Using SimGrid 101

Getting Started to Use SimGrid

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About this Presentation

Goals and Contents

- Installing the framework
- Writing your first MSG simulator (in C, Java or lua)
- Trace replay execution mode
- Other practical considerations

The SimGrid 101 serie

- This is part of a serie of presentations introducing various aspects of SimGrid
- SimGrid 101. Introduction to the SimGrid Scientific Project
- SimGrid User 101. Practical introduction to SimGrid and MSG
- SimGrid User::Platform 101. Defining platforms and experiments in SimGrid
- SimGrid User::SimDag 101. Practical introduction to the use of SimDag
- SimGrid User::Visualization 101. Visualization of SimGrid simulation results
- SimGrid User::SMPI 101. Simulation MPI applications in practice
- SimGrid User::Model-checking 101. Formal Verification of SimGrid programs
- SimGrid Internal::Models. The Platform Models underlying SimGrid
- SimGrid Internal::Kernel. Under the Hood of SimGrid
- Retrieve them from `http://simgrid.gforge.inria.fr/101`

Outline

- Installing SimGrid
  - Stable release
  - Unstable Version
  - The Bindings
- Your First SimGrid Program
  - User Interface(s)
  - Master/Workers
  - Trace Replay
- Further topics
  - Configuring your simulators
  - Surviving in C
  - Bindings Performance
- Conclusion

Installing a stable version (most advised for users)

On Debian, Ubuntu and similar

- `sudo apt-get install simgrid`

On Windows

- Get the installer (from page below), execute it and follow the instructions

From the sources

1. Get the archive: (see below for URL)
2. Open it: `tar xfz simgrid-*.tar.gz`
3. Configure it: `cmake .` or `ccmake .`
4. Install it: `make install`

Download page of the project:

- Direct access: `https://gforge.inria.fr/frs/?group_id=12`
- Idem + more info: `http://simgrid.gforge.inria.fr/download.php`

Details: `http://simgrid.gforge.inria.fr/simgrid/<version>/doc/install.html`

Installing an unstable version (developers only!)

Is unstable for you?

- Simple Rule of Thumb:
  - You plan to use SimGrid ⇝ nope, play safe with stable
  - You plan to improve SimGrid ⇝ yes, use unstable
- The reason why we name it "unstable": we didn't test it on all platforms
- It *can* be relatively usable at a given time, but we cannot promise.
- It *may* fail strangely on you, too. You're on your own here.

Actually installing unstable

- Get source from git:

```
git clone git://scm.gforge.inria.fr/simgrid/simgrid.git
```

- Configure and installing (see instructions for stable)

Build Dependencies

- Depending on what you're touching, you may need more softwares:
  - If you change the XML parsers, you need both flexml and flex

The Bindings

Some people don't like coding in C

- That's reasonable since C is the modern assembly language:
  It can reveal faster but rather verbose and really tedious to get right
- Using C is not enough for maximal performance: you need to really master it

Bindings available for: Java, lua and Ruby

- Why Java: Every potential intern knows it (I guess)
- Why Lua: As simple as script language, but as efficient as C
- Why Ruby: Our team counts very effective Ruby lobbyists
- "Will you add my favorite language?"
  - We could, but it's rather time consuming (threading mess, at least)
  - We probably won't do it ourselves (our time is limited); we welcome patches

Installing the Bindings

- lua is included in the main archive, the others are separated
- Grab their archives, open it, read the README, build it, install it
- You need to install the main SimGrid archive to get the bindings working

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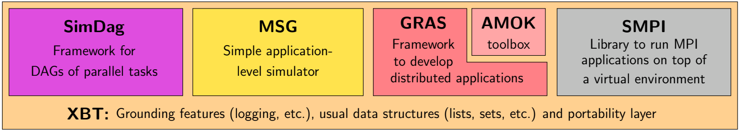
User-visible SimGrid Components



SimDag
Framework for
DAGs of parallel tasks

MSG
Simple application-
level simulator

GRAS
Framework
to develop
distributed applications

AMOK
toolbox

SMPI
Library to run MPI
applications on top of
a virtual environment

XBT: Grounding features (logging, etc.), usual data structures (lists, sets, etc.) and portability layer

SimGrid user APIs

- SimDag: specify heuristics as DAG of (parallel) tasks
- MSG: specify heuristics as Concurrent Sequential Processes (Java/Ruby/Lua bindings available)
- GRAS: develop real applications, studied and debugged in simulator
- SMPI: simulate MPI codes

Which API should I choose?

