



ConPaaS: an integrated runtime environment for elastic cloud applications

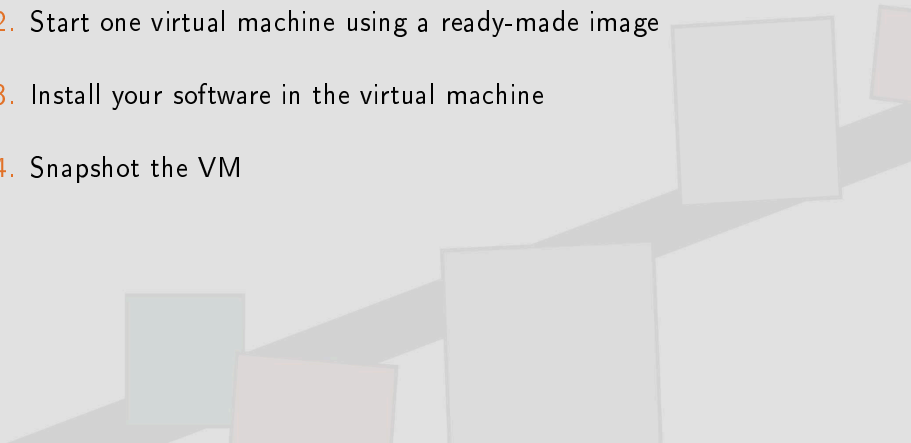
Guillaume Pierre

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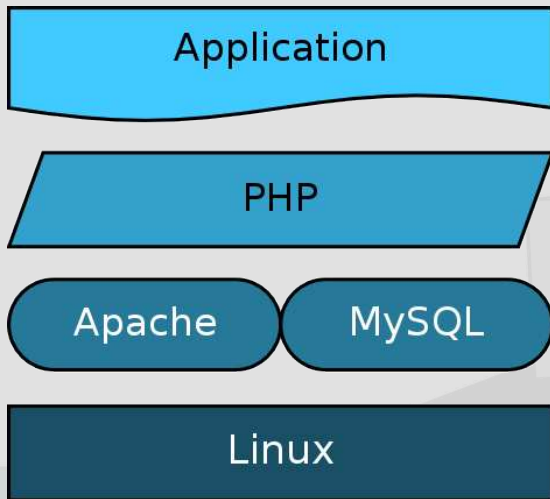


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257438

Deploying an application in the Cloud can be easy

1. Choose a cloud provider
 2. Start one virtual machine using a ready-made image
 3. Install your software in the virtual machine
 4. Snapshot the VM
- 
- A decorative graphic in the bottom right corner of the slide. It features a thick, grey, diagonal line that starts from the bottom left and extends towards the top right. Along this line, several rectangular blocks of varying colors (light blue, light pink, light grey) are placed, some overlapping the line and others appearing to sit on it, creating a sense of a path or a sequence of steps.

What about a slightly more complex application?



What about a slightly more complex application?



ConPaaS takes care of your applications



Web hosting services

The screenshot shows the ConPaaS management interface. At the top, there's a navigation bar with 'ConPaaS - management' and user information. Below that, a 'New php service' card shows a 'stop' button and a dropdown menu with 'default', 'ec2awsland', and 'ec2vagrant' options. A green status indicator shows the service is 'running - started in a few moments ago'. Below this, a table lists 5 instances running in IaaS:

Instance ID	Status	IP Address
Instance i-1cc4aa29	running	54.214.177.245
Instance i-34f6b301	running	50.112.11.151
Instance i-88fab4bd	running	54.245.187.145
Instance i-8afab4bf	running	54.218.239.77
Instance i-8efab4bb	running	54.214.138.145

Below the table, there are buttons for 'php', 'prooxy', 'web', and 'submit'. The 'Code management' section allows updating the stage by 'uploading archive' or 'checking out repository'. At the bottom, 'available code versions' are listed, including 'code-WvHGU3' and 'code-default'.

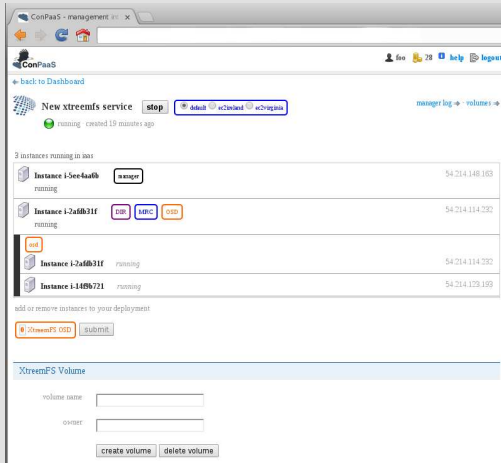
- ▶ Code upload (PHP, Java)
 - ▶ ZIP file upload, git push
 - ▶ Choose the version you want to run
- ▶ Seamless capacity control
 - ▶ Add/remove processing power in one click
- ▶ Coordinated reconfigurations
 - ▶ No service interruption even during reconfigurations

Database services

The screenshot displays the ConPaaS management interface for a MySQL service. At the top, there's a navigation bar with 'ConPaaS' and user information. Below it, a 'New mysql service' card shows the service is 'running' and was created 13 minutes ago. A table lists two instances: 'Instance i-2c9b719' and 'Instance i-08f2bc3d', both in a 'running' state. Below the table, there's a section for adding or removing instances, with a 'MySQL slave' button and a 'submit' button. The 'MySQL Access' section provides server details: 'server address: 54.214.134.70 : 3306', 'user: mysqldb', and a terminal command: 'mysql -h 54.214.134.70 -u mysqldb -p'. There are input fields for 'new password' and 'retype password', with a 'reset password' button. At the bottom, there's a 'Load database from file' section with a 'Choose File' button and a 'Load file' button.

