferedReader(
        new InputStreamReader(socket.getInputStream()));
    PrintWriter out = new PrintWriter(new BufferedWriter(
        new OutputStreamWriter(socket.getOutputStream())),true);
    while(true){
        String str = in.readLine();
        if (str!=null && str.equals("你好")) out.println("你好，我是服务器");
        else out.println("听不懂");
    }
}catch(Exception e){
    e.printStackTrace();
}finally{
    socket.close();server.close();
}
```

A Simple Client

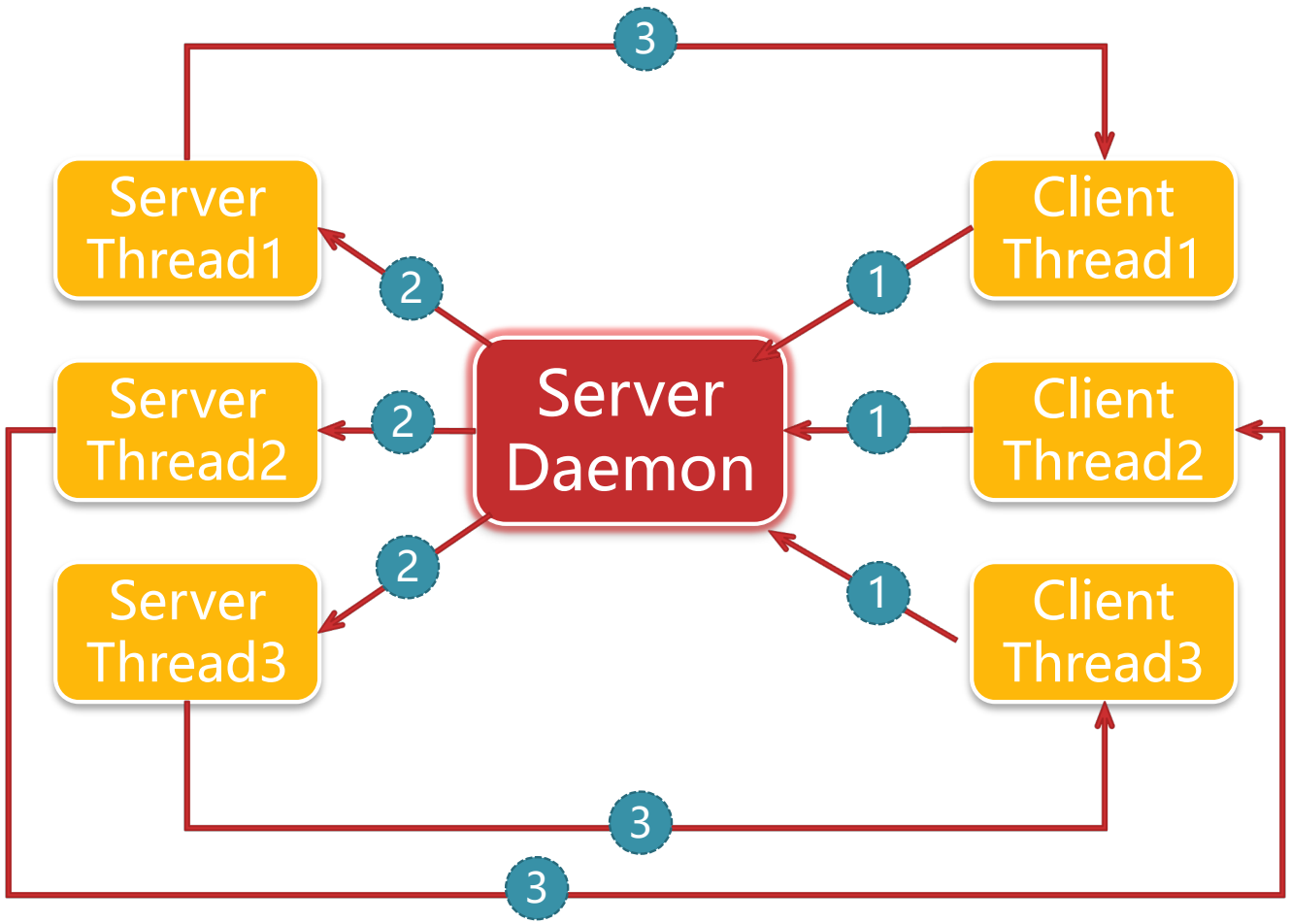
```
Socket socket = new Socket("localhost", 8088);
BufferedReader in = new BufferedReader(
    new InputStreamReader(socket.getInputStream()));
PrintWriter out = new PrintWriter(
    new BufferedWriter(new OutputStreamWriter(
        socket.getOutputStream())),true);
out.println("你好");
Thread.sleep(1000);
out.println("今天星期几？ ");
socket.close();
```

如果关闭client，再重启client（不关闭服务器端），客户端会收到什么样的响应?

TCP and UDP

- TCP
  - Based on connection
  - Using data stream to communicate
  - Secured, low possibility to lose data
- UDP
  - No connection
  - Using data packet to communicate
  - Not secured, possible to lose data
  - Self study: using java.net.DatagramSocket

Multiple Clients – Multiple Threads



Multiple Threads

- Try to program
  - Create a Daemon on server
  - When requested, Daemon create a thread to response.
  - At most 10 concurrent responding threads.
  - Client tells server its name, then server make a greet. After a Bye said by client, corresponding thread on server exits.
  - A client starts 12 threads to request server, each thread staying at least 3s.

ServerDaemon

