Load Testing

After creating the application, it is necessary to benchmark the application to see the effective number of users it can serve concurrently. This can be done through the use of stress testing.

Tsung

Tsung is a feature rich benchmarking tool written in Erlang (running on top of Beam VM), which can spawn millions of virtual users to test the application. It supports centralized and distributed testing environments. Utilizing the actor model in the Beam VM, it provides highly concurrent testing. The tests are defined as XML documents.

Installing Tsung

Tsung is available in many Linux distribution repositories and can be downloaded depending on your package manager. For ArchLinux:

```
yaourt -S tsung --noconfirm
```

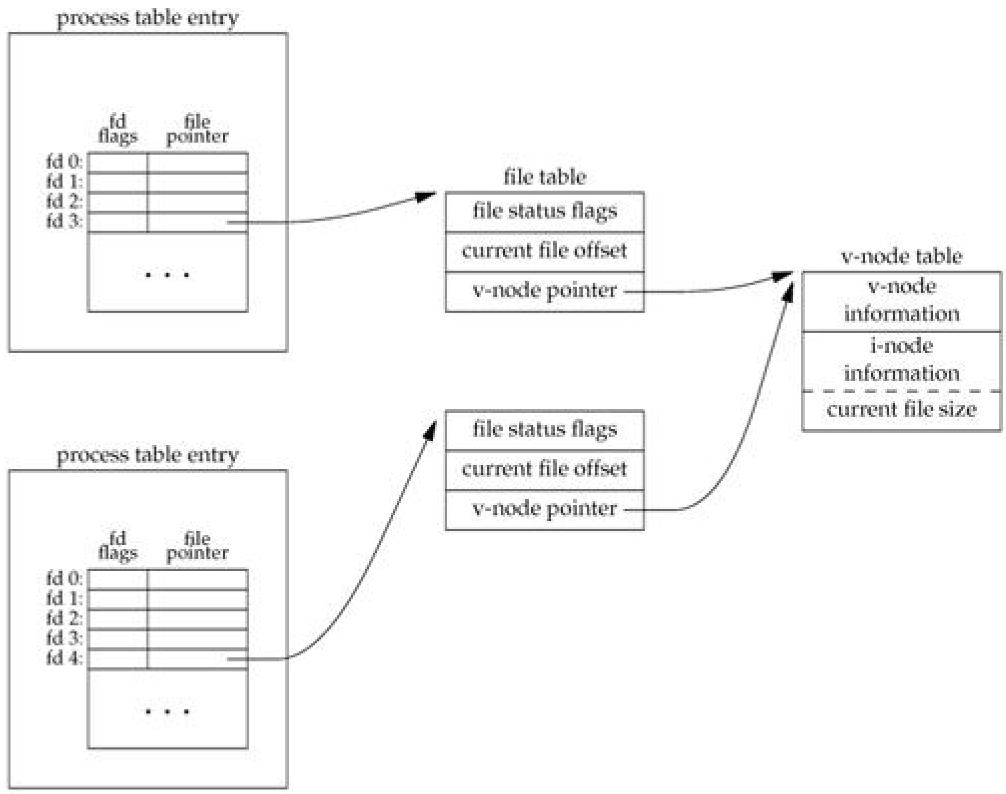
For Mac users, it is availble on homebrew:

```
brew install tsung
```

File Descriptor

The kernel assigns a table to each running process, named *File Descriptor*, this table is responsible for keeping track of which files are open by the said process, by assigning a unique number to each file in the table. The table itself does not carry the file, but a pointer to the file in the kernel (in the filesystem). By default the kernel sets a default maximum for the number of entries per file descriptor tables, it may be overridden.

Figure 3.7. Two independent processes with the same file open



Running Tsung

When running the tests, make sure that the number of users is not too large such that the table overflows and an exception occurs.