- ▶ Relational (MySQL) and NoSQL (Scalarix)
- ▶ Data upload
 - ▶ Choose your administrator password
 - ▶ Upload a database dump
- ▶ Automatic replication
 - ▶ Add/remove replicas in one click

File system service



The screenshot shows the ConPaaS manager interface. At the top, there's a navigation bar with a home icon, a search icon, and a user profile icon. Below that, the main content area displays a 'New xtremfs service' card. The card has a 'stop' button and a 'details' button. Below the card, there's a table listing 3 instances running in 'ios'.

Instance ID	Status	IP Address
Instance i-5ee4a0b	running	54.214.148.163
Instance i-2af0b31f	running	54.214.114.232
Instance i-2af0b31f	running	54.214.114.232
Instance i-14f0b721	running	54.214.129.199

Below the table, there's a section for 'XtremFS Volume' with input fields for 'volume name' and 'order', and buttons for 'create volume' and 'delete volume'.

- ▶ Mount the file system
 - ▶ From your client machine
 - ▶ From other ConPaaS services
- ▶ Read-write data as in a local file system
 - ▶ Full POSIX support
- ▶ Automated capacity scaling
 - ▶ Add/remove storage nodes in one click

High-performance computing services

ConPaaS - management

ConPaaS

This service is running the **demo** version of the TaskFarm service. In this mode the service performs only fictional work and it is meant to be used for showing the interaction with the system.

← back to Dashboard

New taskfarm service **terminate** completed tasks **99** of **500** money spent **150s**

adapting created 5 minutes ago

20%

Sampling Phase

the *.bat file No file chosen File containing the tasks to be run

URL mount path for XtremeFS volume (optional)

Execution phase

schedule

Execution Options

Budget/Cost

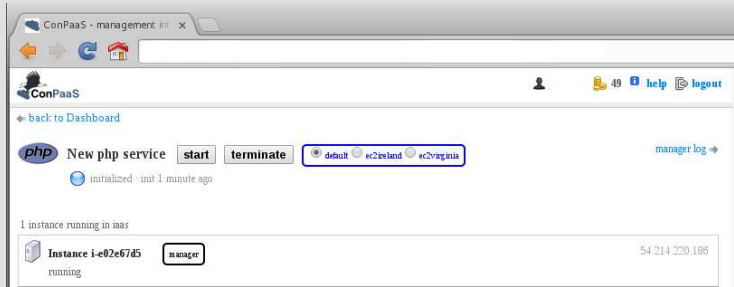
Time needed (minutes)

Cost

Please click on the graph to select an execution

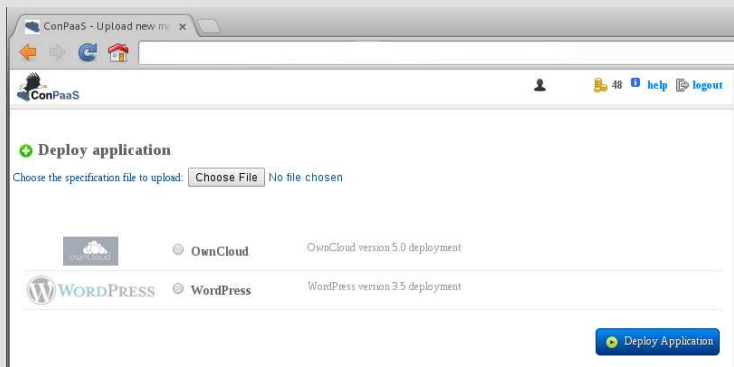
- ▶ **TaskFarming** for scientific workflows and massive batch executions
 - ▶ Control the tradeoff between cost and execution time
- ▶ **MapReduce** for BigData processing
 - ▶ Based on Hadoop

Multi-cloud deployments



- ▶ ConPaaS can use **multiple underlying clouds simultaneously**
 - ▶ For example: OpenNebula in my private cluster, EC2 in Virginia, and EC2 in Oregon
- ▶ Each virtual machine can be started in any cloud
- ▶ All virtual machines are connected using a **multi-point VPN**
 - ▶ Firewall traversal

Automated application deployment



- ▶ ConPaaS can **deploy entire applications in one click**
- ▶ A **manifest file** specifies all relevant information about the application
 - ▶ List of services, code/data to upload, configuration
- ▶ Users can use **ready-made manifests** or upload their own

Release Timeline

Oct 2010: Beginning of the project

Apr 2012: ConPaaS-0.9.0

- ▶ Five services: PHP, Java, MySQL, Scalarix, MapReduce
- ▶ Support of Amazon EC2 and OpenNebula clouds