- Your application is a DAG ⇝ SimDag
- You have a MPI code ⇝ SMPI
- You study concurrent processes, or distributed applications
  - You need graphs about several heuristics for a paper ⇝ MSG
  - You develop a real application (or want experiments on real platform) ⇝ GRAS
- Most popular API: MSG (by far)

The MSG User Interface

Main MSG abstractions

- **Agent:** some code, some private data, running on a given host
- **Task:** amount of work to do and of data to exchange
- Host: location on which agents execute
- Mailbox: Rendez-vous points between agents (think of MPI tags)
  - You send stuff to a mailbox; you receive stuff from a mailbox
  - Network location of sender & receiver have no impact on rendez-vous; Communication timings of course take these locations into account
  - Mailboxes' identifiers are strings, making user code *ways* easier (either `host:port`, yellow page mechanism or whatever you want)

More information

- examples/msg in archive; Reference doc: `doc/group__MSG__API.html`
- Interface extended, never modified since 2002 (if using MSG_USE_DEPRECATED)

The MSG User Interface

Main MSG abstractions

- **Agent:** some code, some private data, running on a given host
  one function + arguments coming from deployment XML file
- **Task:** amount of work to do and of data to exchange
  - `MSG_task_create(name, compute_duration, message_size, void *data)`
  - Communication: `MSG_task_{send,recv}`, `MSG_task_Iprobe`
  - Execution: `MSG_task_execute`
    `MSG_process_sleep`, `MSG_process_{suspend,resume}`
- Host: location on which agents execute
- Mailbox: Rendez-vous points between agents (think of MPI tags)
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More information

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Executive Summary (detailed below)

1. Write the Code of your Agents

```
int master(int argc, char **argv) {

for (i = 0; i < number_of_tasks; i++) {
 t=MSG_task_create(name,comp_size,comm_size,data);
 sprintf(mailbox,"worker-%d",i % workers_count);
 MSG_task_send(t, mailbox);}
```

```
int worker(int ,char**){

sprintf(my_mailbox,"worker-%d",my_id);
while(1) {
  MSG_task_receive(&task, my_mailbox);
  MSG_task_execute(task);
  MSG_task_destroy(task);}
```

2. Describe your Experiment

XML Platform File

```
<?xml version='1.0'?>
<!DOCTYPE platform SYSTEM
"http://simgrid.gforge.inria.fr/simgrid.dtd">
<platform version="3">
<AS id="blah" routing="Full">
  <host id="host1" power="1E8"/>
  <host id="host2" power="1E8"/>
   ...
  <link id="link1" bandwidth="1E6"
                   latency="1E-2"  />
   ...
  <route src="host1" dst="host2">
    <link_ctn id="link1"/>
  </route>
</AS>
</platform>
```

XML Deployment File

```
<?xml version='1.0'?>
<!DOCTYPE platform SYSTEM
"http://simgrid.gforge.inria.fr/simgrid.dtd">
<platform version="3">
<!-- The master process -->
<process host="host1" function="master">
 <argument value="10"/><!--argv[1]:#tasks-->
 <argument value="1"/><!--argv[2]:#workers-->
</process>

<!-- The workers -->
<process host="host2" function="worker">
  <argument value="0"/></process>
</platform>
```

3. Write a main gluing things together, link and run

Master/Workers: Describing the Agents (1/2)

