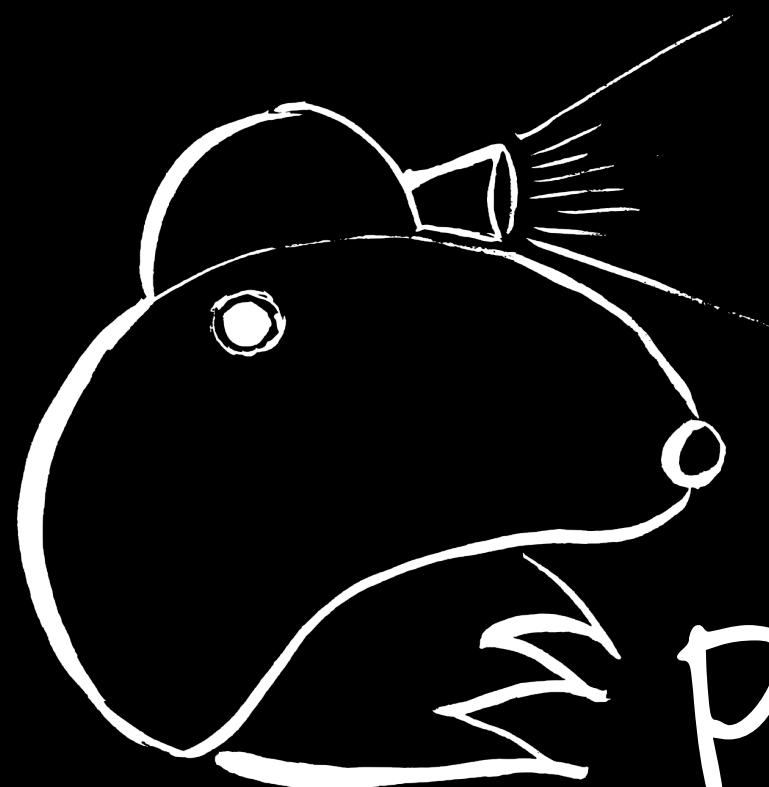


First steps with



penMOLE

Prerequisite

Make sure you have the Java runtime environment 7 or 8

```
reuillon@simplet: /home/reuillon
[reuillon:~] 25s $ java -version
Picked up JAVA_TOOL_OPTIONS: -javaagent:/usr/share/java/jay
atanaag.jar
openjdk version "1.8.0_66-internal"
OpenJDK Runtime Environment (build 1.8.0_66-internal-b01)
OpenJDK 64-Bit Server VM (build 25.66-b01, mixed mode)
[reuillon:~] 3s $
```

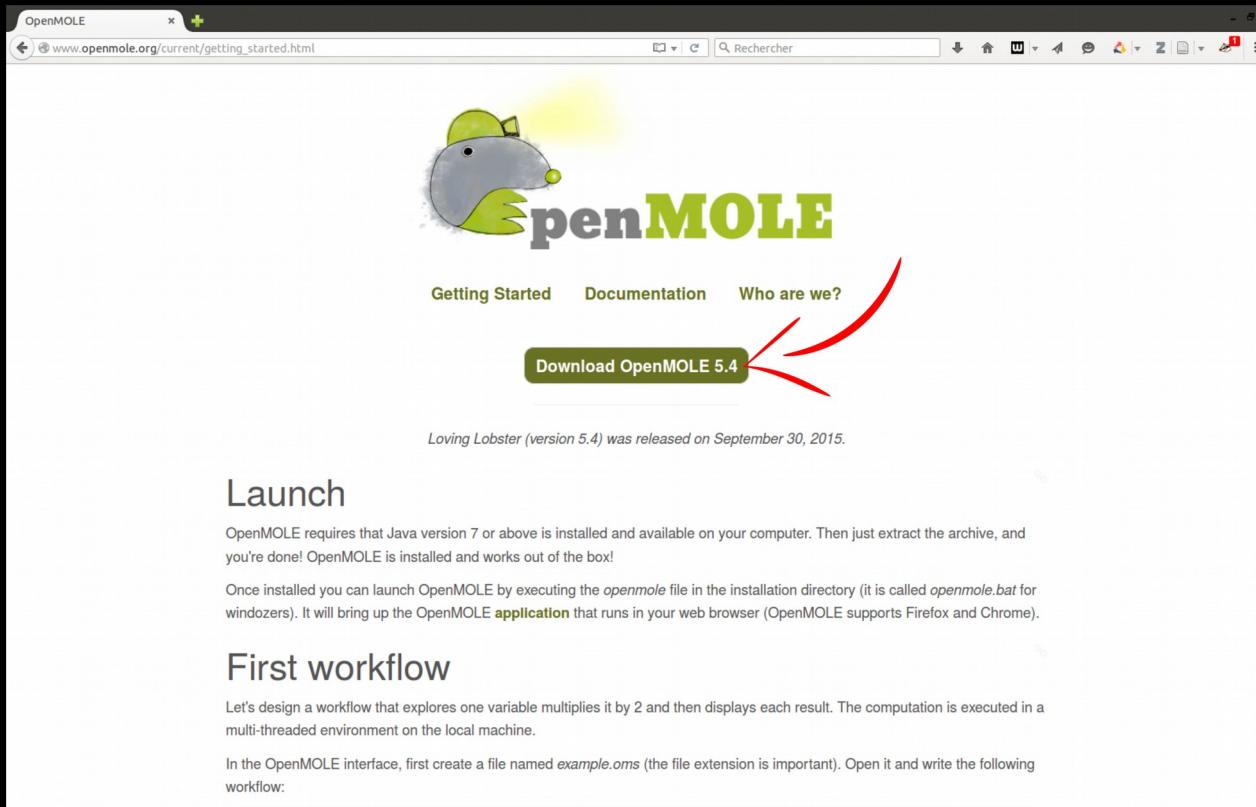
Prerequisite

Make sure you have Chrom(e | um) or
Firefox

Download

Go to: www.openmole.org

Go to: Getting Started.



The screenshot shows a web browser window with the OpenMOLE logo at the top. Below the logo, there are three navigation links: "Getting Started", "Documentation", and "Who are we?". A prominent green button labeled "Download OpenMOLE 5.4" is centered below these links. A red arrow points from the bottom right towards this button. Below the button, a small note states: "Loving Lobster (version 5.4) was released on September 30, 2015." The main content area is titled "Launch" and contains instructions for installing Java and launching the application. Another section titled "First workflow" provides a brief introduction to creating a workflow file.

Getting Started Documentation Who are we?

Download OpenMOLE 5.4

Loving Lobster (version 5.4) was released on September 30, 2015.

Launch

OpenMOLE requires that Java version 7 or above is installed and available on your computer. Then just extract the archive, and you're done! OpenMOLE is installed and works out of the box!

Once installed you can launch OpenMOLE by executing the `openmole` file in the installation directory (it is called `openmole.bat` for windozers). It will bring up the OpenMOLE **application** that runs in your web browser (OpenMOLE supports Firefox and Chrome).

First workflow

Let's design a workflow that explores one variable multiplies it by 2 and then displays each result. The computation is executed in a multi-threaded environment on the local machine.

In the OpenMOLE interface, first create a file named `example.oms` (the file extension is important). Open it and write the following workflow:

Launch

Run:

- Linux | Mac => openmole.sh
- Windoze => openmole.bat

Insecure connection

Connexion non certifiée

https://localhost:36093

Rechercher

Connexion non certifiée

Cette connexion n'est pas certifiée

Vous avez demandé à Firefox de se connecter de manière sécurisée à **localhost:36093**, mais nous ne pouvons pas confirmer que votre connexion est sécurisée.

Normalement, lorsque vous essayez de vous connecter de manière sécurisée, les sites présentent une identification certifiée pour prouver que vous vous trouvez à la bonne adresse. Cependant, l'identité de ce site ne peut pas être vérifiée.

Que dois-je faire ?

Si vous vous connectez habituellement à ce site sans problème, cette erreur peut signifier que quelqu'un essaie d'usurper l'identité de ce site et vous ne devriez pas continuer.

Sortir d'ici !

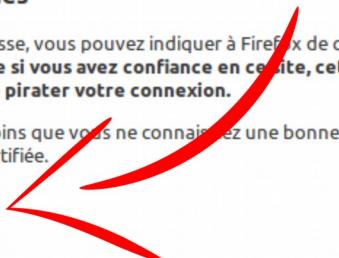
Détails techniques

Je comprends les risques

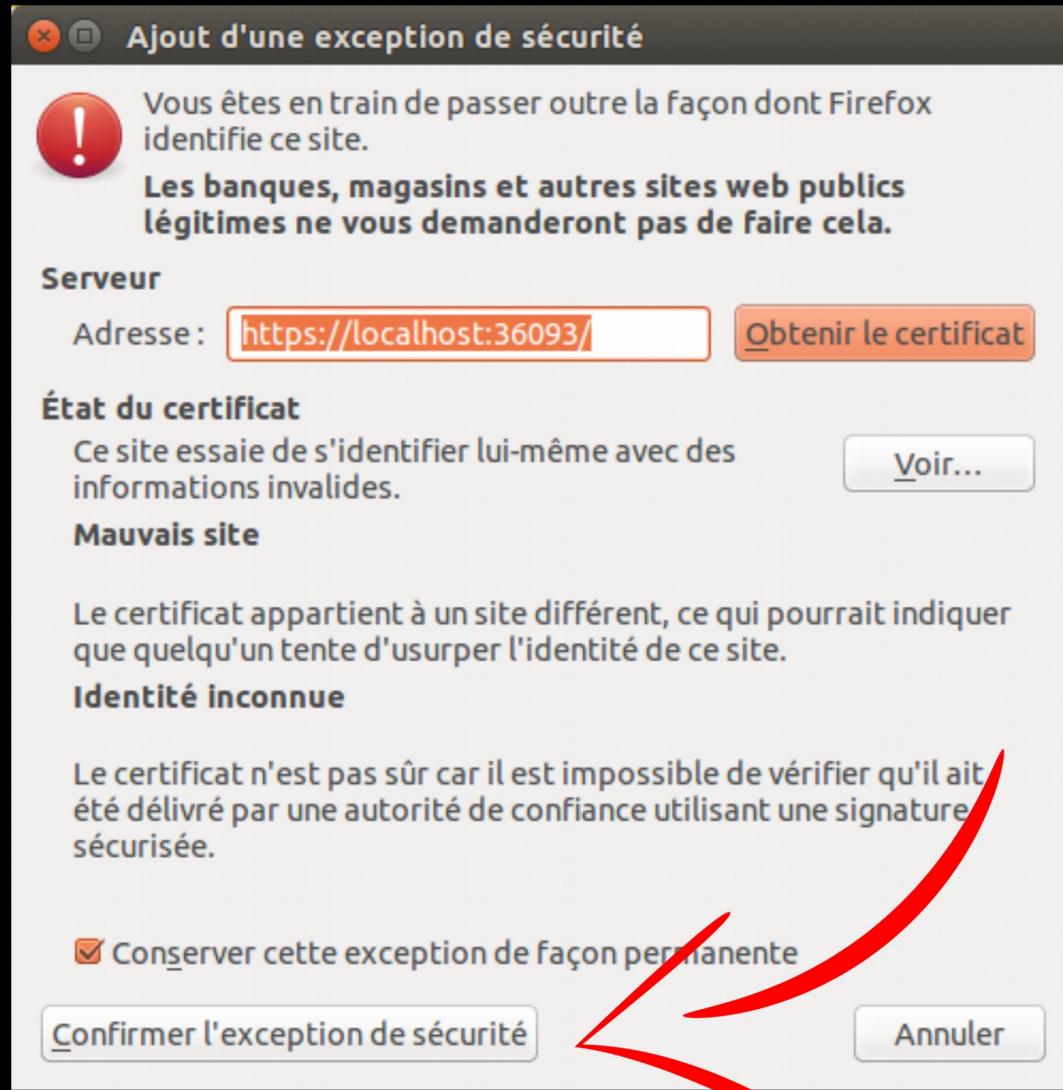
Si vous comprenez ce qui se passe, vous pouvez indiquer à Firefox de commencer à faire confiance à l'identification de ce site. **Même si vous avez confiance en ce site, cette erreur pourrait signifier que quelqu'un est en train de pirater votre connexion.**

N'ajoutez pas d'exception à moins que vous ne connaissez une bonne raison pour laquelle ce site n'utilise pas d'identification certifiée.

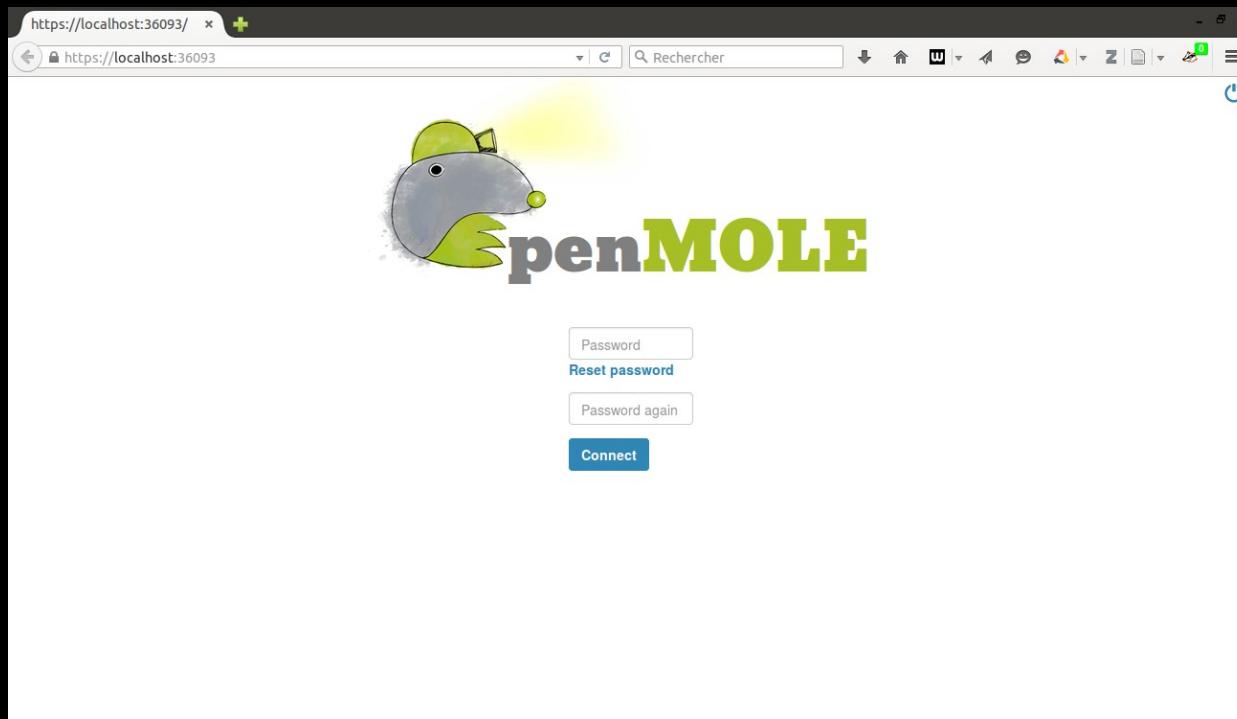
Ajouter une exception...



Insecure connection



OpenMOLE password



Chose a password to encrypt secret data you provide to OpenMOLE: passwords for servers...