For a simple test:

```xml
<?xml version="1.0"?>
<!DOCTYPE tsung SYSTEM "/usr/share/tsung/tsung-1.0.dtd">
<!-- set dumptraffic="true" to dump all received and sent packets -->
<!-- set loglevel="debug" for maximum verbosity -->
<tsung loglevel="notice" dumptraffic="false" version="1.0">

    <!-- Client side setup -->
    <clients>
        <!-- maxusers is the max number of simultaneous clients. Don't set
        it too high because you can run out of file descriptors,
        ssl_esock use 2 fds by connection. -->

        <client host="localhost"  maxusers="500" use_controller_vm="true"/>

        <!-- Several virtual IP can be used to simulate more
        machines. Very useful when a load-balancer use the client's IP to
        distribute the traffic amoung a cluster of servers-->
        <!-- <ip value="192.168.2.223"></ip> -->
        <!-- <ip value="192.168.2.224"></ip> -->
        <!-- </client> -->

        <!-- a second machine is used, with a higher weight, and 2 cpus
        (erlang is not SMP aware, so we starts 2 beams to use all the
        CPUs -->
        <!-- <client host="myhost2" weight="3" maxusers="250" cpu="2">
        <ip value="192.168.2.225"></ip>
        </client> -->

        <!-- If you have a single machine to do the tests, you may add
        this attribute to the client tag: use_controller_vm="true" . This
        will run the virtual users on the same Virtual Machine as the
        controller. Useful if you have problems with starting up remote
        beam -->

    </clients>

    <!-- Server side setup -->
    <!-- Specify where the server is to test
    multiple servers can be defined for distributed testing -->
    <servers>
        <server host="localhost" port="3000" type="tcp"/>
    </servers>

    <!-- to start os monitoring (cpu, network, memory). Use an erlang
    agent on the remote machine or SNMP. Erlang is the default
    The web interface is running at port 8091 -->
    <monitoring>
        <monitor host="localhost" type="erlang"></monitor>
    </monitoring>

    <!-- several arrival phases can be set: for each phase, you can set
    the mean inter-arrival time between new clients and the phase
    duration -->
    <load>
        <arrivalphase phase="1" duration="1" unit="minute">

            <users arrivalrate="20" unit="second"></users>
```

```
        </arrivalphase>
        <arrivalphase phase="2" duration="1" unit="minute">
            <users arrivalrate="30" unit="second"></users>
        </arrivalphase>
    </load>

    <options>

        <!-- HTTP parameters -->
        <!-- If you want to benchmark a proxy server
        instead of a reguler web server-->
        <!--   <default type="ts_http" name="http_use_server_as_proxy" value="true"/>
-->

        <!-- Specify the virtual agent's browser, and the probabilty of each
        new agent spawning each -->

        <option type="ts_http" name="user_agent">
            <user_agent probability="80">Mozilla/5.0 (X11; U; Linux i686; en-US;
rv:1.7.8) Gecko/20050513 Galeon/1.3.21 </user_agent>
            <user_agent probability="20">Mozilla/5.0 (Windows; U; Windows NT 5.2; fr-
FR; rv:1.7.8) Gecko/20050511 Firefox/1.0.4 </user_agent>
        </option>
    </options>

    <sessions>
        <session name="http-example" probability="100" type="ts_http">
            <request> <http url="/" method="GET" version="1.1"></http> </request>
        </session>
    </sessions>
</tsung>
```

SSH Ask-Pass

By default, Tsung uses SSH to connect to the servers to start the Beam VM, thus it requires an SSH askpass application, to request the password from the user.

Linux

Depending on your Linux distribution there are multiple ask-pass clients that can be installed, for **Gnome** interface for example, the application `Seahorse` comes with an ask-pass client. It is found in the repository of most linux distributions and can be installed normally.

In order for Tsung to use the ask pass client, the path to the ask-pass client must be exported in the shell as so:

```
export SSH_ASKPASS=/usr/lib/seahorse/ssh -askpass
```

Note this assumes, you are using Seahorse as the ask-pass client and requires that Tsung is started from the same shell, the variable was exported in. If another ask-pass client is to be used, export the correct path

Mac

Mac users can use the askpass script supplied in the repository. After exporting the `SSH_ASKPASS` variable, another variable needs to be set as so:

```
export DISPLAY=":0"
```

Starting The Test

To run the test:

```
tsung -f http_simple.xml start
```

Note: Mac users may need to copy the XML document type definition (DTD) into the same directory the XML file is in.

A web interface is running at localhost:8091, alternatively you may use the `watch` command to monitor the progress of the tests as so:

```
watch -n1 tsung -f http_simple.xml status
```

Note: Mac users may need to install the `watch` command from brew.

For more details regarding the XML file, consult the official documentation. To send JSON requests in the tests, the quotations must be escaped, for instance:

{"name" : "hamada"} ⟶ {"name" : "hamada"}

Artillery

Similar to Tsung, except that is built on NodeJS utilizing the asynchronous model of the V8 engine (NodeJS VM). Unlike Tsung, it uses YAML format for defining the tests and it is not as feature rich.