Oct 2012: ConPaaS-1.0.0

- ▶ TaskFarming and Selenium services
- ▶ Secure control communications
- ▶ GIT-based code uploads

Feb 2013: ConPaaS-1.1.0

- ▶ XtreamFS service
- ▶ Full control via command-line tools

Jun 2013: ConPaaS-1.2.0

- ▶ Multi-cloud support
- ▶ VPN for internal application communications
- ▶ Automated deployment of entire applications
- ▶ Performance monitoring

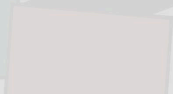
Agenda

Introduction

Architecture

Example application: small-angle neutron scattering

Conclusion



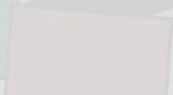
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Architecture

Example application: small-angle neutron scattering

Conclusion



ConPaaS architecture

- ▶ Services
- ▶ Managers
- ▶ Agents
- ▶ Core
- ▶ Applications
- ▶ Manifests
- ▶ Director
- ▶ CLI client
- ▶ Frontend



Services

A decorative graphic at the bottom of the page features a grey path that curves upwards from left to right. Along this path, there are several rectangular blocks of varying colors: a teal block, a pink block, a large light grey block, another light grey block, and a small pink block on the far right. The blocks are arranged in a sequence that follows the curve of the path.

ConPaaS Services

To support a diverse set of use cases we have introduced the concept of **Services**.

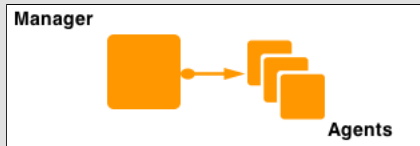
A service is composed by one **Manager** and multiple **Agents**.



ConPaaS Services

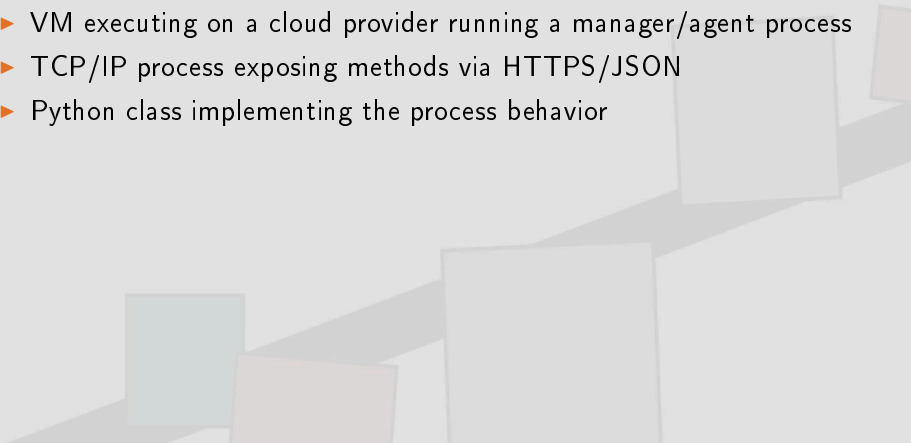
Agents do the real work and accept calls from their Manager only.

The Manager is responsible for adding and removing agents, (re-)configuring them, as well as for other administrative tasks.




ConPaaS Services

Managers and Agents in practice:

- ▶ VM executing on a cloud provider running a manager/agent process
 - ▶ TCP/IP process exposing methods via HTTPS/JSON
 - ▶ Python class implementing the process behavior
- 


ConPaaS Services: Manager

Exposed methods:

- ▶ startup
 - ▶ get_logs
 - ▶ add_nodes
 - ▶ remove_nodes
 - ▶ list_nodes
 - ▶ get_node_info
 - ▶ shutdown
- 
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ConPaaS Services: Manager

Service-specific, MySQL:

- ▶ `load_dump`
 - ▶ `set_password`
- 
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ConPaaS Services: Agent

Exposed method:

- ▶ `check_agent_process`

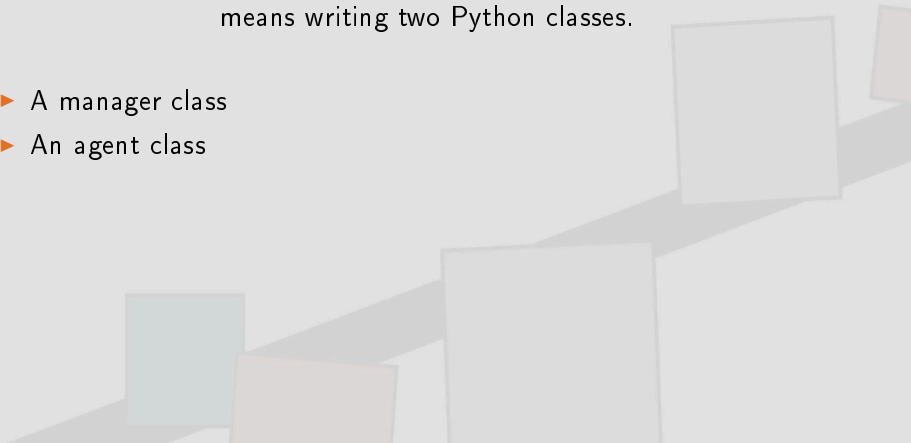
ConPaaS Services: Agent

Service-specific, MySQL:

- ▶ `setup_master`
 - ▶ `setup_slave`
 - ▶ `load_dump`
 - ▶ `set_password`
- 
- A decorative graphic in the bottom right corner of the slide. It features a grey, 3D-style path that starts from the bottom left and extends towards the top right. Along this path, there are several rectangular blocks of varying heights and colors, including light blue, light red, and light grey, which appear to be stepping stones or markers on the path.