Welcome to OpenMOLE

The screenshot shows the OpenMOLE web interface at <https://localhost:34887/>. The interface has a dark theme with a top navigation bar containing various icons. A sidebar on the left includes a 'File' dropdown, a 'File name' input field with a blue 'Upload' button, and a 'Home' button. The main area displays the text 'Create a first OpenMOLE script (.oml)'. Red annotations have been added to highlight specific features: 'Upload files' points to the 'Upload' button in the sidebar; 'Create new files' points to the 'File' dropdown; and 'File browser' points to the sidebar itself.

https://localhost:34887/

File name

Upload files

Create new files

File browser

Rechercher

Home

Create a first OpenMOLE script (.oml)



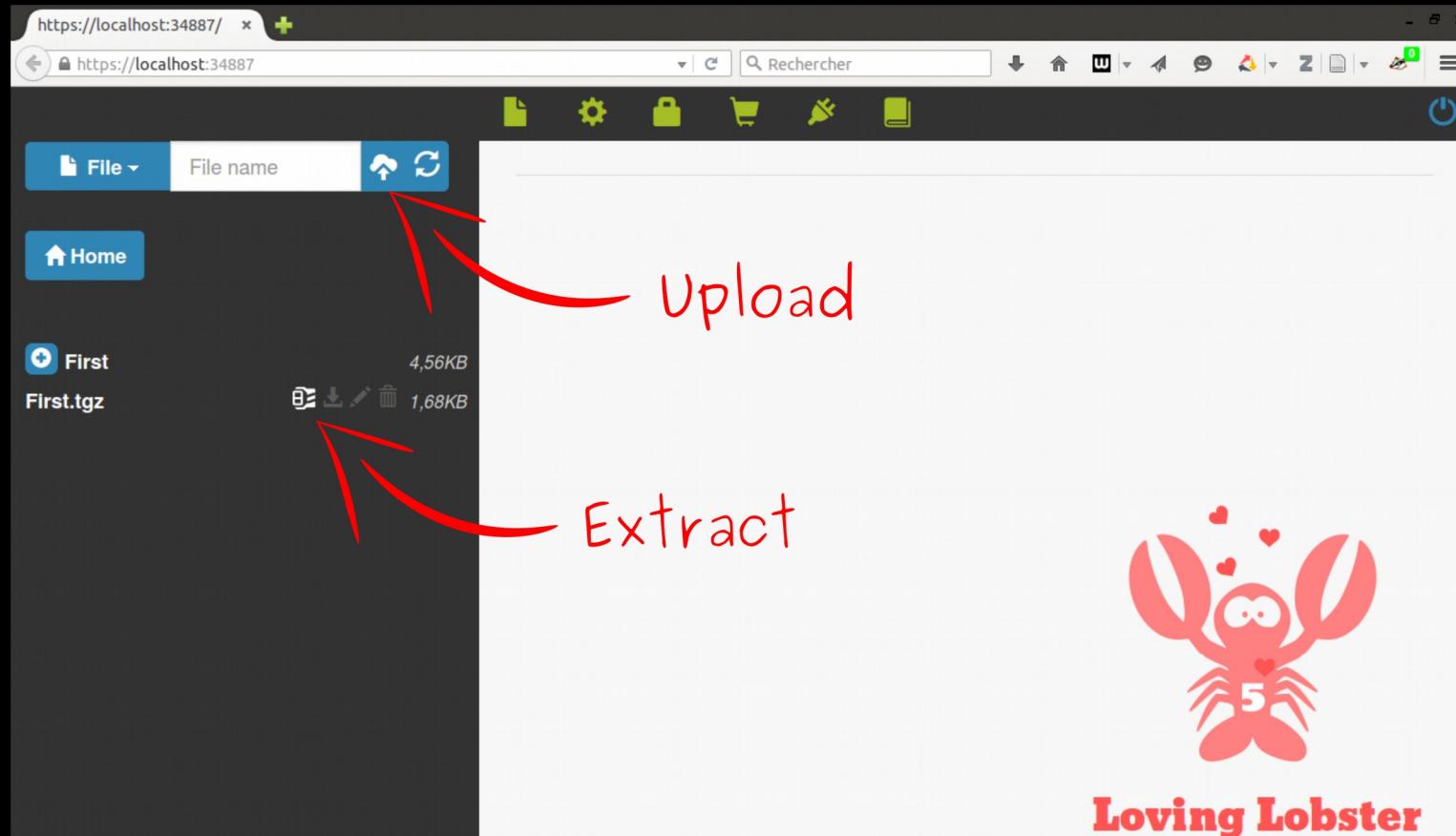
Loving Lobster

First workflow

Go to: www.openmole.org/files/csdcc

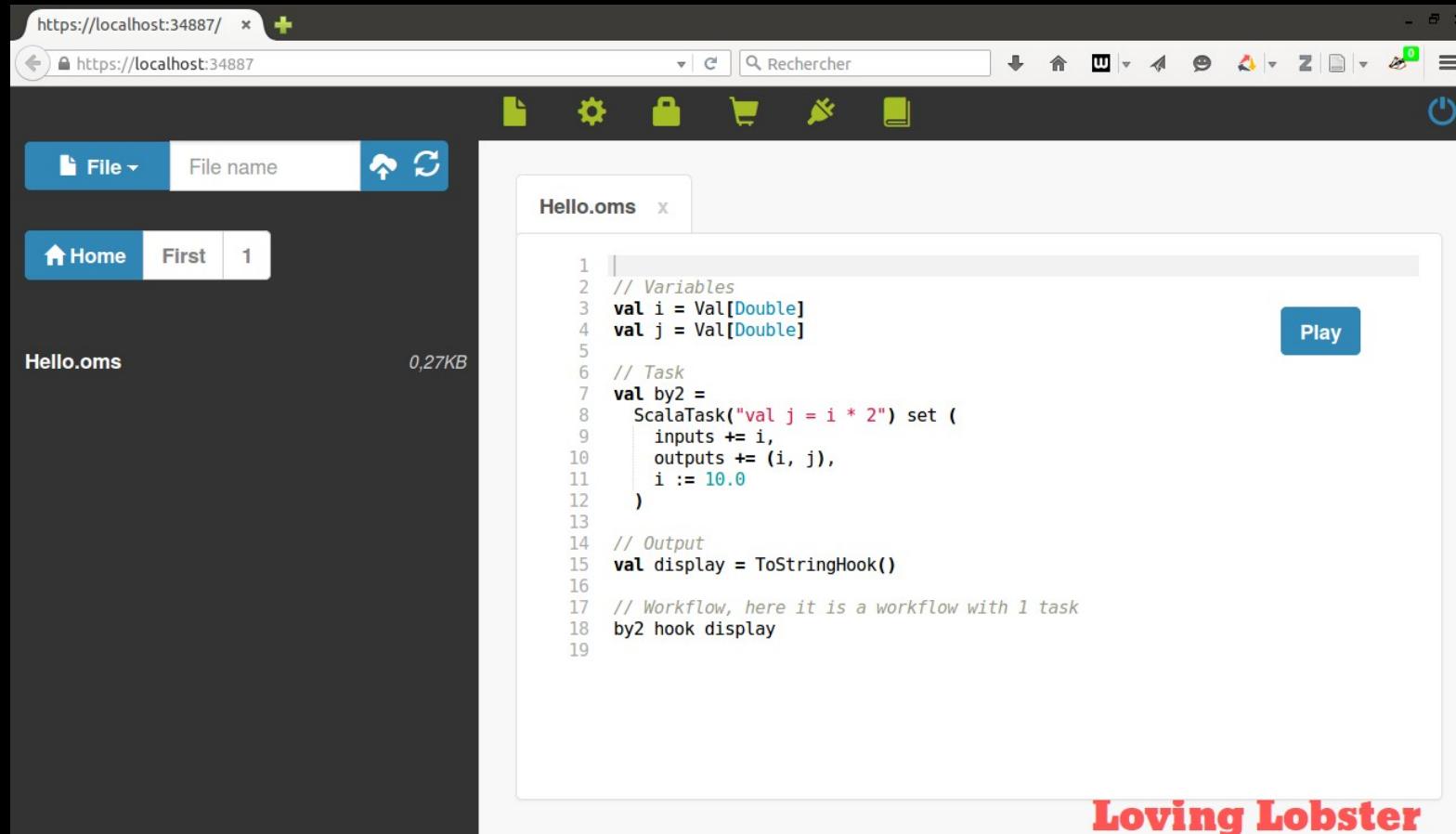
Download First.tgz

First workflow



Upload the archive
Extract it

First workflow

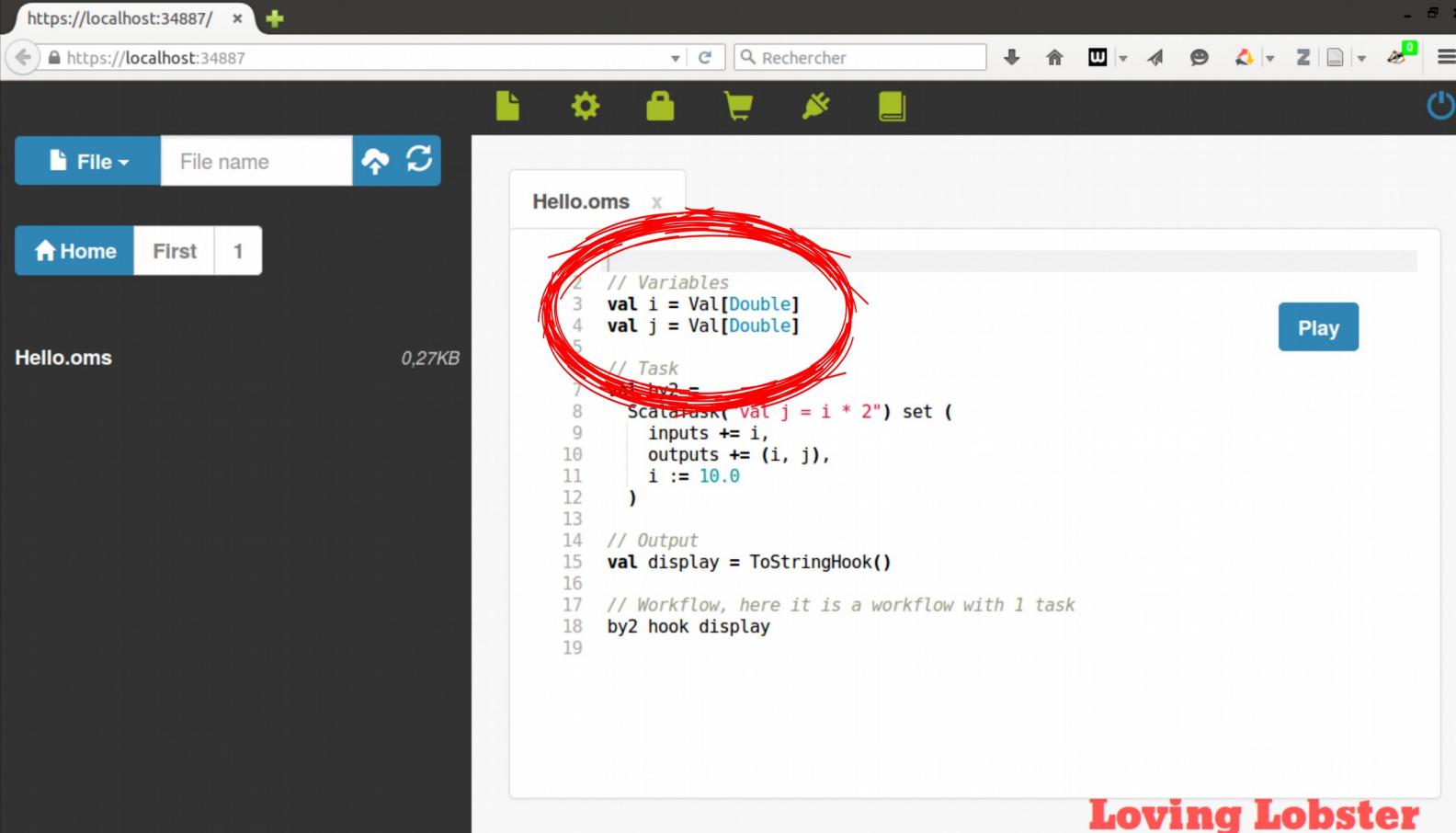


Click on the folder "First"

Click on the folder "1"

Click on the file "Hello.oms"

First workflow



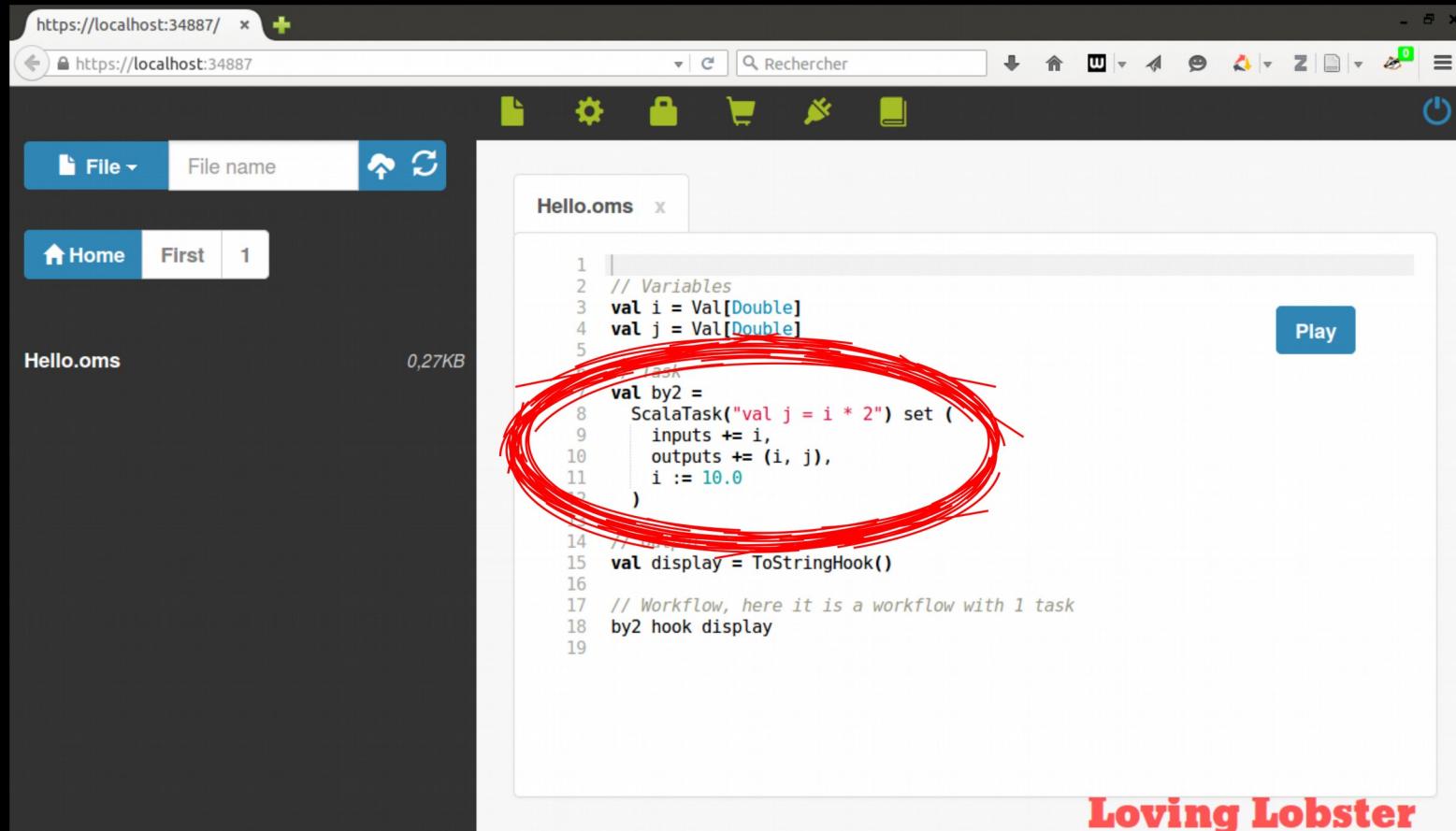
The screenshot shows a web browser window with a dark theme. The address bar displays `https://localhost:34887/`. The main content area is a code editor titled "Hello.oms". A red circle highlights the first two lines of code, which declare typed variables `i` and `j` as `Val[Double]`. The code editor interface includes a toolbar with icons for file operations, a search bar labeled "Rechercher", and a "Play" button. The code itself is a Scala snippet defining a workflow with tasks and output.

```
1 // Variables
2 val i = Val[Double]
3 val j = Val[Double]
4
5 // Task
6 i >= j ->
7   Scaladask("val j = i * 2") set (
8     inputs += i,
9     outputs += (i, j),
10    i := 10.0
11  )
12
13
14 // Output
15 val display = ToStringHook()
16
17 // Workflow, here it is a workflow with 1 task
18 by2 hook display
19
```