```
public class ServerDaemon {
    public static final int PORT = 8080;
    // 用于控制最大可用线程数
    private static final int MAX_THREADS = 10;
    //用于记录当前已创建线程数
    public static int CURRENT_THREADS = 0;
    ServerSocket server;

    public ServerDaemon(){
        System.out.println("Server started.");
        try{server = new ServerSocket(PORT);
            while(true){
                if(CURRENT_THREADS<MAX_THREADS){
                    //创建新的线程相应客户端请求
                    ServerThread thread = new ServerThread(server.accept());
                    thread.start();}}}
        catch(Exception e){e.printStackTrace();  }
        finally{
            try{server.close();}catch(Exception e){e.printStackTrace();}
        }
    }
}
```

ServerThread

```
public class ServerThread extends Thread{
    Socket socket;
    BufferedReader in;
    PrintWriter out;

    public ServerThread(Socket socket) throws IOException{
        ServerDaemon.CURRENT_THREADS++;//记数
        this.socket = socket;
        //创建BufferReader用于输入
        in = new BufferedReader(
                new InputStreamReader(this.socket.getInputStream()));
        //创建PrintWriter用于输出
        out = new PrintWriter(new BufferedWriter(
                new OutputStreamWriter(this.socket.getOutputStream())), true);
    }
```

ServerThread

```
public void run(){
    try{
        while(true){
            String str = in.readLine();
            if(str!=null){
                if(str.equals("bye")){
                    break;
                }else{
                    String greeting = "Hello " + str + ", I am Server.";
                    out.println(greeting);
                }
            }
        }
    }catch(Exception e){
        e.printStackTrace();
    }finally{
        try{
            socket.close();
            ServerDaemon.CURRENT_THREADS--; //减少记数
        }catch(Exception e){e.printStackTrace();}}}
}
```

ClientThread

```
public class ClientThread extends Thread{
    Socket client;
    BufferedReader in;
    PrintWriter out;

    public ClientThread(){
        try{
            InetAddress address = InetAddress.getLocalHost();
            client = new Socket(address, ServerDaemon.PORT);
            in = new BufferedReader(
                    new InputStreamReader(client.getInputStream()));
            out = new PrintWriter(new BufferedWriter(
                    new OutputStreamWriter(client.getOutputStream())), true);
        }catch(Exception e){
            e.printStackTrace();
        }
    }
```

ClientThread

```
    public void run(){
        String threadName = Thread.currentThread().getName();
        out.println(threadName);
        try{
            System.out.println(in.readLine());
            Thread.sleep(3000);
            out.println("bye");
        }catch(Exception e){e.printStackTrace(); }
        finally{
            try{client.close();}catch(Exception e){e.printStackTrace();}
        }
    }

    public static void main(String[] args){
        for(int i=0; i<12; i++){
            ClientThread client = new ClientThread();
            client.start();
        }}
}
```

But something goes wrong…