ConPaaS Services

Adding support for a new service to ConPaaS means writing two Python classes.

- ▶ A manager class
 - ▶ An agent class
- 
- A decorative graphic at the bottom of the slide shows a grey path leading upwards and to the right. Along this path are several rectangular blocks of varying heights and colors, including light blue, light red, and light grey, suggesting a staircase or a series of steps.

ConPaaS Services

Different ConPaaS services actually have a lot in common.

Manager and Agent classes do not have to be written completely from scratch.

Inherit from **ConPaaS Core**.

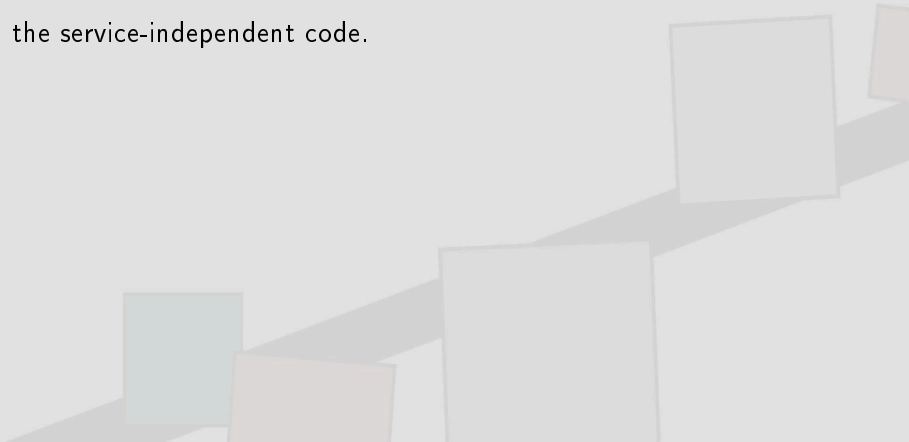


Core

A 3D bar chart with five bars of varying heights and colors (teal, pink, grey, grey, pink) on a light grey background. The word "Core" is centered above the bars.

ConPaaS Core

All the service-independent code.



ConPaaS Core

`conpaas.core.manager.BaseManager`

`conpaas.core.agent.BaseAgent`

ConPaaS Core

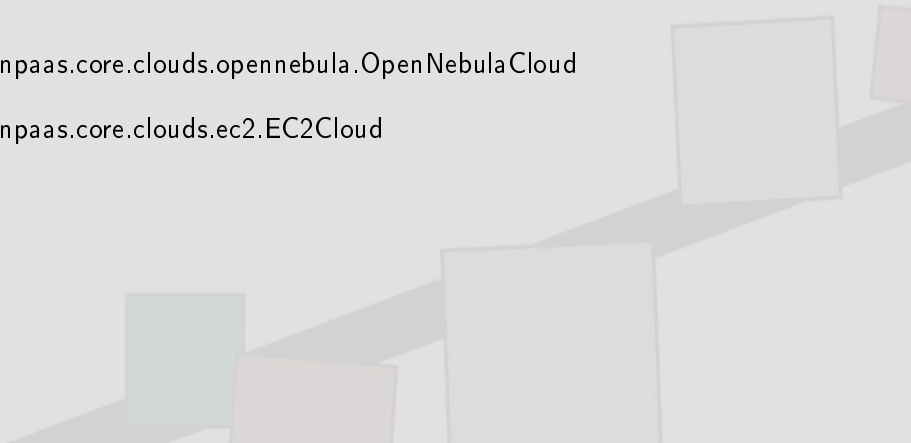
- ▶ IaaS
 - ▶ HTTPS
 - ▶ IPOP
 - ▶ Ganglia
 - ▶ ...
- 
- A decorative graphic at the bottom of the slide shows a grey path leading from the bottom left towards the top right. Along this path, several rectangular blocks are placed, some overlapping. The blocks are colored in shades of teal, pink, and light grey.