Loving Lobster

Express the dataflow
Variables are typed

First workflow



A screenshot of a web browser window displaying a Scala code editor. The URL is <https://localhost:34887/>. The code editor shows a file named "Hello.oms" with the following content:

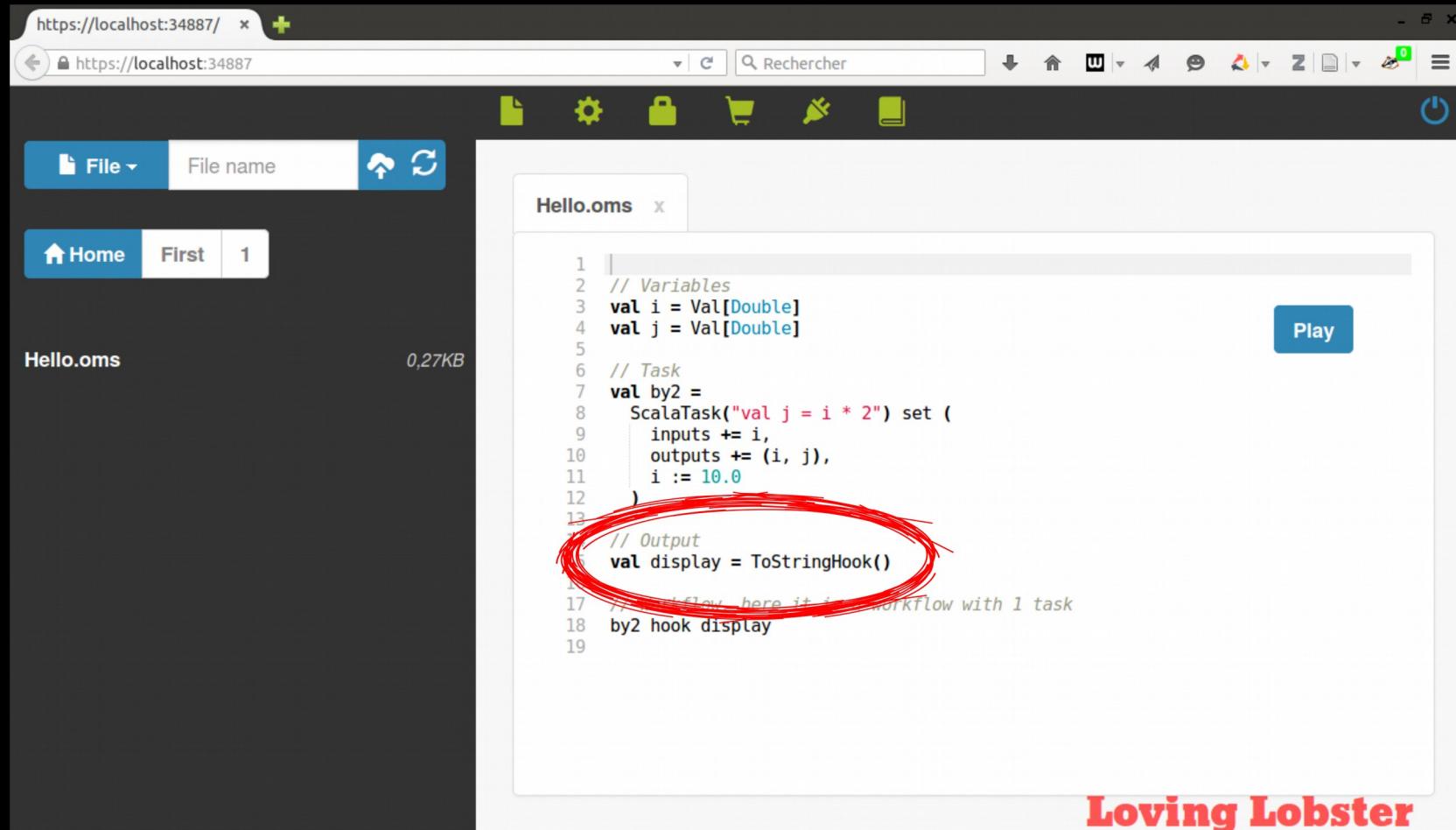
```
1 // Variables
2 val i = Val[Double]
3 val j = Val[Double]
4
5 // TASK
6 val by2 =
7   ScalaTask("val j = i * 2") set (
8     inputs += i,
9     outputs += (i, j),
10    i := 10.0
11  )
12
13 // WORKFLOW
14 val display = ToStringHook()
15
16 // Workflow, here it is a workflow with 1 task
17 by2 hook display
18
19
```

The line `val by2 =` is circled with a red marker. A blue "Play" button is visible on the right side of the code editor. The browser interface includes a file manager, search bar, and various icons at the top.

Loving Lobster

Express computation
Uses inputs, produces outputs
(may specify default values)

First workflow



The screenshot shows a web browser window with the URL <https://localhost:34887/>. The page displays a file named "Hello.oms" with a size of 0,27KB. The file content is a Scala code snippet:

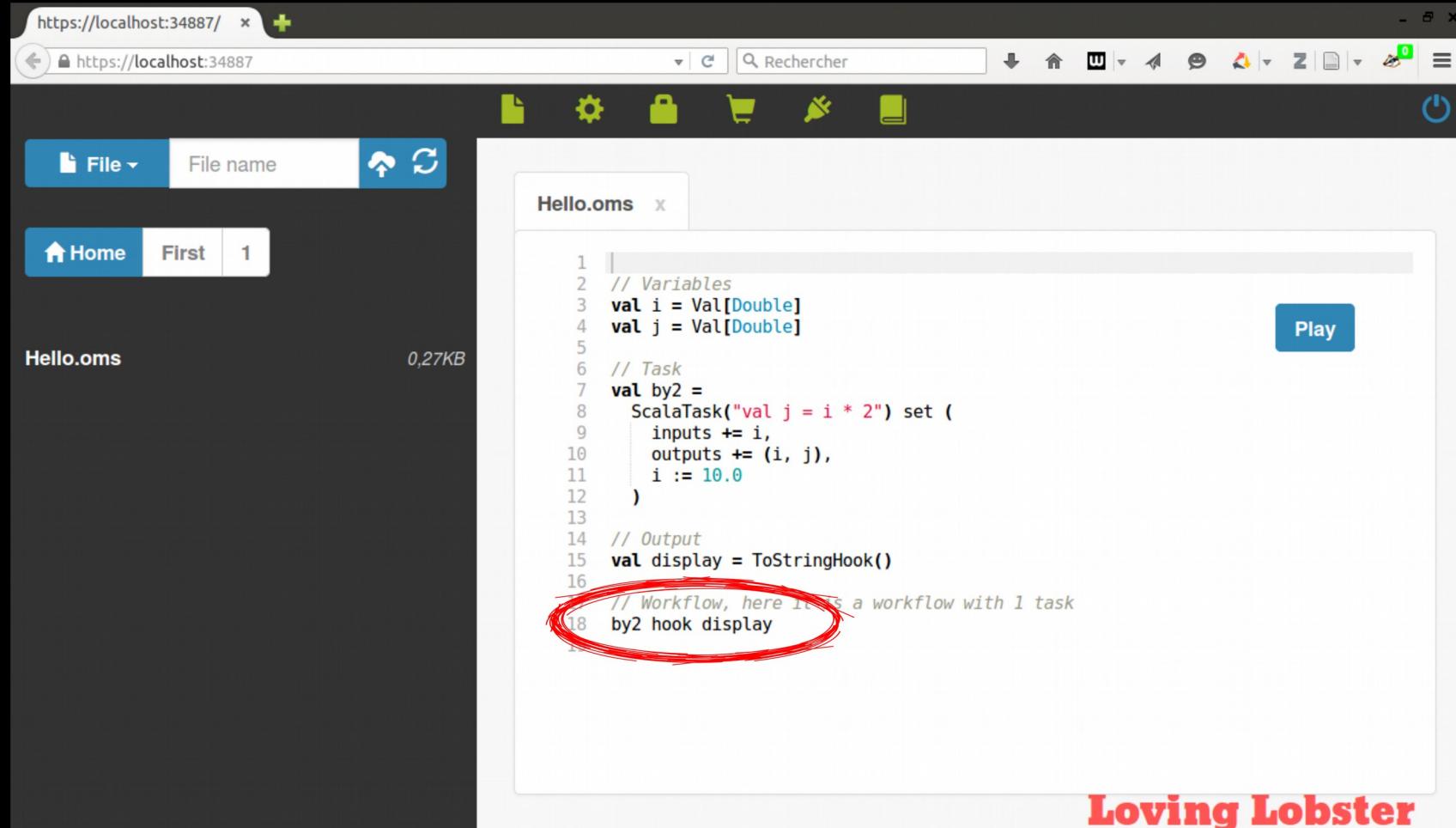
```
1 // Variables
2 val i = Val[Double]
3 val j = Val[Double]
4
5 // Task
6 val by2 =
7   ScalaTask("val j = i * 2") set (
8     inputs += i,
9     outputs += (i, j),
10    i := 10.0
11  )
12
13 // Output
14 val display = ToStringHook()
15
16 // Workflow here it is a workflow with 1 task
17 by2 hook display
18
19
```

A red oval highlights the line `val display = ToStringHook()`. A blue "Play" button is visible on the right side of the code editor.

Loving Lobster

Express output operations
Always runs locally

First workflow



https://localhost:34887/ x +

https://localhost:34887 Rechercher

File name

File Home First 1

Hello.oms 0,27KB

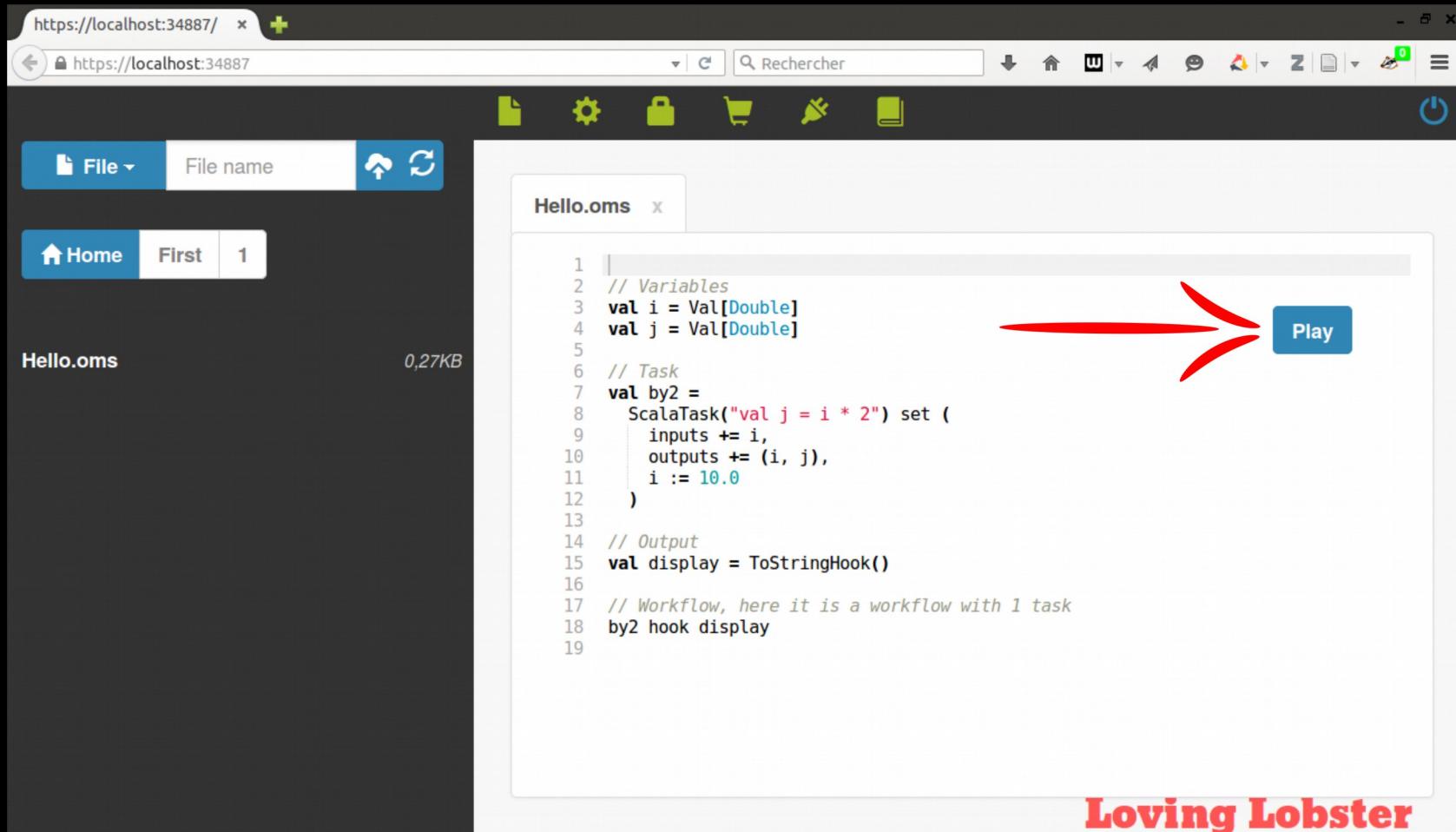
```
1 // Variables
2 val i = Val[Double]
3 val j = Val[Double]
4
5 // Task
6 val by2 =
7   ScalaTask("val j = i * 2") set (
8     inputs += i,
9     outputs += (i, j),
10    i := 10.0
11  )
12
13 // Output
14 val display = ToStringHook()
15
16 // Workflow, here it's a workflow with 1 task
17
18 by2 hook display
```