Installing Artillery

To install artillery:

```
npm install -g artillery
```

Running Artillery

```yaml
config:
  target: "http://localhost:3000"
  phases:
    - duration: 60
      arrivalRate: 5
    - duration: 120
      arrivalRate: 5
      rampTo: 50
    - duration: 600
      arrivalRate: 50
  payload:
    path: "users.csv"
    fields:
      - "username"  # Will create a local variable username to be used below
      - "password" # Will create a local variable password to be used below
scenarios:
  - name: "Search and buy"
    flow: # Flow is an array of operations that a user may perform
      - post:
          url: "/auth"
          json:
            username: "{{username}}"
            password: "{{password}}"
      - get:
          url: "/details/{{ id }}"
      - think: 3
      - post:
          url: "/cart"
          json:
            productId: "{{ id }}"
```

Artillery allows for inserting data from a CSV file, for example: it is possible to have a precompiled list of usernames and passwords to be tested in a CSV file. To run the test:

> artillery run http_simple.yml

More commands and information can be found in the official documentation.

VisualVM

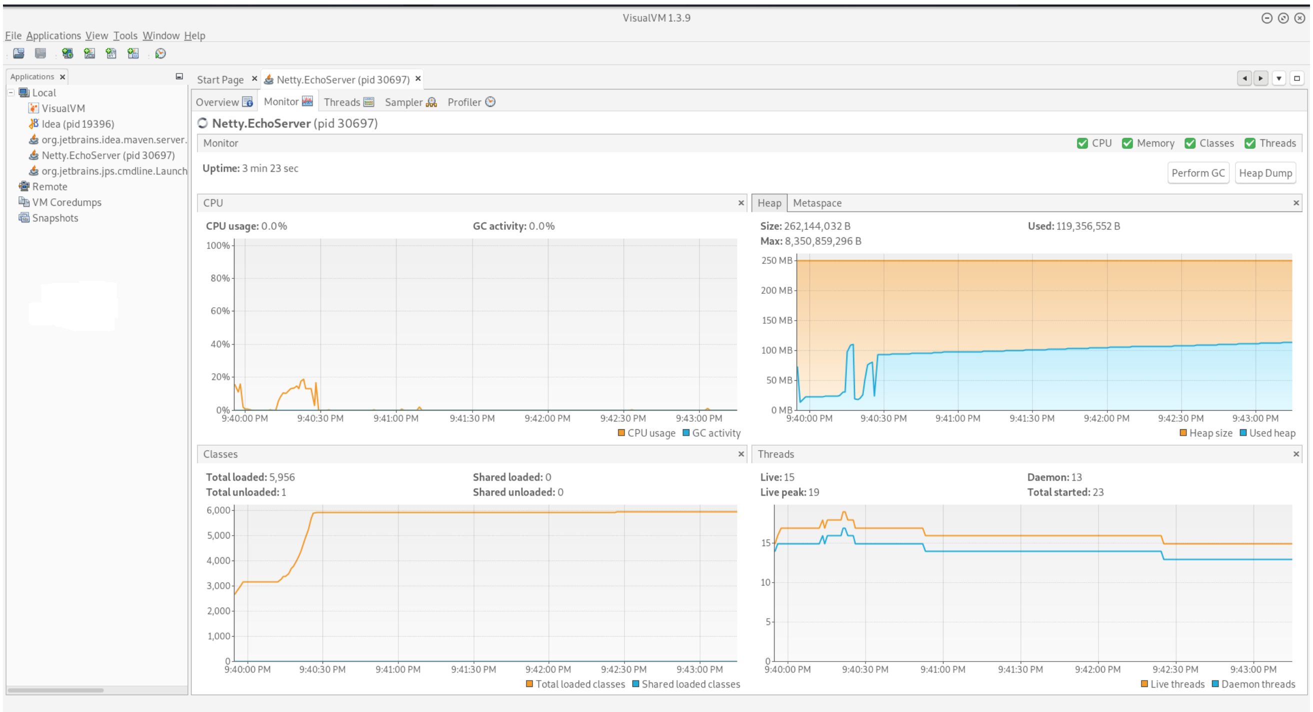
VisualVM is a tool used to monitor the internal state of the JVM per application. The application may be started with the application that is to be monitored or, attached to a running application. IntelliJ offers a VisualVM plugin, that allows for monitoring an application while it starts.