```
ClientThread [Java Application] C:\Program Files\Jav
Sun Dec 29 12:10:19 CST 2019
Hello Thread-0, I am Server.
Hello Thread-1, I am Server.
Hello Thread-2, I am Server.
Hello Thread-3, I am Server.
Hello Thread-4, I am Server.
Hello Thread-5, I am Server.
Hello Thread-6, I am Server.
Hello Thread-7, I am Server.
Hello Thread-8, I am Server.
Hello Thread-9, I am Server.
```

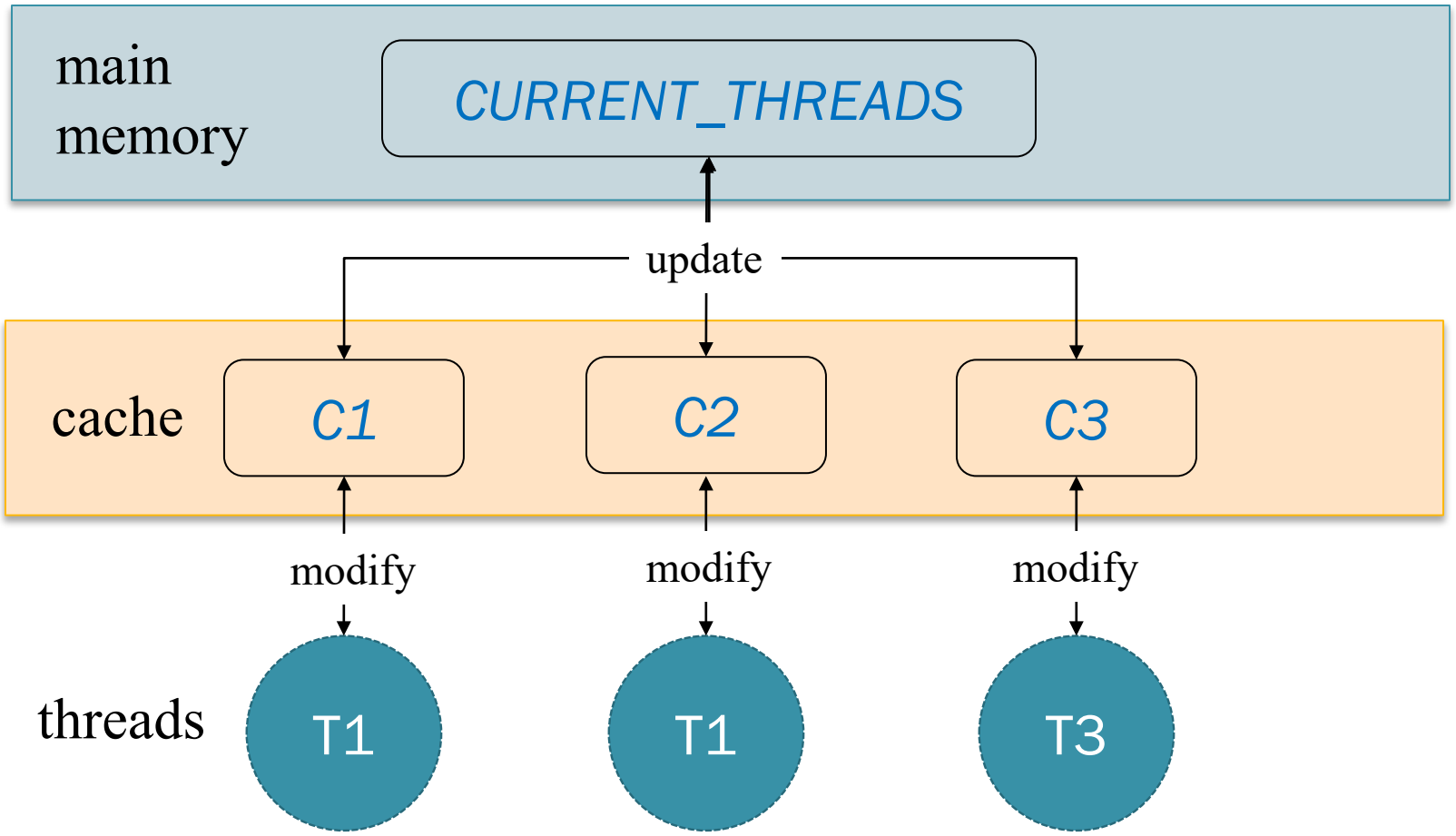
On the client side, why the program cannot continue with Thread-10 and Thread-11?

The problem is here…

In ServerDaemon, the while(true) loop contains a single if() statement, but no other statements. And *CURRENT_THREADS* is a shared static variable.