Play

Loving Lobster

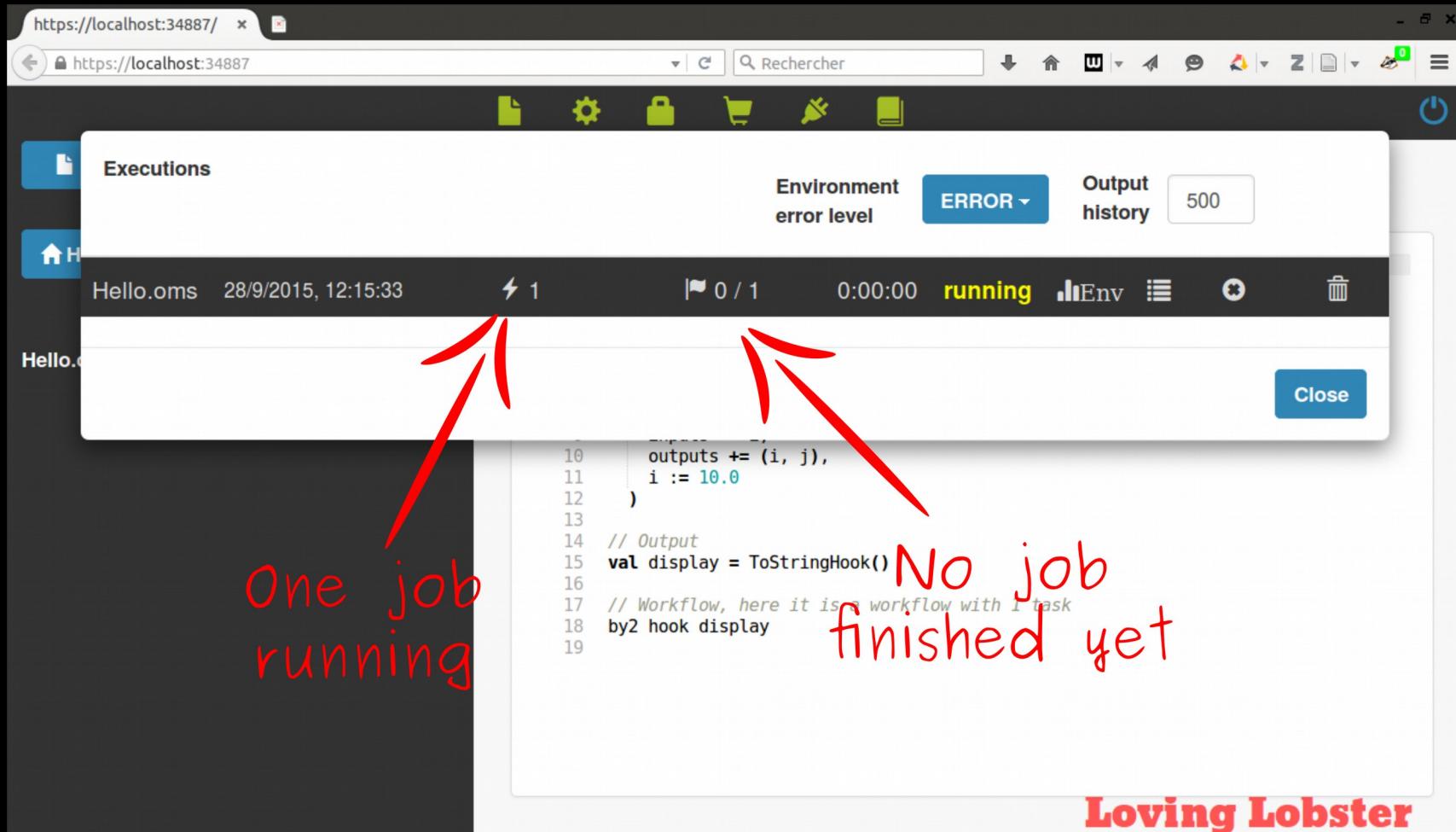
Express workflow composition
Here: One task + One hook

First workflow



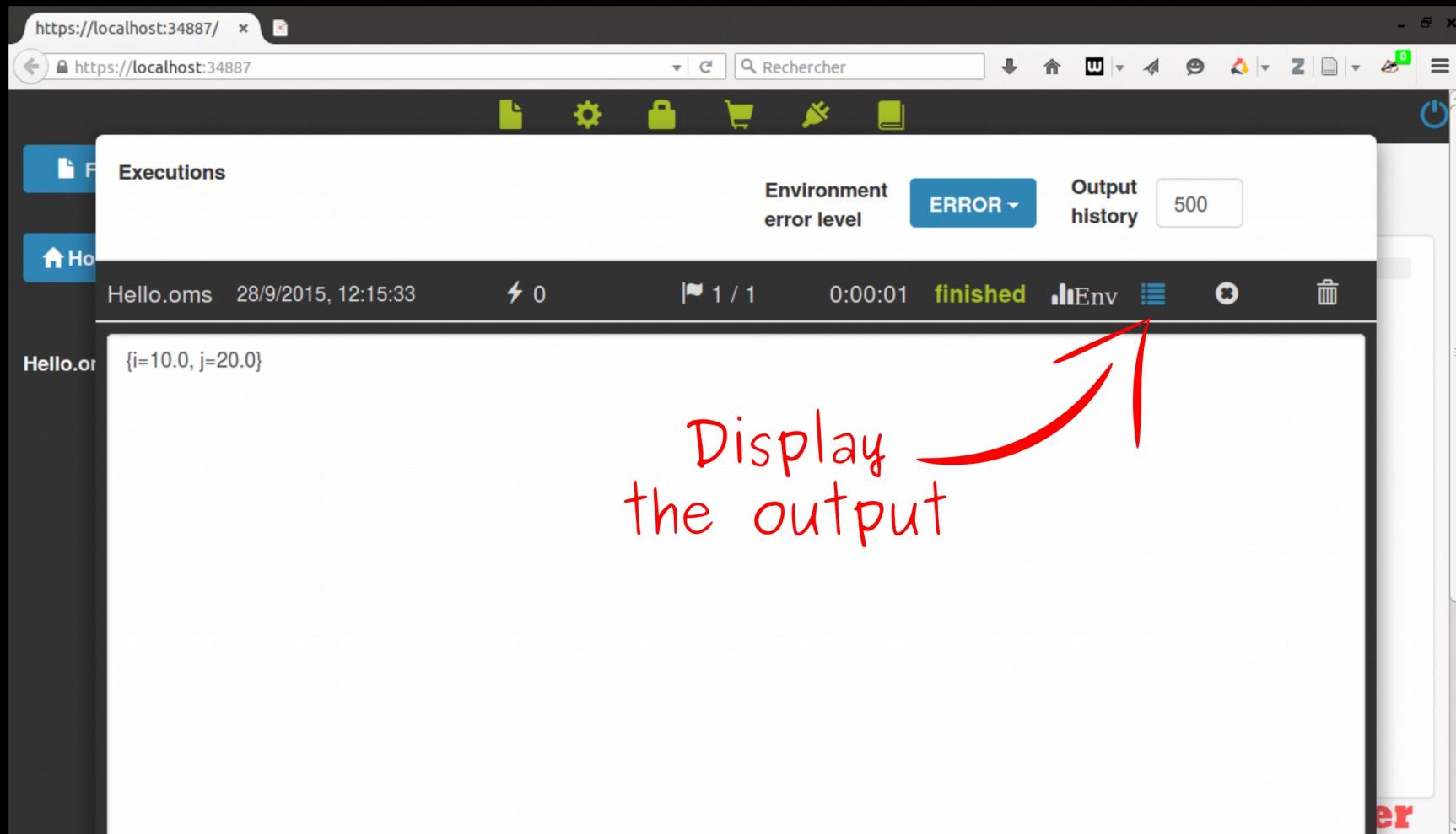
And now lets run!

First workflow



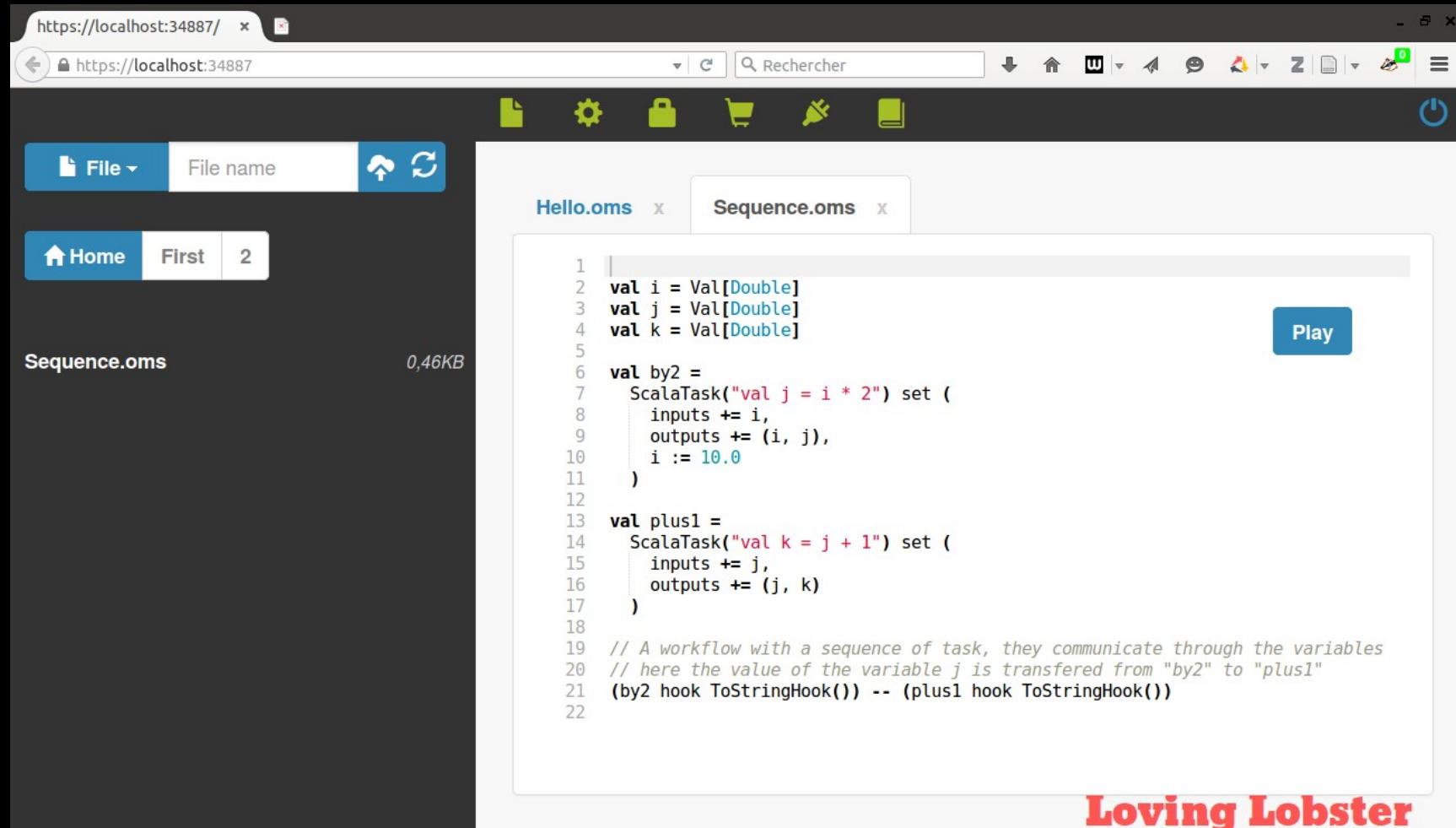
Running...

First workflow



Display the result.

The sequence



A screenshot of a web browser window displaying a Scala code editor. The URL is `https://localhost:34887/`. The code editor shows two tabs: `Hello.oms` and `Sequence.oms`. The `Sequence.oms` tab is active, containing the following Scala code:

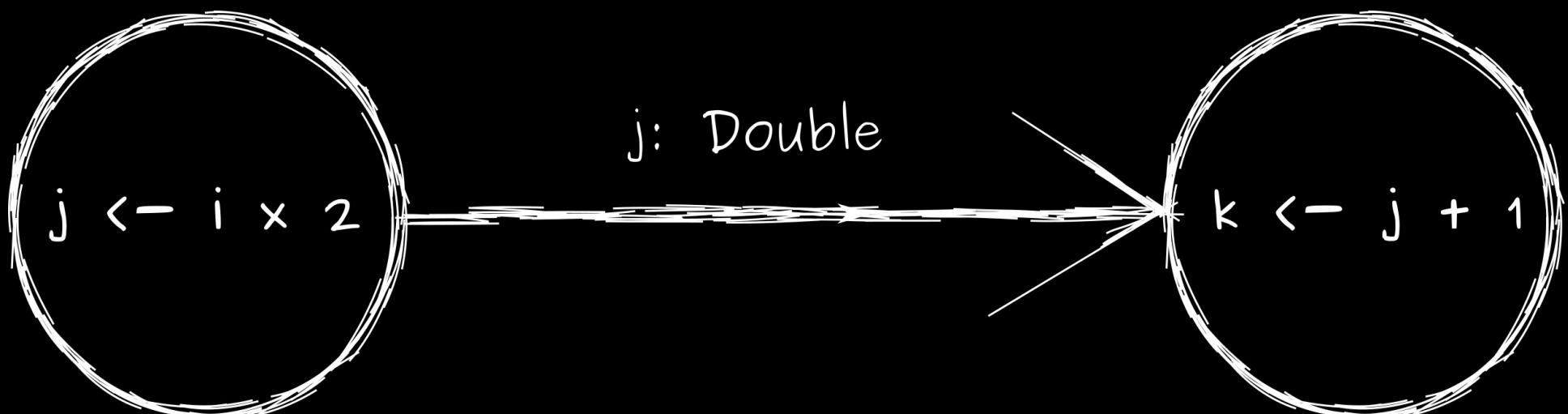
```
1  |||  
2  val i = Val[Double]  
3  val j = Val[Double]  
4  val k = Val[Double]  
5  
6  val by2 =  
7    ScalaTask("val j = i * 2") set (  
8      inputs += i,  
9      outputs += (i, j),  
10     i := 10.0  
11   )  
12  
13  val plus1 =  
14    ScalaTask("val k = j + 1") set (  
15      inputs += j,  
16      outputs += (j, k)  
17    )  
18  
19 // A workflow with a sequence of task, they communicate through the variables  
20 // here the value of the variable j is transferred from "by2" to "plus1"  
21 (by2 hook ToStringHook()) -- (plus1 hook ToStringHook())  
22
```

On the right side of the code editor, there is a blue **Play** button. At the bottom right of the entire window, the text **Loving Lobster** is displayed in red.

Go to the directory "2"
Click on "Sequence.oms"

The sequence

Tasks communicate through variables.