Monitoring An Application

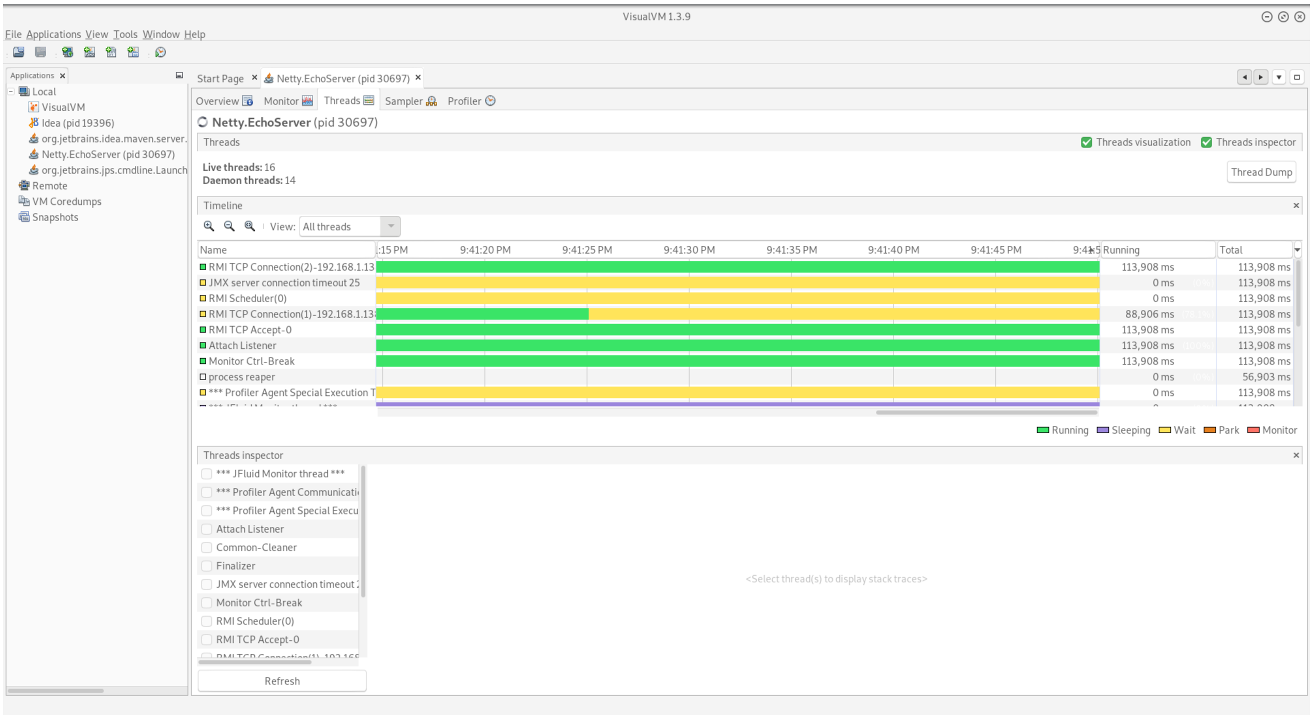
Start your application normally from within the IDE while ensuring that the following JVM arguments are placed:

> `-Xverify:none`

Start VisualVM and the interface should look like this:



It is possible to monitor remote JVMs by connecting to the remote machine using its IP. Heading over to the `Threads` tab the interface should look like this:



Thread State	Description
Running	Thread is currently executing
Sleeping	Thread is currently not in use
Waiting	Thread is blocked by a mutex/barrier and requires another thread to relinquish the lock
Parked	Thread is not permitted to execute by removing it from the scheduling process
Monitor	Thread is blocked