ConPaaS Core: multiple clouds

`conpaas.core.clouds.base.BaseCloud`

`conpaas.core.clouds.opennebula.OpenNebulaCloud`

`conpaas.core.clouds.ec2.EC2Cloud`

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ConPaaS Core: IPOP

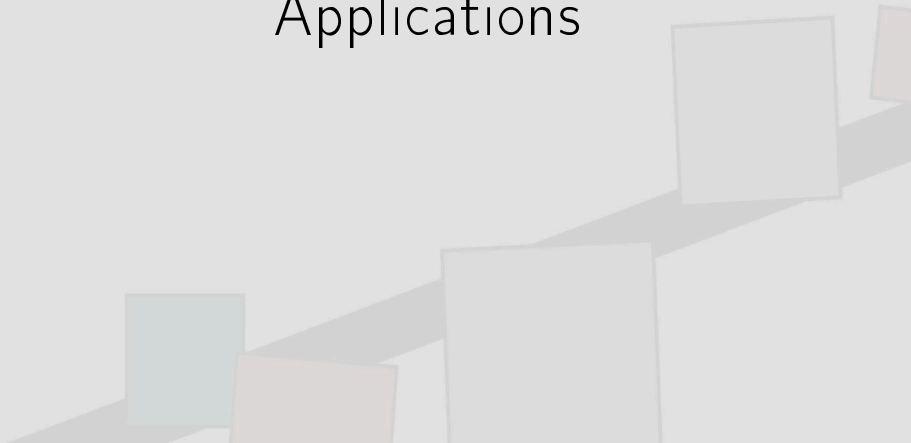
IP over P2P.

Easily deploy VPNs across multiple domains.

ConPaaS uses IPOP to create per-**application** VPNs.

A decorative graphic at the bottom of the slide shows a grey path leading upwards and to the right. Along this path are several rectangular blocks of varying heights and colors, including light blue, light red, and light grey, suggesting a step-by-step process or a sequence of components.

Applications

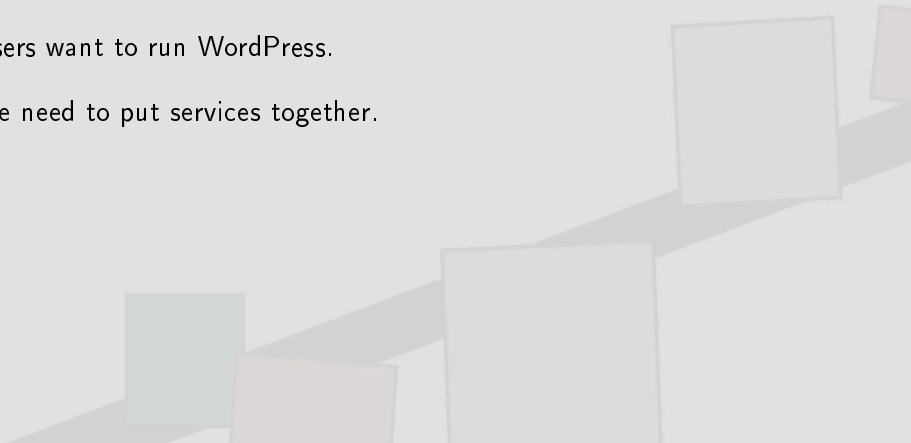
A decorative graphic at the bottom of the slide features a grey path that curves upwards from left to right. Along this path, several squares are placed, appearing as if they are on the ground. From left to right, the visible squares are: a teal square, a pink square, a large light grey square, another light grey square, and a small pink square on the far right edge.

Applications

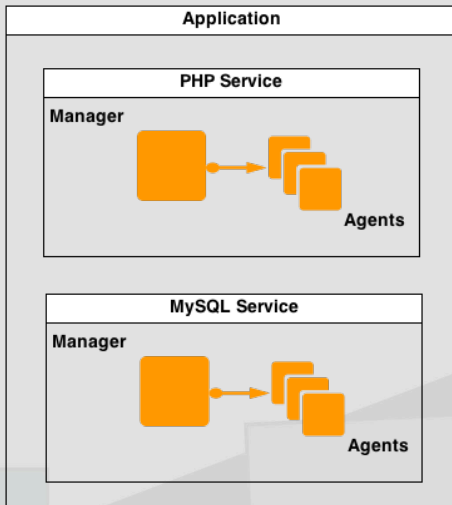
Users do not want to deploy a web server and a database system.

Users want to run WordPress.


We need to put services together.



Applications



Applications

- ▶ Set of services
 - ▶ Belonging to a user
 - ▶ With a name
- 
- A decorative graphic at the bottom of the slide shows a grey path leading from the bottom left towards the top right. Along this path, several rectangular blocks are placed. From left to right, there is a light blue block, a light red block, a light grey block, another light grey block, and a partial light red block on the far right.

Application Manifests

Files describing which services are needed to create a certain ConPaaS application.

JSON data format.

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Application Manifests: Sudoku

```
{
  "Description" : "Sudoku example",
  "Services" : [
    {
      "ServiceName" : "PHP sudoku backend",
      "Type" : "php",
      "Start" : 0,
      "Archive" : "http://www.example.org/sudoku.tar.gz"
    }
  ]
}
```

Application Manifests: MediaWiki

```
{
  "Description" : "Wiki in the Cloud",
  "Services" : [
    {
      "ServiceName" : "Wiki-Webserver",
      "Type" : "java",
      "Archive" : "http://example.org/scalaris-wiki.war",
      "Start" : 1
    },
    {
      "ServiceName" : "Wiki-Database",
      "Type" : "scalaris",
      "Archive" : "http://example.org/wikipediadump",
      "Start" : 1
    }
  ]
}
```

Director



Director

Keeps track of:

- ▶ users
- ▶ credentials
- ▶ applications

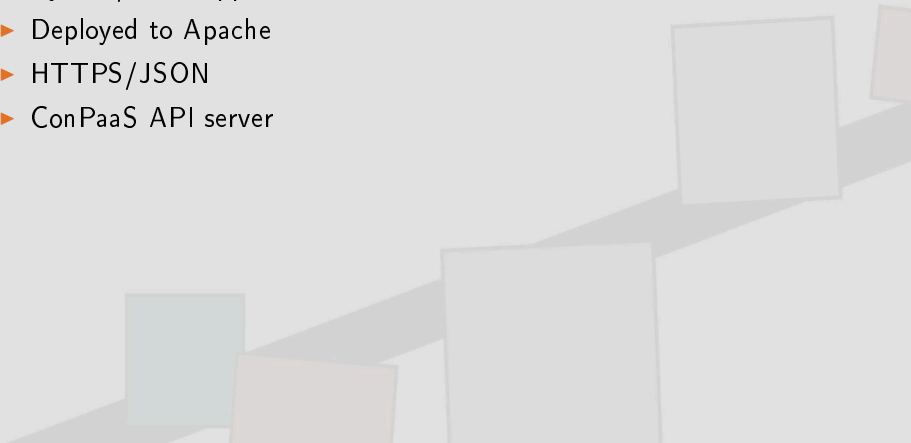
Handles the life-cycle of ConPaaS applications.

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Director




Director

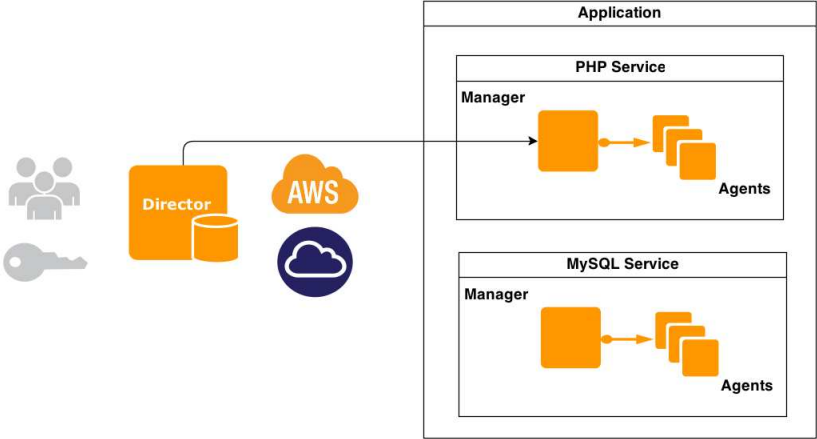
- ▶ Python/Flask application
 - ▶ Deployed to Apache
 - ▶ HTTPS/JSON
 - ▶ ConPaaS API server
- 
- A decorative graphic in the bottom right corner of the slide. It features a grey, 3D-style path that curves upwards from the bottom left towards the right. Along this path, several rectangular blocks are placed, appearing to be stepping stones. The blocks are light grey with thin black outlines and are slightly offset from the path, giving them a floating or stepping appearance. The colors of the blocks vary slightly, with some being a pale blue and others a pale pink.

Director

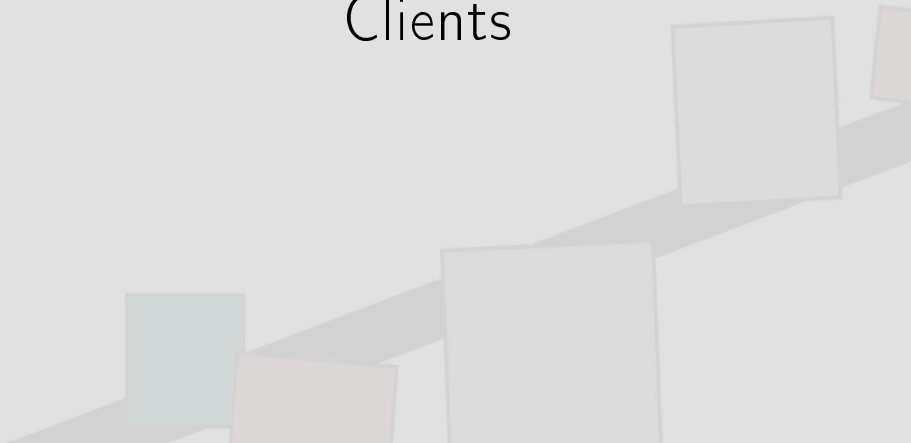
Certification Authority issuing certificates for:

- ▶ users
 - ▶ managers
 - ▶ agents
- 
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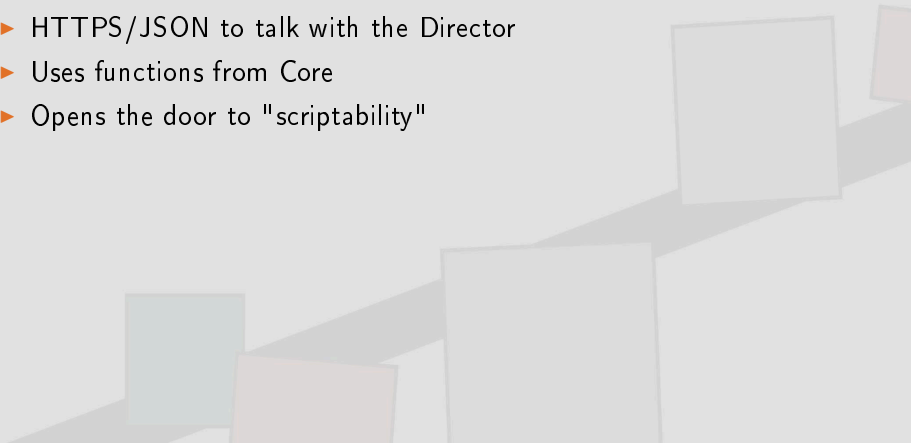
Director