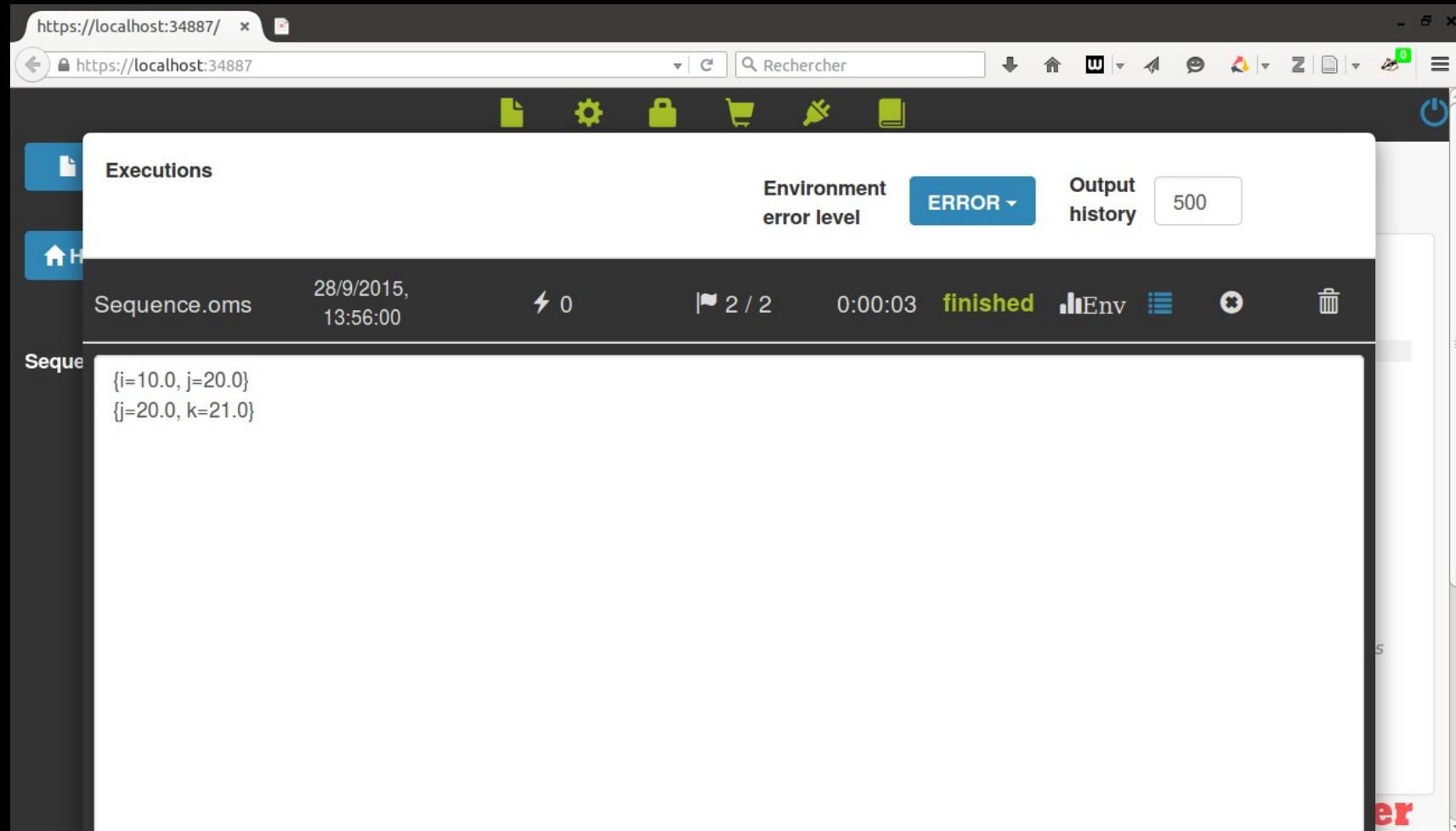


The sequence

A sequence of task is represented by --

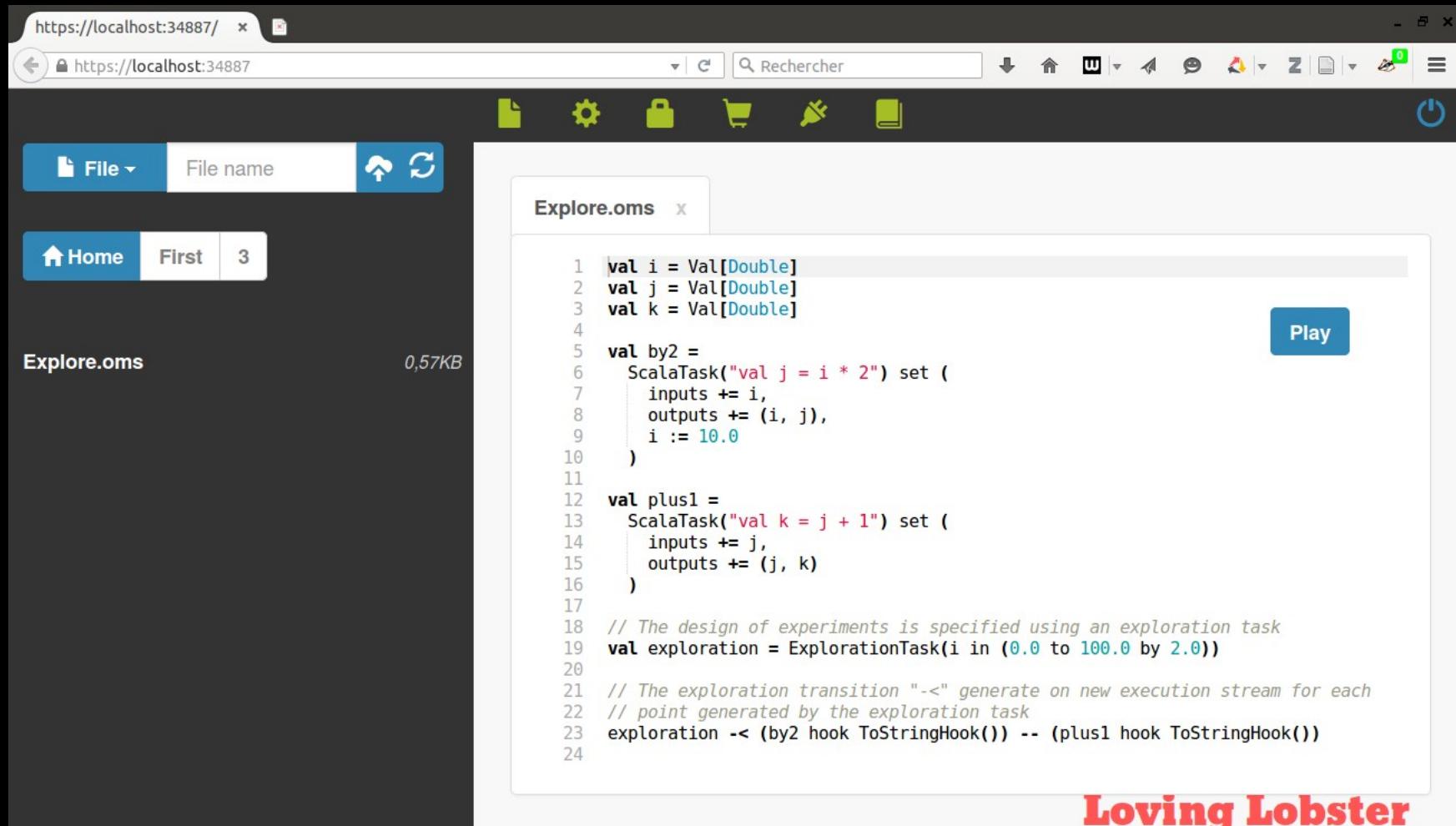
```
18
19 // A workflow with a sequence of task, they communicate through the variables
20 // here the value of the variable j is transferred from "by2" to "plus1"
21 (by2 hook ToStringHook()) -- (plus1 hook ToStringHook())
22
```

The sequence



Run the workflow.

The exploration



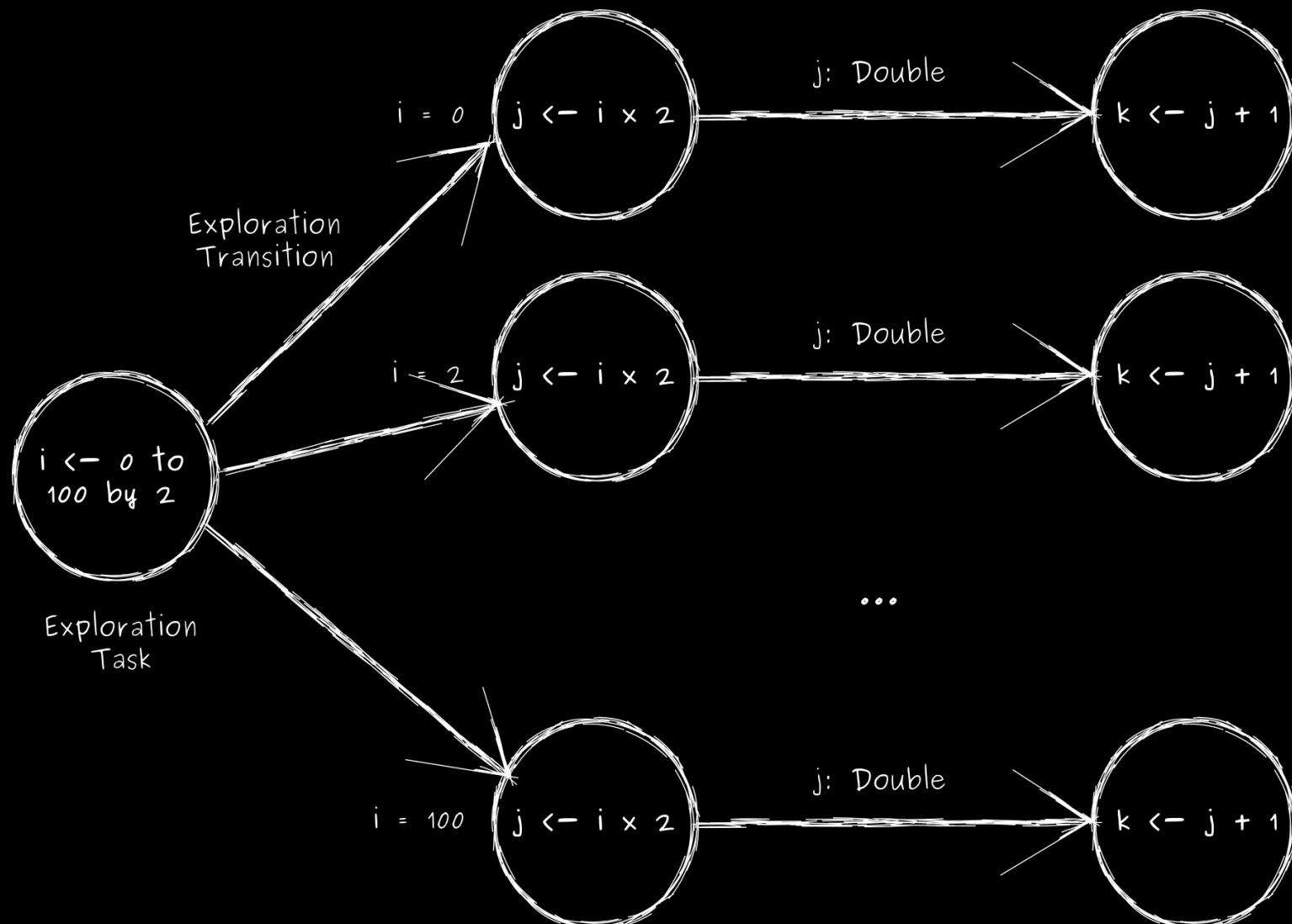
A screenshot of a web browser window displaying a file named "Explore.oms". The browser interface includes a header with a search bar and various icons, a toolbar with file operations like "File", "Upload", and "Refresh", and a navigation bar with "Home", "First", and "3". The main content area shows the code for "Explore.oms" with line numbers 1 through 24. The code defines Scala tasks for generating values i, j, and k, and for performing operations like doubling and adding 1. It also specifies an exploration task for value i ranging from 0.0 to 100.0. A "Play" button is visible on the right side of the code editor.

```
1 val i = Val[Double]
2 val j = Val[Double]
3 val k = Val[Double]
4
5 val by2 =
6   ScalaTask("val j = i * 2") set (
7     inputs += i,
8     outputs += (i, j),
9     i := 10.0
10   )
11
12 val plus1 =
13   ScalaTask("val k = j + 1") set (
14     inputs += j,
15     outputs += (j, k)
16   )
17
18 // The design of experiments is specified using an exploration task
19 val exploration = ExplorationTask(i in (0.0 to 100.0 by 2.0))
20
21 // The exploration transition "-<" generate on new execution stream for each
22 // point generated by the exploration task
23 exploration -< (by2 hook ToStringHook()) -- (plus1 hook ToStringHook())
```

Loving Lobster

Go to the directory "3"
Click on "Sequence.oms"

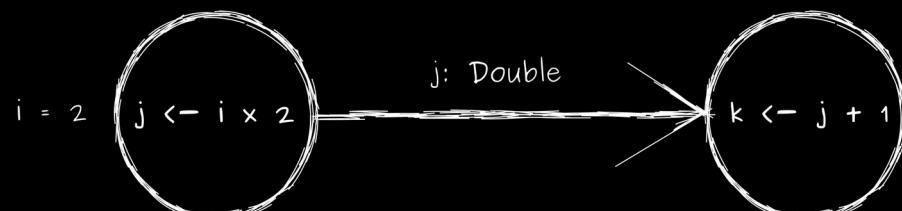
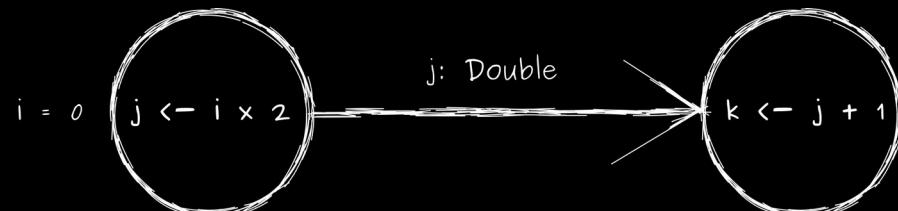
The exploration



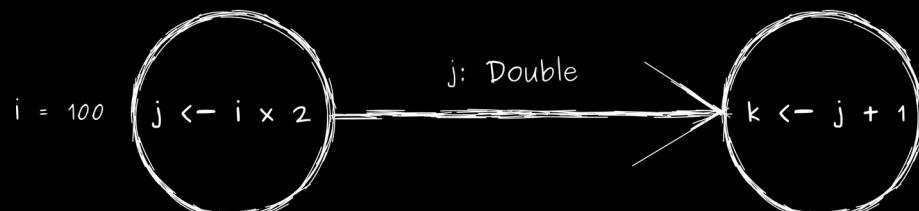
Exploration Task + Exploration Transition

The exploration

The objective is to execute the sequence of tasks for many input values:



...



The exploration

```
18 // The design of experiments is specified using an exploration task  
19 val exploration = ExplorationTask(i in (0.0 to 100.0 by 2.0))  
20
```

The exploration task contains the design of experiments.