The master has a large number of tasks to dispatch to its workers for execution

```
#include <msg/msg.h> /* mandatory cruft */
XBT_LOG_NEW_DEFAULT_CATEGORY(tuto,"all the info and debug messages of this tutorial");
```

```
int master(int argc, char *argv[ ]) {
 int number_of_tasks = atoi(argv[1]);       double task_comp_size = atof(argv[2]);
 double task_comm_size = atof(argv[3]);     int workers_count = atoi(argv[4]);
 char mailbox[80];                          char buff[64];
 int i;                                     m_task_t task;

 /* Dispatching (dumb round-robin algorithm) */
 for (i = 0; i < number_of_tasks; i++) {
   sprintf(buff, "Task_%d", i);
   task = MSG_task_create(buff, task_comp_size, task_comm_size, NULL);
   sprintf(mailbox,"worker-%d",i % workers_count);
   XBT_INFO("Sending %̈s¨ to mailbox %̈s̈", task->name, mailbox);
   MSG_task_send(task, mailbox);
 }
 /* Send finalization message to workers */
 XBT_INFO("All tasks dispatched. Let’s stop workers");
 for (i = 0; i < workers_count; i++) {
   sprintf(mailbox,"worker-%ld",i % workers_count);
   MSG_task_send(MSG_task_create("finalize", 0, 0, 0), mailbox);
 }

 XBT_INFO("Goodbye now!"); return 0;
}
```

Master/Workers: Describing the Agents (2/2)

```
int worker(int argc, char *argv[ ]) {
  m_task_t task;                 int errcode;
  int id = atoi(argv[1]);
  char mailbox[80];

  sprintf(mailbox,"worker-%d",id);

  while(1) {
    errcode = MSG_task_receive(&task, mailbox);
    xbt_assert(errcode == MSG_OK, "MSG_task_get failed");

    if (!strcmp(MSG_task_get_name(task),"finalize")) {
      MSG_task_destroy(task);
      break;
    }

    XBT_INFO("Processing ’%s’", MSG_task_get_name(task));
    MSG_task_execute(task);
    XBT_INFO("’%s’ done", MSG_task_get_name(task));
    MSG_task_destroy(task);
  }

  XBT_INFO("I’m done. See you!");
  return 0;
}
```

Master/Workers: gluing things together

```
int main(int argc, char *argv[ ]) {

  MSG_global_init(&argc,argv);

  /* Declare all existing agent, binding their name to their function */
  MSG_function_register("master", &master);
  MSG_function_register("worker", &worker);

  /* Load a platform instance */
  MSG_create_environment("my_platform.xml"); // we could take the names of XML files as argv
  /* Load a deployment file */
  MSG_launch_application("my_deployment.xml");

  /* Launch the simulation (until its end) */
  MSG_main();

  XBT_INFO("Simulation took %g seconds",MSG_get_clock());
}
```

Compiling and Executing the result

```
$ gcc *.c -lsimgrid -o my_simulator
$ ./my_simulator
[verbose output removed]
```

Master/Workers: deployment file

Specifying which agent must be run on which host, and with which arguments

XML deployment file

```
<?xml version="1.0"?>
<!DOCTYPE platform SYSTEM "http://simgrid.gforge.inria.fr/simgrid.dtd">
<platform version="3">

  <!-- The master process (with some arguments) -->
  <process host="Tremblay" function="master">
     <argument value="6"/>        <!-- Number of tasks -->
     <argument value="50000000"/> <!-- Computation size of tasks -->
     <argument value="1000000"/>  <!-- Communication size of tasks -->
     <argument value="3"/>        <!-- Number of workers -->
  </process>

  <!-- The worker process (argument: mailbox number to use) -->
  <process host="Jupiter" function="worker"><argument value="0"/></process>
  <process host="Fafard"  function="worker"><argument value="1"/></process>
  <process host="Ginette" function="worker"><argument value="2"/></process>

</platform>
```

Thanks to mailboxes, the master doesn't have to know where the workers are (nor the contrary)