Clients

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CLI client

- ▶ Python CLI application
 - ▶ HTTPS/JSON to talk with the Director
 - ▶ Uses functions from Core
 - ▶ Opens the door to "scriptability"
- 
- A decorative graphic at the bottom of the slide shows a grey path leading upwards and to the right. Along the path are several rectangular blocks of different colors: a teal block, a pink block, a large grey block, and another grey block further up the path.

CLI client

```
Usage: /usr/local/bin/cpsclient.py COMMAND [params]
COMMAND is one of the following
```

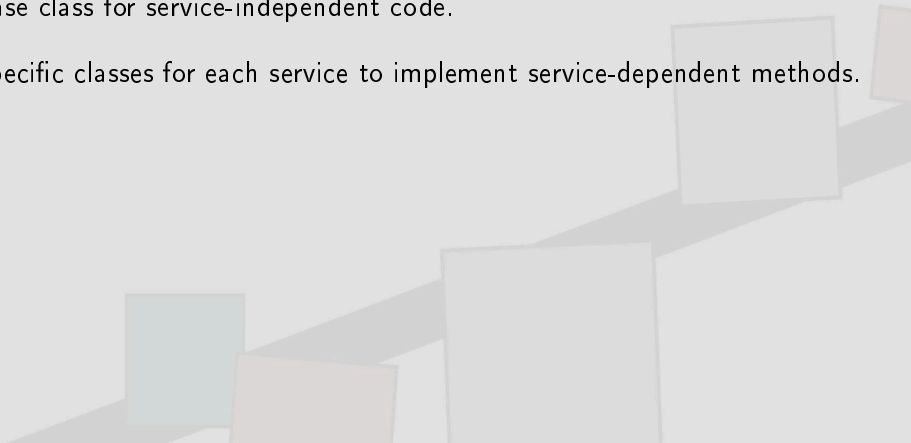
```
credentials          # set your ConPaaS credentials
listapp              # list all applications
available            # list supported services
clouds               # list available clouds
list                 [appid]      # list running services under an application
deleteapp            appid         # delete an application
createapp             appname       # create a new application
manifest             filename      # upload a new manifest
download_manifest    appid         # download an existing manifest
create               servicetype [appid] # create a new service [inside a specific application]
start                serviceid [cloud] # startup the given service [on a specific cloud]
info                 serviceid     # get service details
logs                 serviceid     # get service logs
stop                 serviceid     # stop the specified service
terminate            serviceid     # delete the specified service
rename               serviceid newname # rename the specified service
startup_script        serviceid filename # upload a startup script
usage                serviceid     # show service-specific options
```

```
ema@orion: ~/dev/conpaas$
```

CLI client

Base class for service-independent code.

Specific classes for each service to implement service-dependent methods.

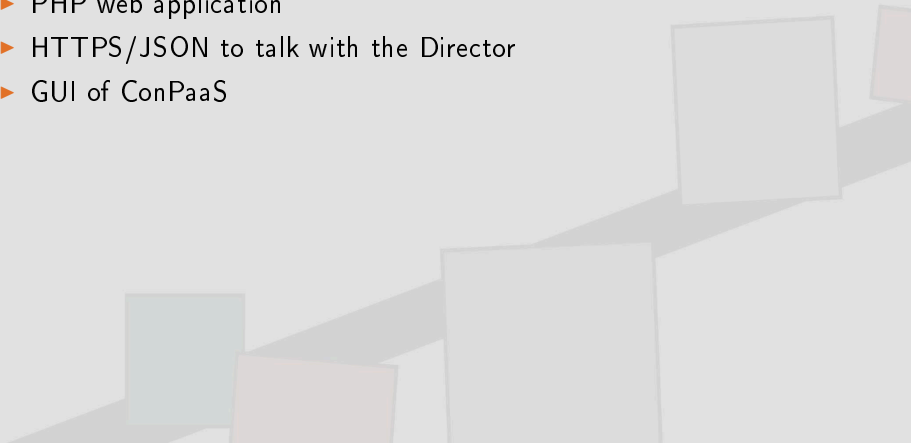
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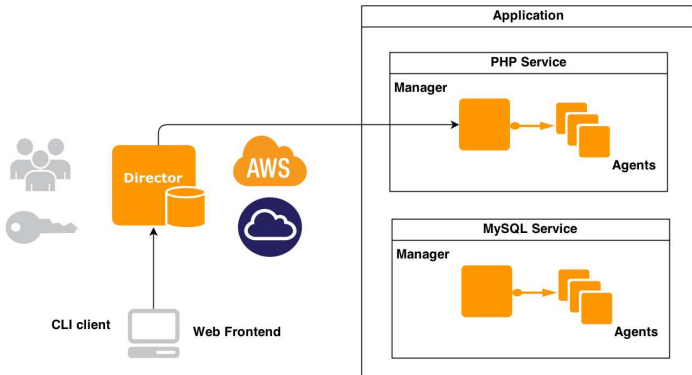
CLI client

```
ema@orion:~$ cpsclient.py create mysql
Creating new manager on 192.168.122.26... done.
ema@orion:~$
ema@orion:~$
ema@orion:~$
ema@orion:~$
ema@orion:~$ cpsclient.py list
type  sid application_id vmid name                manager
-----
mysql  1                1 1437 New mysql service 192.168.122.26
ema@orion:~$
ema@orion:~$
ema@orion:~$
ema@orion:~$
ema@orion:~$ cpsclient.py help 1
Usage: /usr/local/bin/cpsclient.py COMMAND [params]
COMMAND is one of the following

  credentials                # set your ConPaaS credentials
  listapp                    # list all applications
  available                  # list supported services
  clouds                     # list available clouds
  list                       [appid] # list running services under an application
  deleteapp                  appid  # delete an application
  createapp                  appname # create a new application
  manifest                   filename # upload a new manifest
  download_manifest         appid    # download an existing manifest
  create                     servicetype [appid] # create a new service [inside a specific application]
  start                      serviceid [cloud] # startup the given service [on a specific cloud]
  info                       serviceid # get service details
  logs                       serviceid # get service logs
  stop                       serviceid # stop the specified service
  terminate                  serviceid # delete the specified service
  rename                     serviceid newname # rename the specified service
  startup_script             serviceid filename # upload a startup script
  usage                      serviceid # show service-specific options
  set_password               serviceid password
  add_nodes                  serviceid count [cloud]
  remove_nodes               serviceid count
ema@orion:~$
```