```
public ServerDaemon(){
    System.out.println("Server started.");
    try{
        server = new ServerSocket(PORT);
        while(true){
            if(CURRENT_THREADS<MAX_THREADS){
                System.out.println("Server daemon with " + CURRENT_THREADS + "threads");
                ServerThread thread = new ServerThread(server.accept());
                thread.start();
            }
        }
    }catch(Exception e){
```

The problem is here…



The while(true) trap

```
while(true) {
    // single statement is a trap!!!
}
```

Solution 1: Poll

Let the while(true) loop take a break, this is called **Poll**

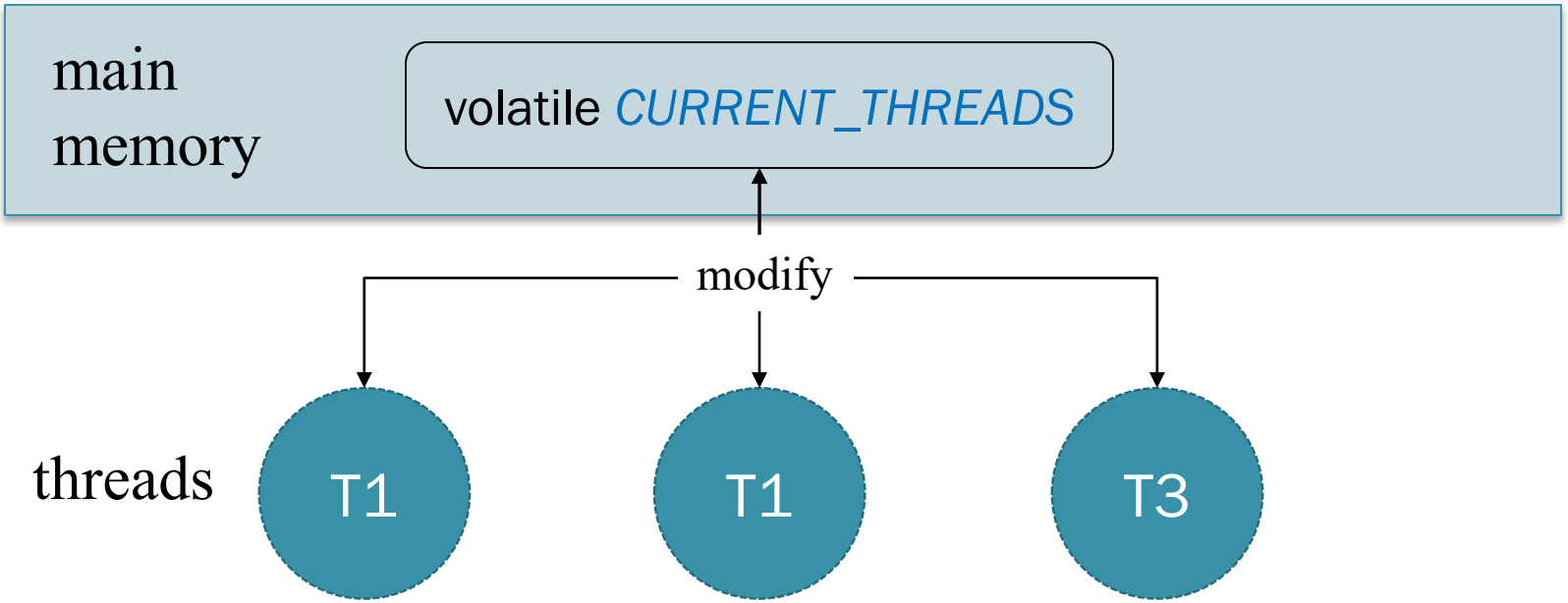
```
while(true){
    if(CURRENT_THREADS<MAX_THREADS){
        System.out.println("Server daemon with " + CURRENT_THREADS + "threads");
        ServerThread thread = new ServerThread(server.accept());
        thread.start();
    }
    Thread.sleep(1);
}
```

Or anything like System.out.println("…");

Solution 2: volatile

```
public volatile static int CURRENT_THREADS = 0;
```

which means this shared variable should be always up-to-date, and it is identical for each thread that access it.



When will the blocked clients send message?

- The blocked clients (thread 11,12) will send message to the ServerThread
  - before the ServerThread is created?
  - after the ServerThread is created?
- The client side:

预期结果：前10个线程先运行，输出自己的当前时间，后2个线程后运行，输出的时间应当比前10个线程多5000ms，但是…

```
public void run() {
    this.clientTime = String.valueOf(System.currentTimeMillis());
    out.println(clientTime);
    try {
        Thread.sleep(5000);
        client.close();
    } catch (Exception e) {
        e.printStackTrace();
    }
}
```