Master/Worker in Java (1/2)

```
import simgrid.msg.*;
public class BasicTask extends simgrid.msg.Task {
   public BasicTask(String name, double computeDuration, double messageSize) {
       super(name, computeDuration, messageSize);
}  }
public class FinalizeTask extends simgrid.msg.Task {
   public FinalizeTask() {
      super("finalize",0,0);
}  }
public class Worker extends simgrid.msg.Process {
   public Worker(Host host, String name, String[]args) { // Mandatory: this constructor is
      super(host,name,args);                             //            used internally
   }
   public void main(String[ ] args) throws TransferFailureException, HostFailureException,
                                           TimeoutException, TaskCancelledException {
      String id = args[0];

      while (true) {
         Task t = Task.receive("worker-" + id);
         if (t instanceof FinalizeTask)
            break;
         BasicTask task = (BasicTask)t;
         Msg.info("Processing ’" + task.getName() + "’");
         task.execute();
         Msg.info("’" + task.getName() + "’ done ");
       }
      Msg.info("Received Finalize. I’m done. See you!");
}   }
```

Master/Workers in Java (2/2)

```
import simgrid.msg.*;
public class Master extends simgrid.msg.Process {
   public Master(Host host, String name, String[]args) { // mandatory constructor
      super(host,name,args);
   }
   public void main(String[ ] args) throws MsgException {
      int numberOfTasks = Integer.valueOf(args[0]).intValue();
      double taskComputeSize = Double.valueOf(args[1]).doubleValue();
      double taskCommunicateSize = Double.valueOf(args[2]).doubleValue();
      int workerCount = Integer.valueOf(args[3]).intValue();

      Msg.info("Got "+  workerCount + " workers and " + numberOfTasks + " tasks.");

      for (int i = 0; i < numberOfTasks; i++) {
         BasicTask task = new BasicTask("Task_" + i ,taskComputeSize,taskCommunicateSize);
         task.send("worker-" + (i % workerCount));

         Msg.info("Send completed for the task " + task.getName() +
                  " on the mailbox 'worker-" + (i % workerCount) +  "'");
      }
      Msg.info("Goodbye now!");
}  }
```

The rest of the story

- No need to write the glue (thanks to Java introspection)
- The XML files are exactly the same (beware of capitalization for deployment)

Master/Workers in Lua (1/2)

```
function Master(...)
  local nb_task, comp_size, comm_size, slave_count = unpack(arg)

  -- Dispatch the tasks
  for i = 1, nb_task do
    local tk = simgrid.task.new("Task " .. i, comp_size, comm_size)
    local alias = "worker " .. (i % worker_count)
    simgrid.info("Sending  ’" .. tk:get_name() .."’ to ’" .. alias ..".’")
    tk:send(alias)
    simgrid.info("Done sending ’".. tk:get_name() .."’ to ’" .. alias .."’")
  end
  -- Sending finalize message to others
  for i = 0, worker_count - 1 do
    local alias = "worker " .. i;
    simgrid.info("Sending finalize to " .. alias)
    local finalize = simgrid.task.new("finalize", comp_size, comm_size)
    finalize:send(alias)
  end
end
```

Master/workers in Lua (2/2)

The worker

```
function Worker(...)
  local my_mailbox="worker " .. arg[1]

  while true do
    local tk = simgrid.task.recv(my_mailbox)
    if (tk:get_name() == "finalize") then
      simgrid.info("Got finalize message")
      break
    end
    tk:execute()
  end

  simgrid.info("Worker ’" ..my_mailbox.."’: I’m done. See you!")
end
```

Setting up your experiment

```
require "simgrid"
simgrid.platform("my_platform.xml")
simgrid.application("my_deployment.xml")
simgrid.run()
simgrid.info("Simulation’s over. See you.")
```

Master/Workers in Ruby (1/2)

Some mandatory headers

```
require 'simgrid'
include MSG
```

The master

```
class Master < MSG::Process
  def main(args)
     numberOfTask = Integer(args[0])
     taskComputeSize = Float(args[1])
     taskCommunicationSize = Float(args[2])
     workerCount = Integer(args[3])
     for i in 0..numberOfTask-1
        task = Task.new("Task_"+ i.to_s, taskComputeSize , taskCommunicationSize);
        mailbox = "worker " + (i%workerCount).to_s
        MSG::info("Master Sending "+ task.name + " to " + mailbox)
        task.send(mailbox)
        MSG::info("Master Done Sending " + task.name + " to " + mailbox)
     end
     for i in 0..workerCount-1
        mailbox = "worker " + i.to_s
        finalize_task = Task.new("finalize",0,0)
        finalize_task.send(mailbox)
     end
  end
end
```