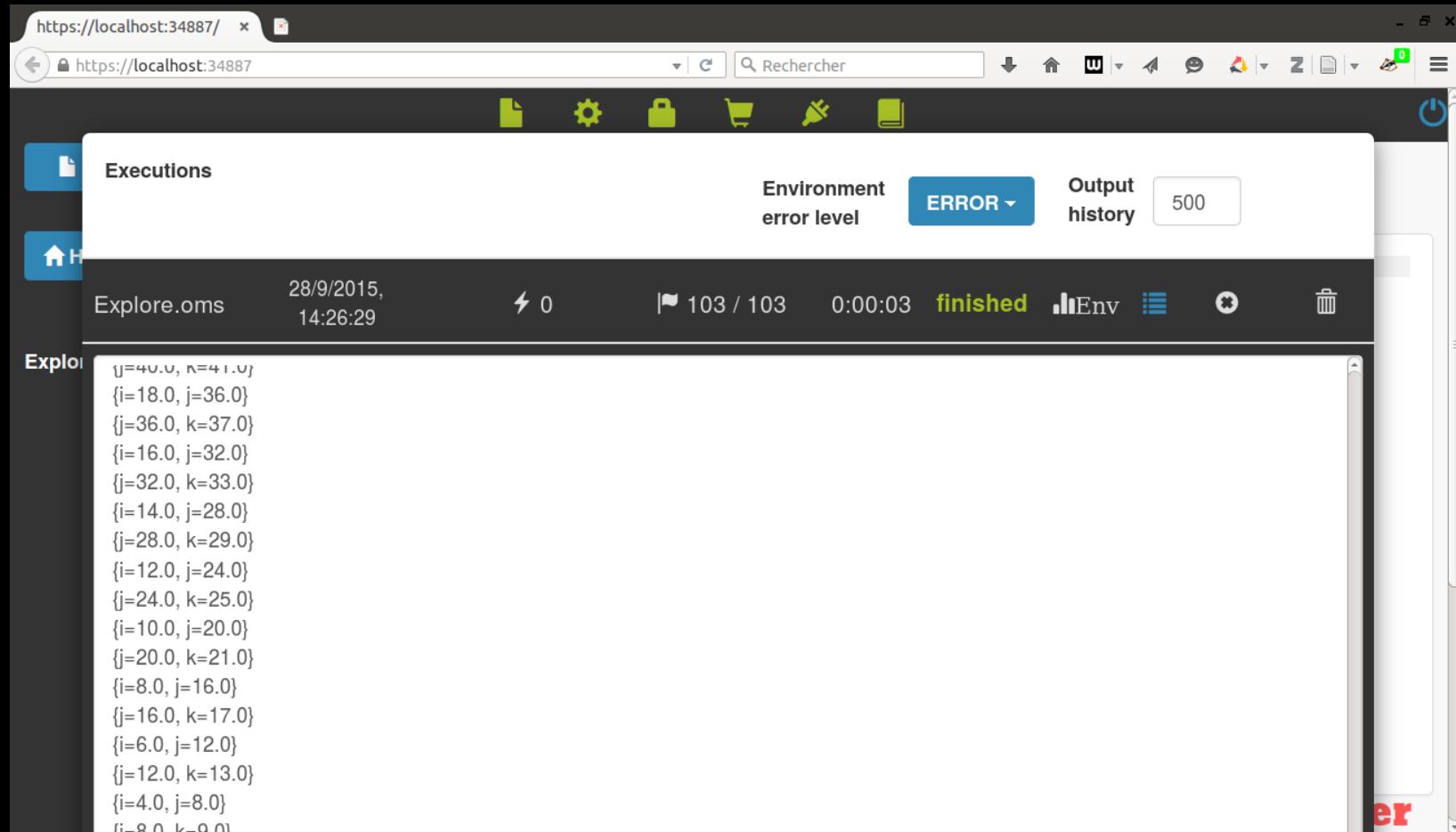
A design of experiments can compose many things (see the Sampling doc).

The exploration

```
21 // The exploration transition "-<" generate on new execution stream for each
22 // point generated by the exploration task
23 exploration -< (by2 hook ToStringHook()) -- (plus1 hook ToStringHook())
```

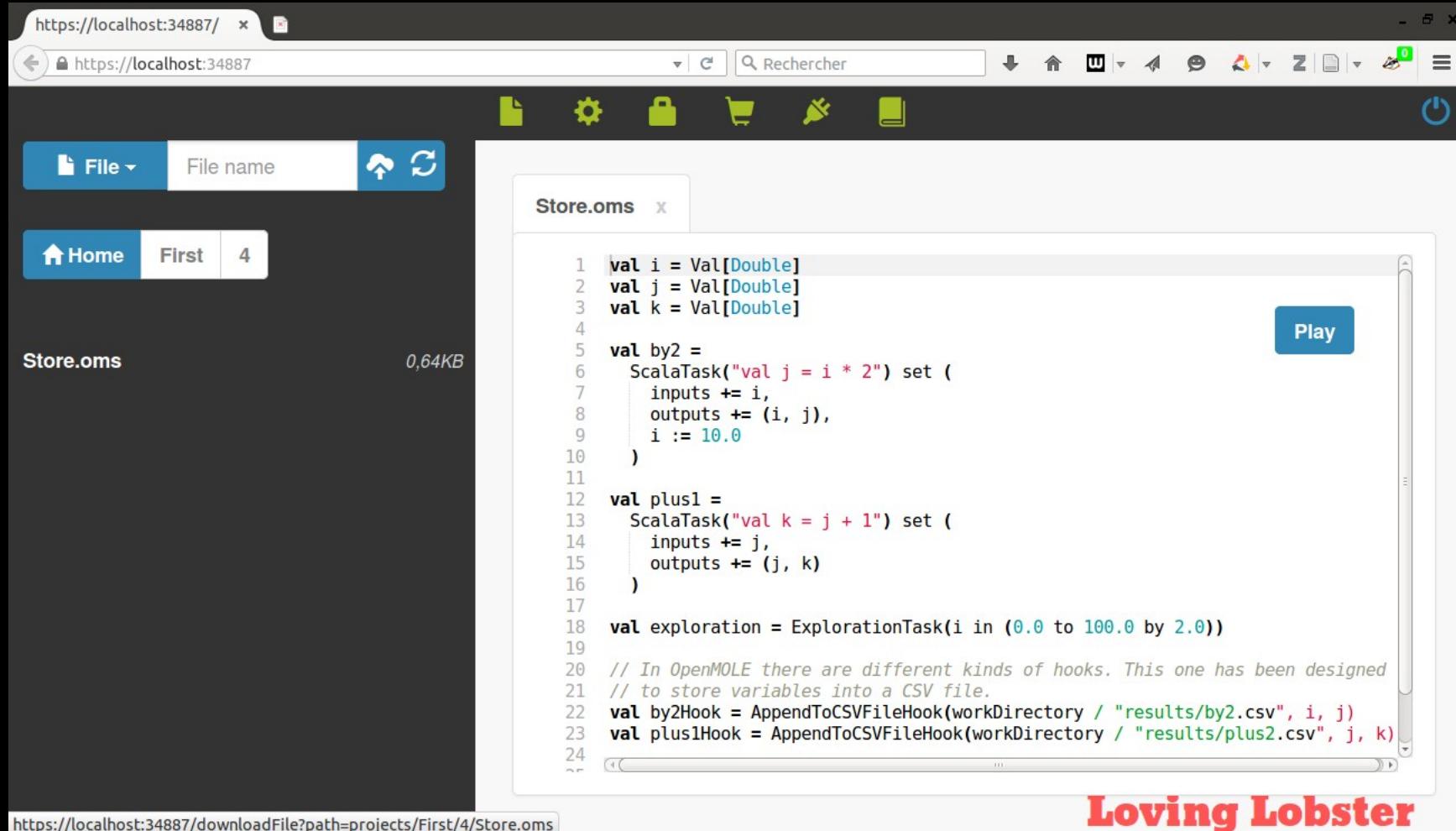
The notation for the exploration
transition is “-<”.

The exploration



Run it

Store results in files



The screenshot shows a web-based interface for managing OpenMOLE projects. At the top, a browser window displays the URL <https://localhost:34887/>. Below the browser is a toolbar with various icons. On the left, there's a sidebar with a 'File' dropdown, a 'File name' input field, and upload/download/cancel buttons. The main area shows a file named 'Store.oms' with a size of 0,64KB. The file content is a Scala script:

```
1 val i = Val[Double]
2 val j = Val[Double]
3 val k = Val[Double]
4
5 val by2 =
6   ScalaTask("val j = i * 2") set (
7     inputs += i,
8     outputs += (i, j),
9     i := 10.0
10   )
11
12 val plus1 =
13   ScalaTask("val k = j + 1") set (
14     inputs += j,
15     outputs += (j, k)
16   )
17
18 val exploration = ExplorationTask(i in (0.0 to 100.0 by 2.0))
19
20 // In OpenMOLE there are different kinds of hooks. This one has been designed
21 // to store variables into a CSV file.
22 val by2Hook = AppendToCSVFileHook(workDirectory / "results/by2.csv", i, j)
23 val plus1Hook = AppendToCSVFileHook(workDirectory / "results/plus2.csv", j, k)
24
```

A 'Play' button is located in the bottom right corner of the code editor. The bottom right corner of the main area contains the text 'Loving Lobster'.

<https://localhost:34887/downloadFile?path=projects/First/4/Store.oms>

Go to the directory "4"
Click on "store.oms"

Store results in files

```
20 // In OpenMOLE there are different kinds of hooks. This one has been designed  
21 // to store variables into a CSV file.  
22 val by2Hook = AppendToCSVFileHook(workDirectory / "results/by2.csv", i, j)  
23 val plus1Hook = AppendToCSVFileHook(workDirectory / "results/plus2.csv", j, k)  
24
```

The “AppendToCSVFileHook” stores results in CSV Files.

“workDirectory” is the directory of the script.

Store results in files

```
25 exploration -< (by2 hook by2Hook) -- (plus1 hook plus1Hook)
```

The hooks are hooked on the tasks.

Store results in files

A screenshot of a web browser displaying the OpenMOLE interface at <https://localhost:34887/>. The page shows a code editor window titled "Store.oms" containing Scala code for a task named "by2". A red arrow points from the text "Refresh" to the refresh icon in the browser's toolbar. The code editor also features a "Play" button. Below the editor is a file list with two entries: "results" (1,07KB) and "Store.oms" (0,64KB). The "Store.oms" file is selected. At the bottom right of the page, the text "Loving Lobster" is displayed.

```
val by2 = ScalaTask("val i = j * 2") set (
    inputs += i,
    outputs += (i, j),
    i := 10.0
)

val plus1 =
ScalaTask("val k = j + 1") set (
    inputs += j,
    outputs += (j, k)
)

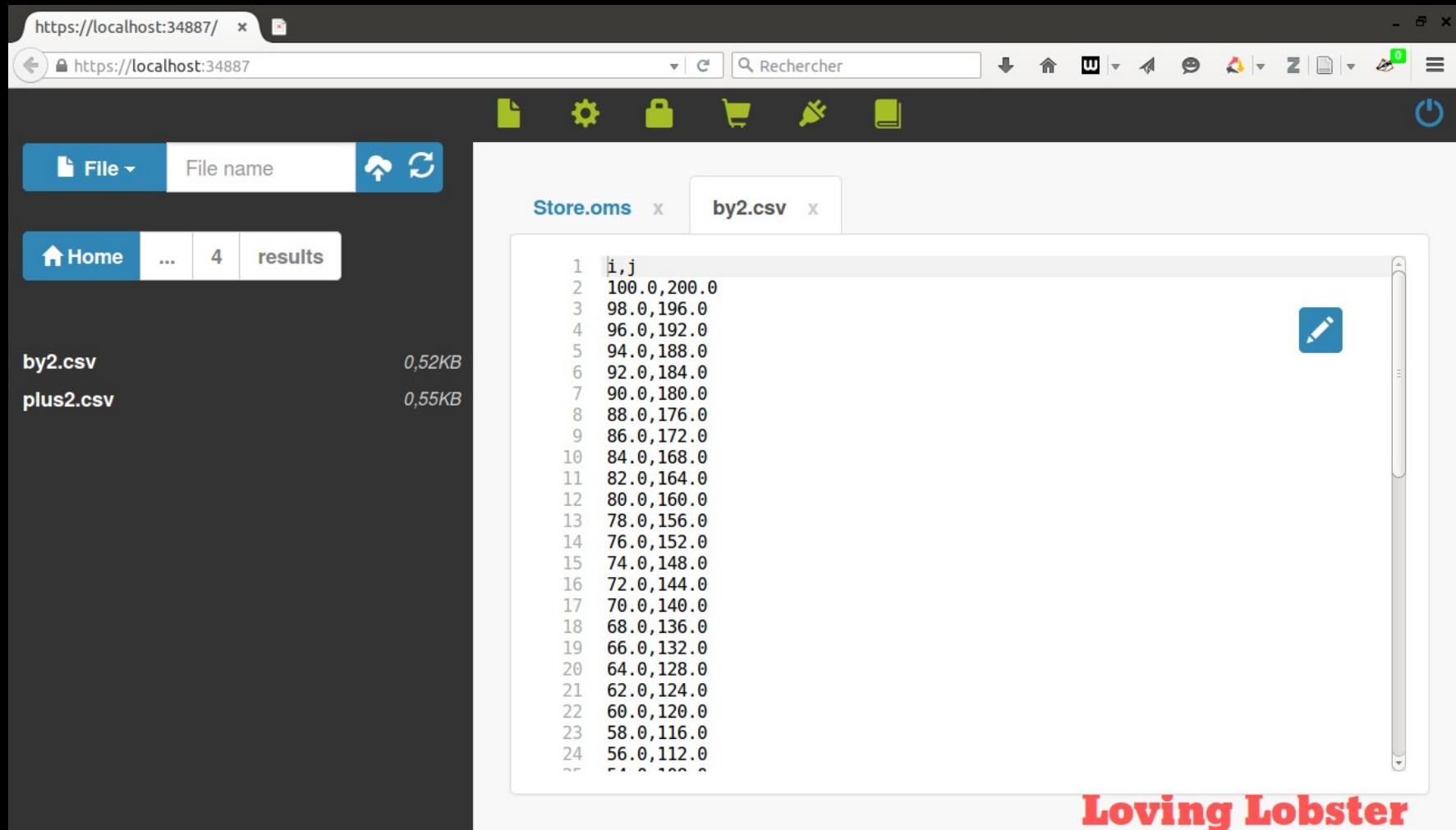
val exploration = ExplorationTask(i in (0.0 to 100.0 by 2.0))

// In OpenMOLE there are different kinds of hooks. This one has been designed
// to store variables into a CSV file.
val by2Hook = AppendToCSVFileHook(workDirectory / "results/by2.csv", i, j)
val plus1Hook = AppendToCSVFileHook(workDirectory / "results/plus2.csv", j, k)
exploration <- (by2 hook by2Hook) -- (plus1 hook plus1Hook)
```

Loving Lobster

Run it and refresh.

Store results in files



The screenshot shows a web browser window with the URL <https://localhost:34887/>. The interface is a file manager or storage application. On the left, there's a sidebar with a 'File' dropdown, a 'File name' search bar, and a toolbar with icons for file operations. Below the sidebar, there are links for 'Home', '...', '4 results', 'by2.csv' (0,52KB), and 'plus2.csv' (0,55KB). The main area displays two files: 'Store.oms' and 'by2.csv'. The 'by2.csv' file is open, showing its contents in a table-like format. The data consists of 24 rows, each with two columns: 'i,j' and a numerical value. A blue edit icon is located in the top right corner of the 'by2.csv' preview area. At the bottom right of the main content area, the text 'Loving Lobster' is displayed in red.

i,j	
2	100.0,200.0
3	98.0,196.0
4	96.0,192.0
5	94.0,188.0
6	92.0,184.0
7	90.0,180.0
8	88.0,176.0
9	86.0,172.0
10	84.0,168.0
11	82.0,164.0
12	80.0,160.0
13	78.0,156.0
14	76.0,152.0
15	74.0,148.0
16	72.0,144.0
17	70.0,140.0
18	68.0,136.0
19	66.0,132.0
20	64.0,128.0
21	62.0,124.0
22	60.0,120.0
23	58.0,116.0
24	56.0,112.0

Results have been stored in the "results" folder.