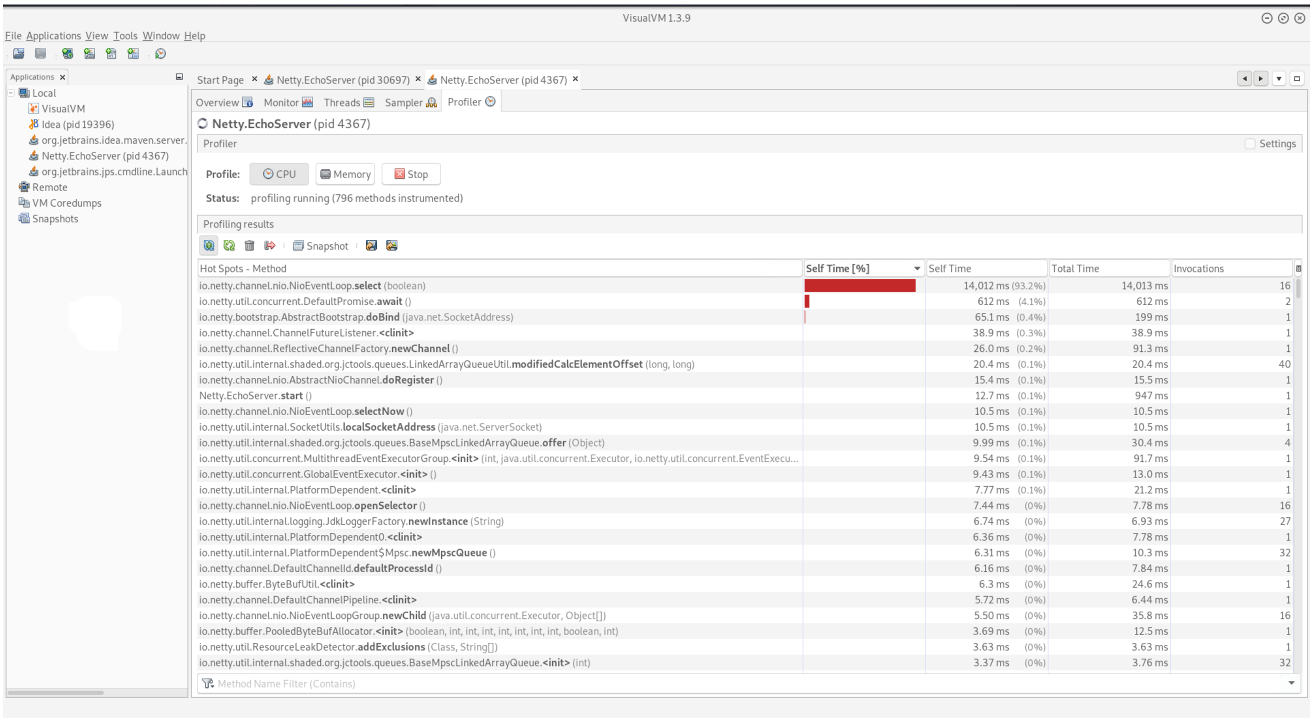
Profiling An Application

To get statistics regarding the CPU and memory time spent the application needs to be profiled while it is starting up. Before profiling it is important to calibrate the profiling tool which can be found in:

Tools → Options → Profiling → Manage

Note: while calibrating, it is important to disable dynamic frequency scaling on the CPU to avoid incorrect results, several tools exist to disable this, on Linux for example, the `cpupower` tool can do this by locking the maximum and minimum clocks at the same value.

To enable profiling while the application starts, the plugin needs to be installed from the plugin manager in the Tools menu. After running the plugin, an output similar to this should be available:



Extra Reading

Actor Model

This is a programming paradigm in which a system is compromised of actors. Actors are the smallest units of computation, they can:

1. Send and receive messages
2. Maintain a private state not shared by others
3. Act independently isolated from other actors

Actors can run concurrently but not necessarily in parallel, to explain the difference between concurrent and parallel we take a look at an analogy:

We wish to build two walls opposite each other, there is a pile of bricks and the bricks need to be carried each time you move build the wall. The *serial* solution would be to build one wall, then after finishing the wall, build the other wall. The *concurrent* solution would be to divide the wall into columns, and lay one column on each side, each time you carry the bricks to avoid repeated trips to the bricks pile. The *parallel* solution would be to hire **an extra** worker so that both of them build at the same time, however this will incur more resources to be used (paying another worker in this instance).

For an actor to run in parallel on the same message, they both need to receive the same message.

Beam VM

The Beam VM used by Erlang is not a virtual machine in the typical virtual machine sense, in other words typically virtual machines abstract the hardware layer by mapping calls from the program to the instruction set of the supporting hardware. For example, if Java was running on an x86 machine, it would map the instructions from the byte class file into actual x86 hardware instructions, if it runs on ARM architecture, it would be mapping to ARM instructions. Beam VM uses the actor model and uses processes instead of thread. Internally Beam VM spawns a process as an actor instead of a thread such it can more easily monitor and schedule the process than a thread, as each process has a unique name, it additionally enforces that processes only communicate through message passing with each other such that if a process has failed, it can roll back to the private state it held, or be completely restarted, depending on the scenario without affecting the entire system. Processes inside the Beam VM are very lightweight and do not incur significant overhead while creating them.

Beam VM is used in highly scalable applications (it mostly used in mobile communication systems and banking) as its "let it fail" approach allows for faster recovery of data rather than forcing the programmer to think of all possible scenarios where an application can fail and handle it in the code.