Master/Workers in Ruby (2/2)

The worker

```
class Worker < MSG::Process
  def main(args)
    mailbox = "worker " + args[0]
    while true
       task = Task.receive(mailbox)
       if (task.name == "finalize")
          break
       end
       task.execute
       MSG::debug("Worker ’" + mailbox + "’ done executing task "+ task.name + ".")
    end
    MSG::info("I’m done, see you")
  end
end
```

Setting up your experiment

```
MSG.createEnvironment("platform.xml")
MSG.deployApplication("deploy.xml")
MSG.run
puts "Simulation time : " + MSG.getClock .to_s
MSG.exit
```

Some more polishing is needed

- Not much ruby users so far ⇝ needs more tests

Trace Replay: Separate your applicative workload

C code

```
static void action_blah(xbt_dynar_t parameters) { ... }
static void action_blih(xbt_dynar_t parameters) { ... }
static void action_bluh(xbt_dynar_t parameters) { ... }
int main(int argc, char *argv[]) {
    MSG_global_init(&argc, argv);
    MSG_create_environment(argv[1]);
    MSG_launch_application(argv[2]);
    /* No need to register functions as usual: actions started anyway */
    MSG_action_register("blah", blah);
    MSG_action_register("blih", blih);
    MSG_action_register("bluh", bluh);

    MSG_action_trace_run(argv[3]); // The trace file to run
}
```

Deployment

```
<?xml version='1.0'?>
<!DOCTYPE platform SYSTEM
  "http://simgrid.gforge.inria.fr/simgrid.dtd">
<platform version="3">
  <process host="Tremblay" function="toto"/>
  <process host="Jupiter" function="tutu"/>
  <process host="Fafard" function="tata"/>
</platform>
```

Trace file

```
tutu blah toto 1e10
toto blih tutu
tutu bluh 12
toto blah 12
```

Trace Replay (2/2)

Separating the trace of each process

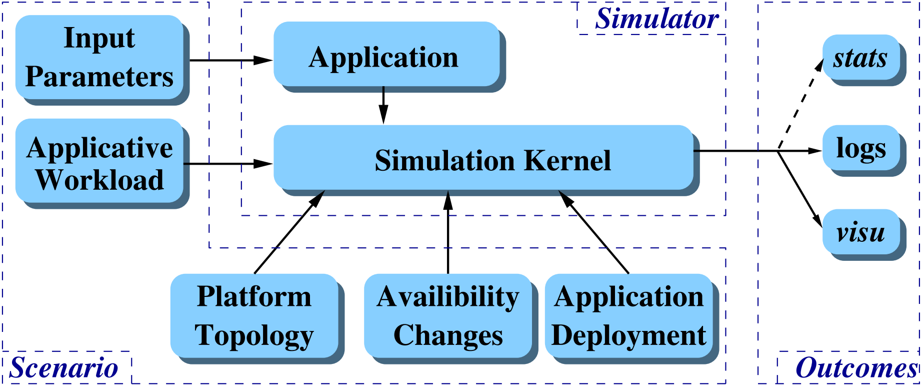
- Because it's sometimes more convenient (for MPI, you'd have to merge them)
- Simply pass NULL to MSG_action_trace_run()
- Pass the trace file to use as argument to each process in deployment

```
<?xml version=’1.0’?>
<!DOCTYPE platform SYSTEM "http://simgrid.gforge.inria.fr/simgrid.dtd">
<platform version="3">
  <process host="Tremblay" function="toto">
    <argument value="actions_toto.txt"/>
  </process>
  <process host="Jupiter" function="tutu">
    <argument value="actions_tutu.txt"/>
  </process>
</platform>
```