Store results in files

A screenshot of a web browser window showing a file viewer interface. The URL in the address bar is <https://localhost:34887/>. The page title is "Store.oms". On the left, there's a sidebar with "File" dropdown, "File name" input, and upload/download/cancel buttons. Below that is a navigation bar with "Home", "...", "4", and "results". Under "results", there are two files: "by2.csv" and "plus2.csv". A red arrow points from the "by2.csv" file to a download icon (a blue downward arrow) with the text "Download" written over it. The "by2.csv" file has a size of "0,52KB". The main content area shows the contents of "by2.csv" as a table:

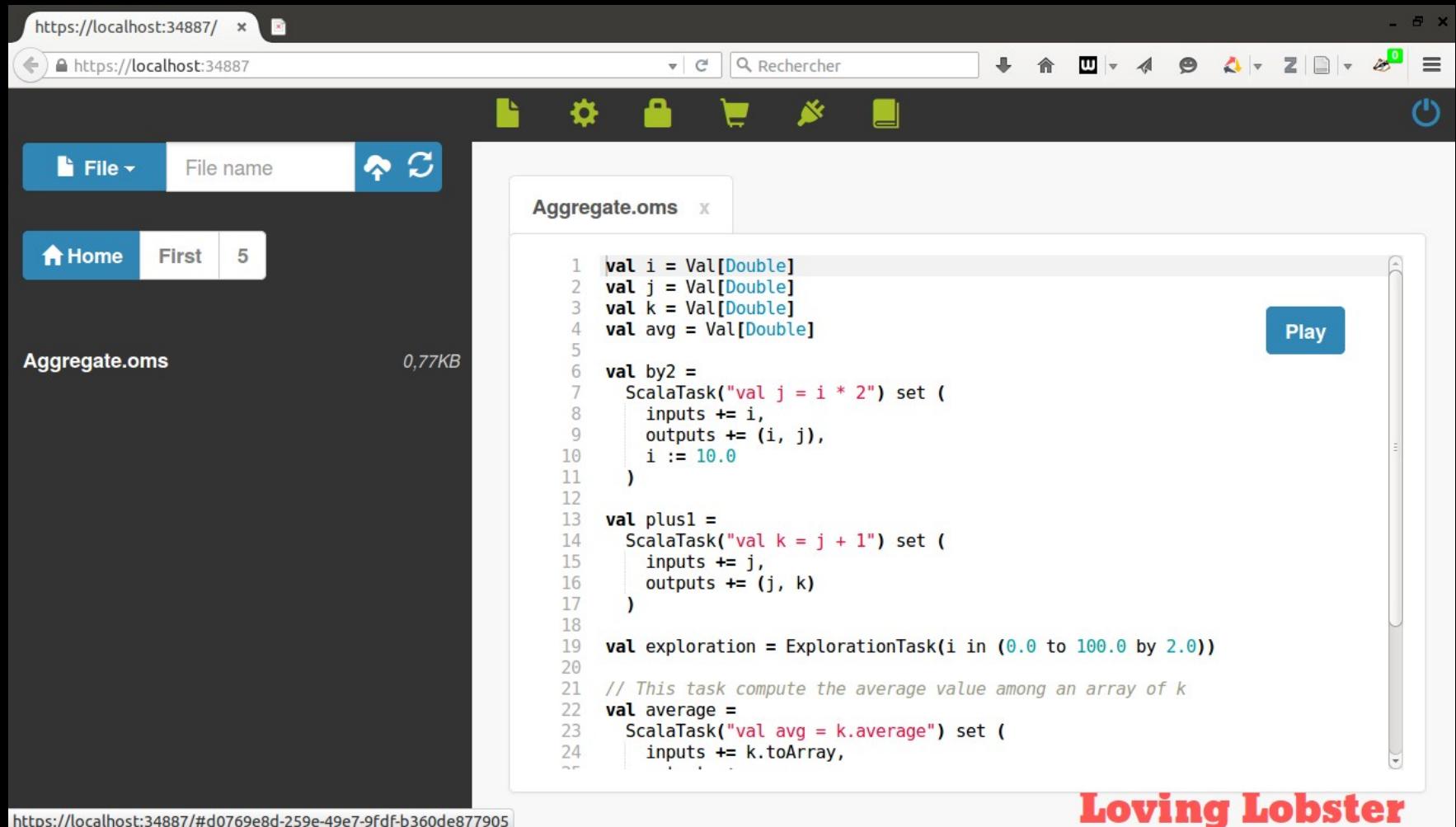
	i,j
1	100.0,200.0
2	98.0,196.0
3	96.0,192.0
4	94.0,188.0
5	92.0,184.0
6	90.0,180.0
7	88.0,176.0
8	86.0,172.0
9	84.0,168.0
10	82.0,164.0
11	80.0,160.0
12	78.0,156.0
13	76.0,152.0
14	74.0,148.0
15	72.0,144.0
16	70.0,140.0
17	68.0,136.0
18	66.0,132.0
19	64.0,128.0
20	62.0,124.0
21	60.0,120.0
22	58.0,116.0
23	56.0,112.0
24	54.0,108.0

The bottom right corner of the main content area contains the text "Loving Lobster" in red.

<https://localhost:34887/downloadFile?path=projects/First/4/results/by2.csv>

You can download it.

Aggregate



The screenshot shows a web browser window with the URL <https://localhost:34887/>. The page displays a file named "Aggregate.oms" with a size of 0,77KB. The file content is a Scala code snippet:

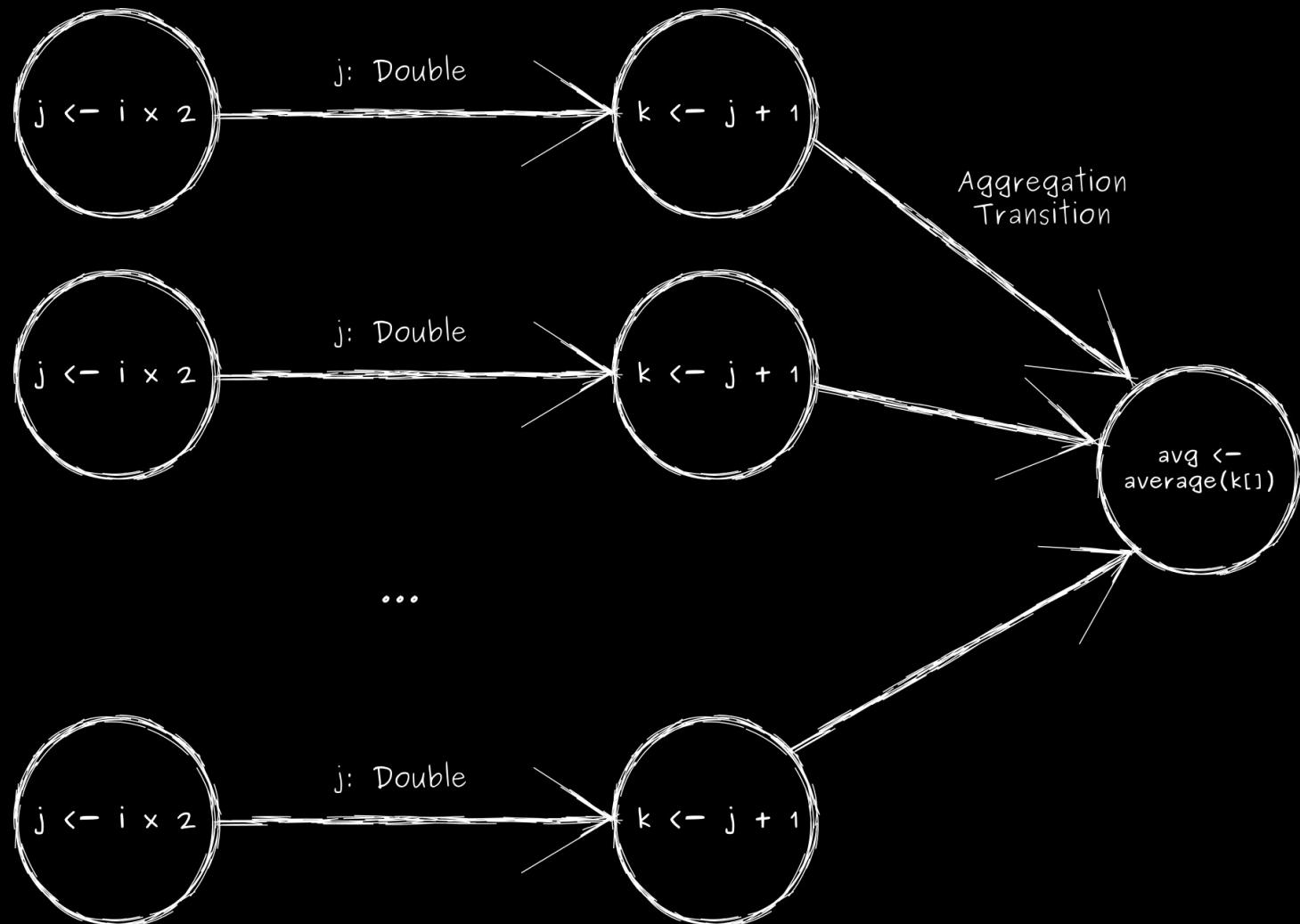
```
1 val i = Val[Double]
2 val j = Val[Double]
3 val k = Val[Double]
4 val avg = Val[Double]
5
6 val by2 =
7   ScalaTask("val j = i * 2") set (
8     inputs += i,
9     outputs += (i, j),
10    i := 10.0
11  )
12
13 val plus1 =
14   ScalaTask("val k = j + 1") set (
15     inputs += j,
16     outputs += (j, k)
17   )
18
19 val exploration = ExplorationTask(i in (0.0 to 100.0 by 2.0))
20
21 // This task compute the average value among an array of k
22 val average =
23   ScalaTask("val avg = k.average") set (
24     inputs += k.toArray,
```

A "Play" button is visible on the right side of the code editor. The browser interface includes a toolbar with various icons and a navigation bar with "Home", "First", and "5". The address bar shows the URL again.

Loving Lobster

Go to the directory "5"
Click on "Aggregate.oms"

Aggregate



Gathers the results

Aggregate

```
21 // This task compute the average value among an array of k
22 val average =
23   ScalaTask("val avg = k.average") set (
24     inputs += k.toArray,
25     outputs += avg
26   )
27
```

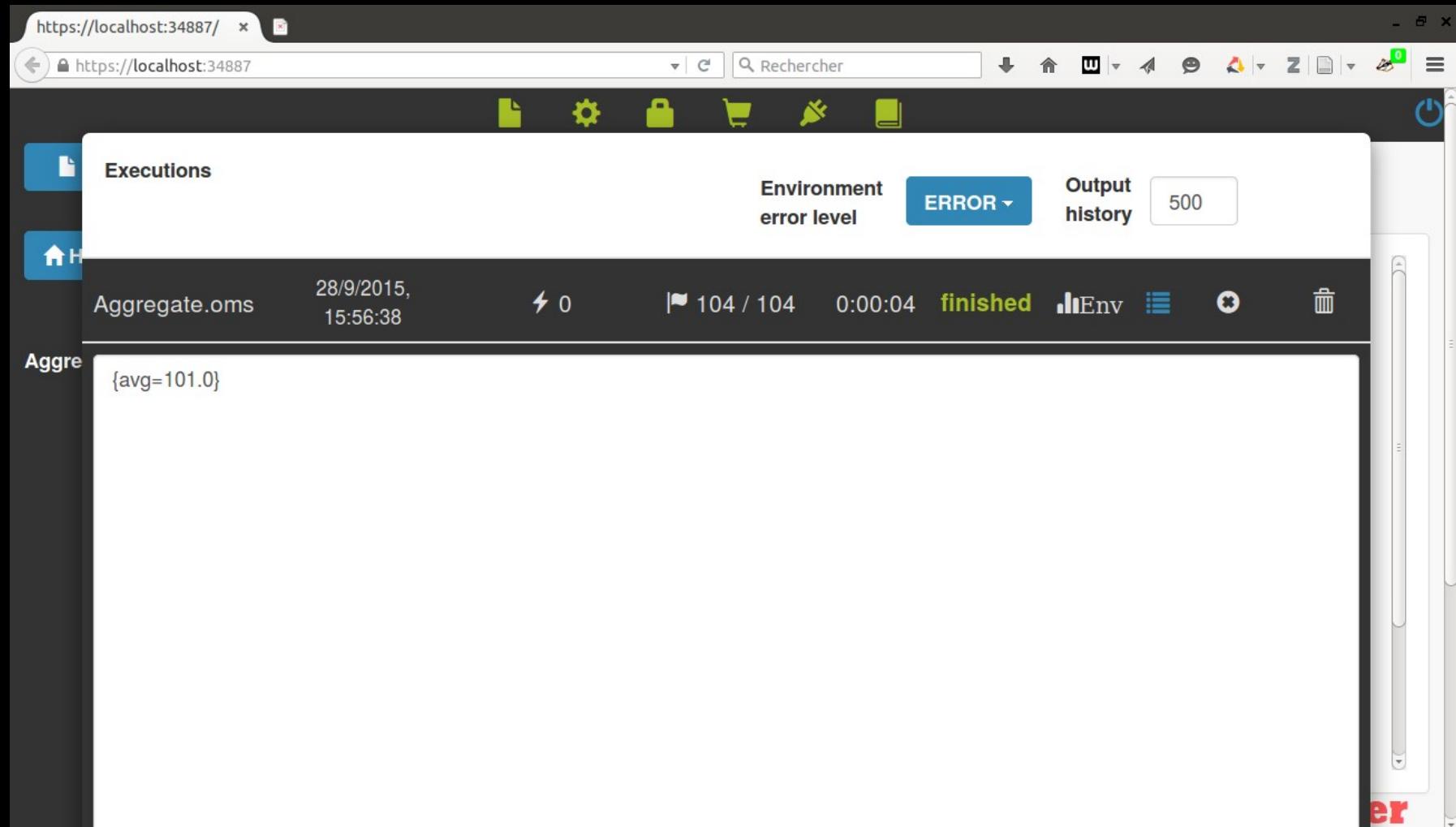
Computes the average over the values of k.
Takes the input "k: Array[Double]".
Produces "avg: Double".