```
public static void main(String[] args) {
    for (int i = 0; i < NUM_OF_CLIENTS; i++) {
        ClientThread client = new ClientThread();
        client.start();
    }
}
```

When will the blocked clients send message?

- ServerDaemon: only allow 10 concurrent clients;

```
while (true) {
    if (CURRENT_THREADS < MAX_THREADS) {
        ServerThread thread = new ServerThread(server.accept());
        thread.start();
    }
    Thread.sleep(1);
}
```

实际结果：后2个线程输出的时间几乎和前10个线程一样。说明服务器端在server.accept()之前，客户端就提前输出到了服务器端的缓存中，无需等待服务器的accept。

- ServerThread: each thread receives and prints the currentTimeMillies from a given client;

```
try {
    String str = in.readLine();
    while (str != null) {
        System.out.println(str);
        str = in.readLine();
    }
} catch (Exception e) {
    e.printStackTrace();
```

```
} finally {
    ServerDaemon.CURRENT_THREADS--;
    try {
        socket.close();
    } catch (Exception e) {
        e.printStackTrace();
    }
}
```

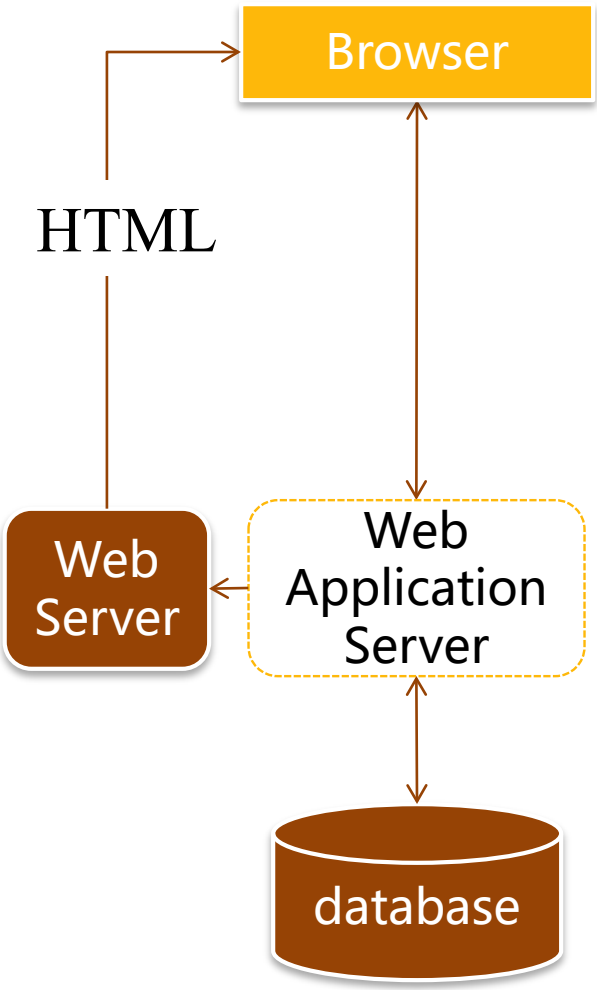
多客户端线程访问服务器端时，服务器端对接受消息保持开放（多个客户端可以随时向服务器端发送消息），但对回复消息保持限制（只同时回复K个先来的客户）。一般会用线程池做服务器端的负载均衡。

Java Concurrent

https://www.cnblogs.com/dolphin0520/p/3920373.html

Java Web Enlightenment

- Web server is on Port 80
  - Apache
  - nginx
  - IIS
- Web App server
  - Tomcat
  - Jboss
  - WebSphere



Java Web Enlightenment

- Web front
  - JSP / Servlet
  - RIA(Rich Internet Application)
    - JavaScript / AJAX
    - JavaFX
    - Flex
    - Silverlight
- Web backend（middleware）
  - Heavy-weighted J2EE – EJB
  - Light-weighted J2EE – Spring / Struts / Hibernate

A Simple Example – Read a Web Page

```
try{
    URL coseURL = new URL("http://cose.seu.edu.cn");
    URLConnection connection = coseURL.openConnection();
    BufferedReader in = new BufferedReader(
        new InputStreamReader(connection.getInputStream()));
    String html = in.readLine();
    while(html!=null){
        System.out.println(html);
        html = in.readLine();
    }
}catch(Exception e){
    e.printStackTrace();
}
```

Self-study

- HTML syntax
- Parsing HTML
  - http://www.open-open.com/30.htm
- Installing Apache Tomcat
  - Write your personal page, and test it

Thanks

Each ending leads to a beginning.

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