Action Semantic

- This mecanism is completely agnostic: attach the meaning you want to events
- In examples/actions/action.c, we have pre-written event functions for:
  - Basics: send, recv, sleep, compute
  - MPI-specific: isend, irecv, wait, barrier, reduce, bcast, allReduce

SimGrid is not a Simulator



That's a Generic Simulation Framework

Configuring your simulators

Every simulator using SimGrid accepts a set of options

- -help: get some help
- -help-models: long help on models
- -log: configure the verbosity
- -cfg: change some settings

Note: SMPI-specific settings, are only visible in SMPI simulators

The log argument

- It's similar to Log4J, but in C
- You can increase the amount of output for some specific parts of SimGrid
- Example: See everything by using –log=root.thres:debug
- List of all existing channels: doc/html/group__XBT__log__cats.html

XBT from 10,000 feets

C is a basic language: we reinvented the wheel for you

Logging support: Log4C

```
XBT_LOG_NEW_DEFAULT_CATEGORY(test,
    "my own little channel");
XBT_LOG_NEW_SUBCATEGORY(details, test,
    "Another channel");

INFO1("Value: %d", variable);
CDEBUG3(details,"blah %d %f %d", x,y,z);
```

Exception support

```
xbt_ex_t e;
TRY {
  block
} CATCH(e) {
  block /* DO NOT RETURN FROM THERE */
}
```

Debugging your code

- Ctrl-C once: see processes' status
- Press it twice (in 5s): kill simulator

xbt_backtrace_display_current()

```
Backtrace (displayed in thread 0x90961c0):
---> In master() at masterslave_mailbox.c:35
---> In ?? ([0x4a69ba5])
```

Advanced data structures

- Hash tables (Perl's ones)
- Dynamic arrays, FIFOs
- SWAG (don't use); Graphs

String functions

- bprintf: malloc()ing sprintf
- trim, split, subst, diff
- string buffers

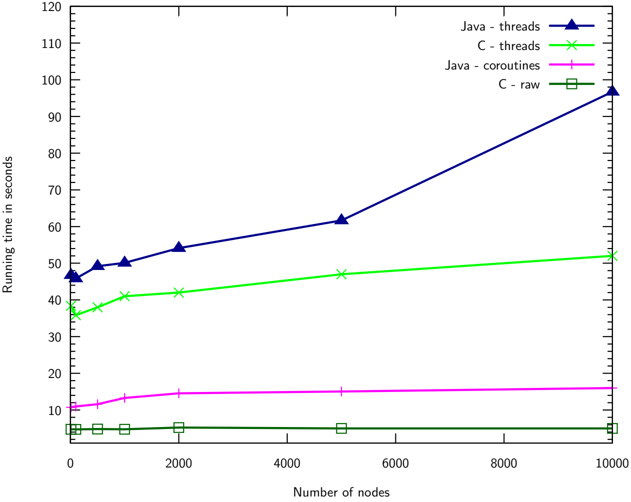
Threading support

- Portable wrappers (Lin, Win, Mac, Sim)
- Synchro (mutex, conds, semaphores)

Other

- Mallocators
- Configuration support
- Unit testing (check src/testall)
- Integration tests (tesh: testing shell)

Bindings Performance



- C: breath taking
- Java: not too bad (JVM patch $\leadsto$ good)
- Others: a bit behind

(version 3.7.1)

Conclusion: Finding the documentation

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User manuals are for wimps

- Real Men read some slides 'cause they are more concise
- They read the examples, pick one modify it to fit their needs
- They may read 2 or 5% of the reference guide to check the syntax
- In doubt, they just check the source code

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So, where is all SimGrid documentation?

- The SimGrid tutorial is a 200 slides presentation (motivation, models, example of use, internals)
- Almost all features of UAPI are demoed in an example (coverage testing)
- The reference guide contains a lot in introduction sections (about XBT)
- The FAQ contains a lot too; The code is LGPL anyway
- (actually, our documentation is not that bad. is it?)