Aggregate

```
28 // The ">-" transition waits for the completion of all execution streams.  
29 // Then it generates an array of values containing all the values of "k"  
30 // generated by the executions of the task "plus1" and launches "average".  
31 exploration -< by2 -- plus1 >- (average hook ToStringHook())
```

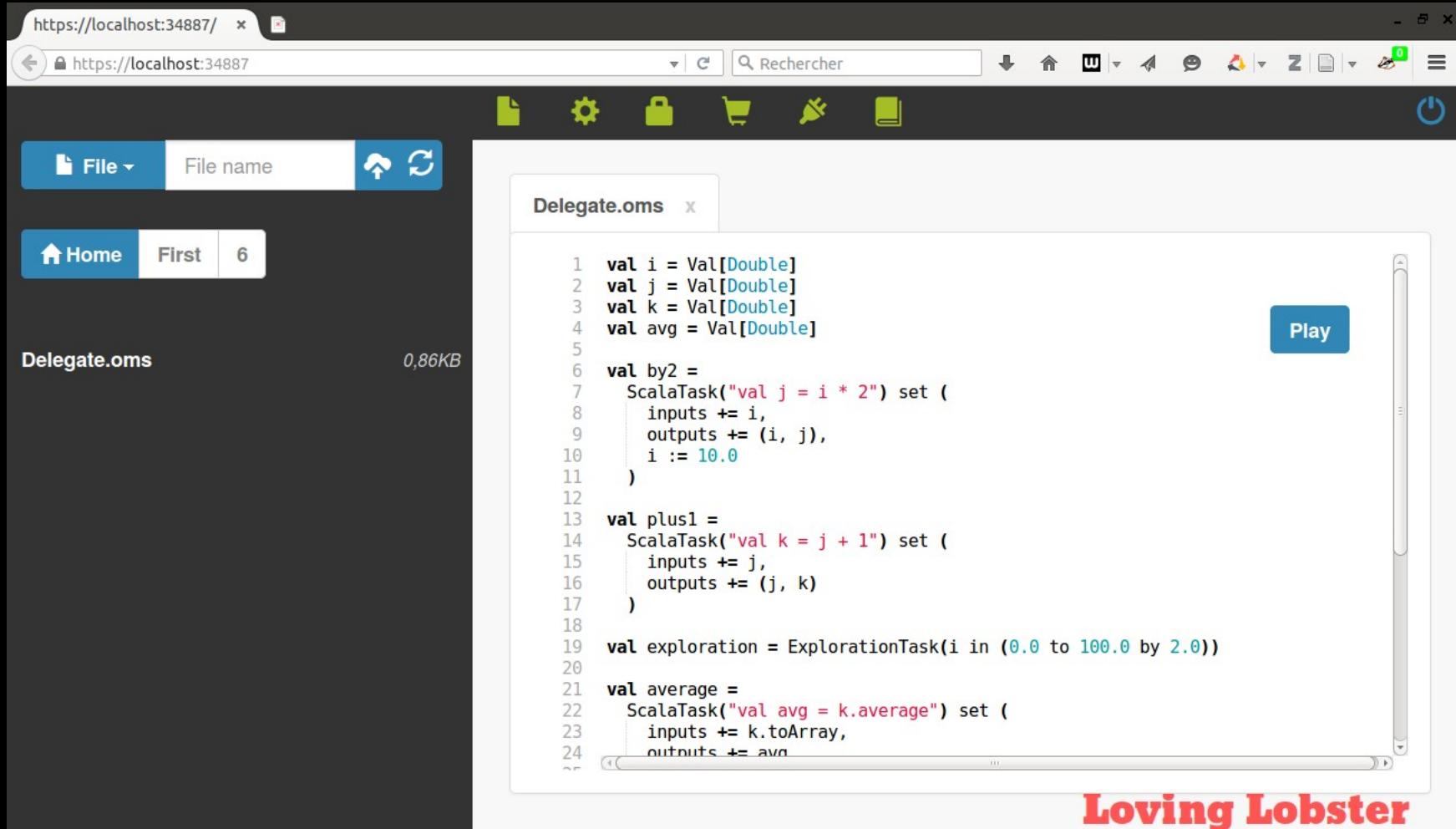
The aggregation transition is noted ">-". It gathers the results among the execution streams produced by the matching "-<".

Aggregate



Run it.

Delegate the execution



The screenshot shows a web browser window with the URL <https://localhost:34887/>. The page displays a file named "Delegate.oms". The file content is as follows:

```
1 val i = Val[Double]
2 val j = Val[Double]
3 val k = Val[Double]
4 val avg = Val[Double]
5
6 val by2 =
7   ScalaTask("val j = i * 2") set (
8     inputs += i,
9     outputs += (i, j),
10    i := 10.0
11  )
12
13 val plusl =
14   ScalaTask("val k = j + 1") set (
15     inputs += j,
16     outputs += (j, k)
17   )
18
19 val exploration = ExplorationTask(i in (0.0 to 100.0 by 2.0))
20
21 val average =
22   ScalaTask("val avg = k.average") set (
23     inputs += k.toArray,
24     outputs += avg
25 )
```

A "Play" button is visible on the right side of the code editor.

Loving Lobster

Go to the directory "6"
Click on "Delegate.oms"

Delegate the execution

```
27 // Run 4 parallel processes on the local computer  
28 val env = LocalEnvironment(4)
```

Declare an execution environment:
4 concurrent local executions

Delegate the execution

```
35 // The on keyword is used to delegate tasks to execution environments  
36 exploration -< (by2 on env) -- (plus1 on env) >- (average hook ToStringHook())
```

Use the “on” keyword to delegate the task executions.

Delegate the execution

A screenshot of a web browser displaying a task delegation interface at <https://localhost:34887/>. The interface shows an execution log for a file named "Delegate.oms" from 29/9/2015, 13:34:22. The log indicates 104 tasks completed in 0:00:06, labeled as "finished". A red annotation with the text "Display execution environments" points to the environment information section, which shows "LocalEnvironment@543458035". Below the log, a code editor displays Scala code for parallel processing:

```
13 val plus1 =
14   ScalaTask("val k = j + 1") set (
15     inputs += j,
16     outputs += (j, k)
17   )
18
19 val exploration = ExplorationTask(i in (0.0 to 100.0 by 2.0))
20
21 val average =
22   ScalaTask("val avg = k.average") set (
23     inputs += k.toArray,
24     outputs += avg
25   )
26
27 // Run 4 parallel processes on the local computer
28 val env = LocalEnvironment(4)
29
```

Loving Lobster

Run it!

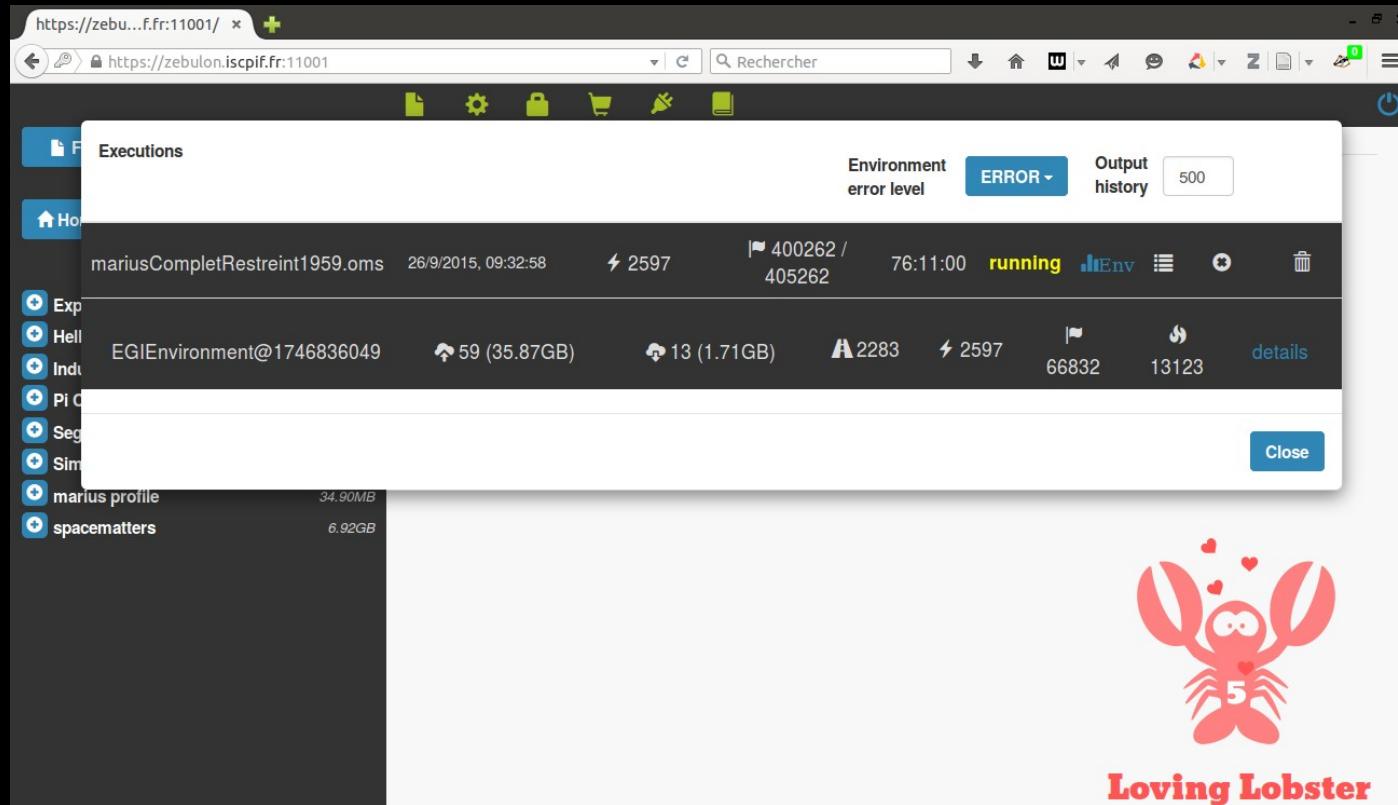
Delegate the execution

Many execution environments are supported:

- most cluster systems
- the EGI Grid
- multi-core servers
- desktop-grid
- ... cloud is planned

If your favorite environment is not supported yet, please contact us.

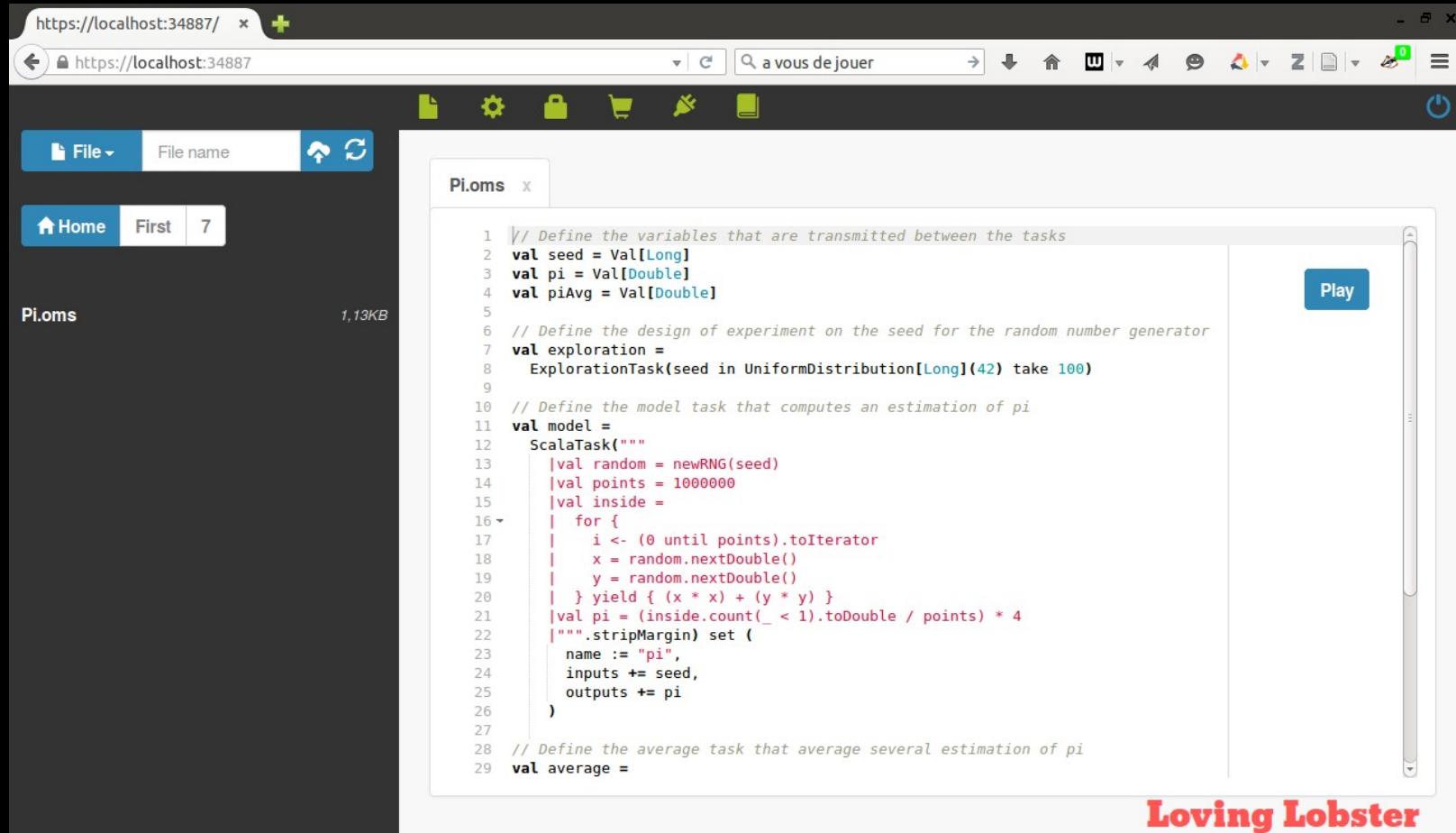
Delegate the execution



OpenMOLE scales!

Millions of jobs, +100GB of data

And now, play on!



The screenshot shows a web-based Scala code editor interface. The URL is <https://localhost:34887/>. The title bar says "Pi.oms". The code editor displays the following Scala code:

```
1 // Define the variables that are transmitted between the tasks
2 val seed = Val[Long]
3 val pi = Val[Double]
4 val piAvg = Val[Double]
5
6 // Define the design of experiment on the seed for the random number generator
7 val exploration =
8   ExplorationTask(seed in UniformDistribution[Long](42) take 100)
9
10 // Define the model task that computes an estimation of pi
11 val model =
12   ScalaTask("""
13     |val random = newRNG(seed)
14     |val points = 1000000
15     |val inside =
16     |  for {
17     |    i <- (0 until points).toIterator
18     |    x = random.nextDouble()
19     |    y = random.nextDouble()
20     |  } yield { (x * x) + (y * y) }
21     |val pi = (inside.count(_ < 1).toDouble / points) * 4
22     |""".stripMargin) set (
23       name := "pi",
24       inputs += seed,
25       outputs += pi
26     )
27
28 // Define the average task that average several estimation of pi
29 val average =
```

On the right side of the code editor, there is a "Play" button. At the bottom right of the window, the text "Loving Lobster" is displayed.

Go to the directory "7"
Click on "Pi.oms"

And now, play on!

Pi: computes an approximation of Pi
using the Monte-Carlo method

Exploration: generates seeds for the
pseudo-random numbers generator of Pi

Average: compute the average among
several realizations of Pi

And now, play on!

Objective 1: distribute the executions of
the task "Pi"

Objective 2: aggregate the values
computed by "Pi" and display the average

Coming next:

How to distribute a native (Linux)
application (R, Scilab, C++, Python...) to
thousands of computers.