Frontend

- ▶ PHP web application
 - ▶ HTTPS/JSON to talk with the Director
 - ▶ GUI of ConPaaS
- 
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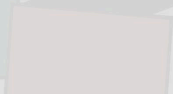
Agenda

Introduction

Architecture

Example application: small-angle neutron scattering

Conclusion



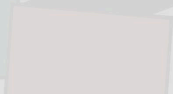
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Introduction

Architecture

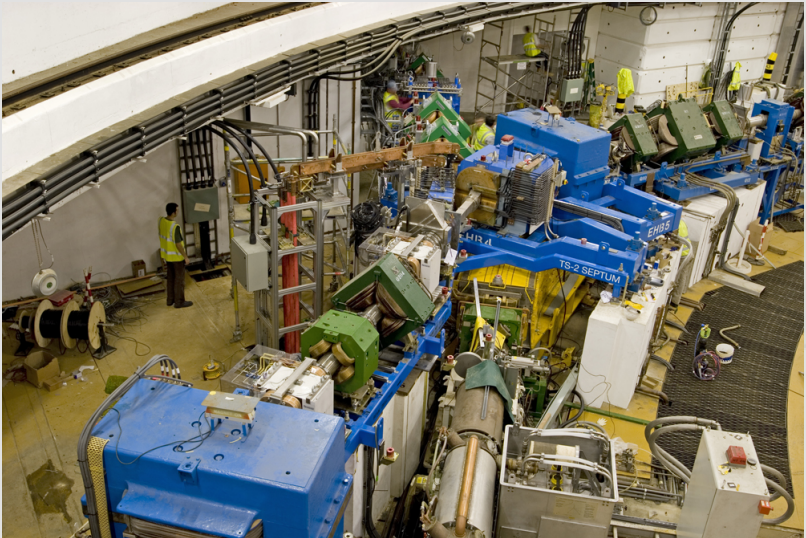
Example application: small-angle neutron scattering

Conclusion

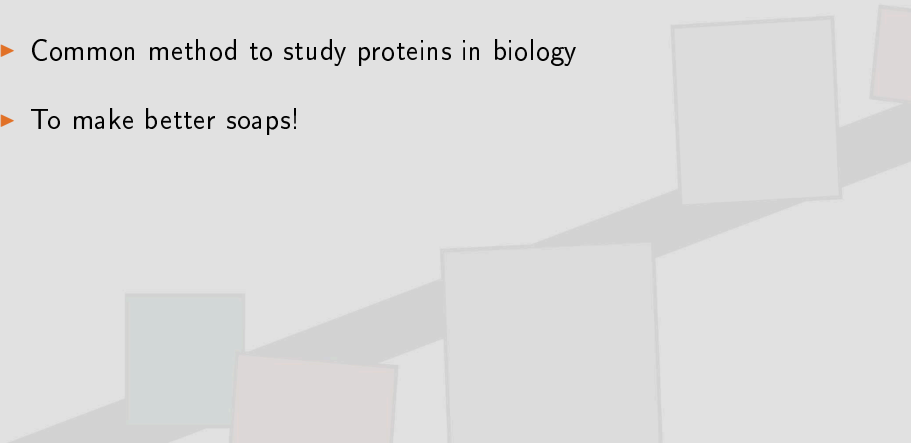


Data comes from this...

Small-angle neutron scattering



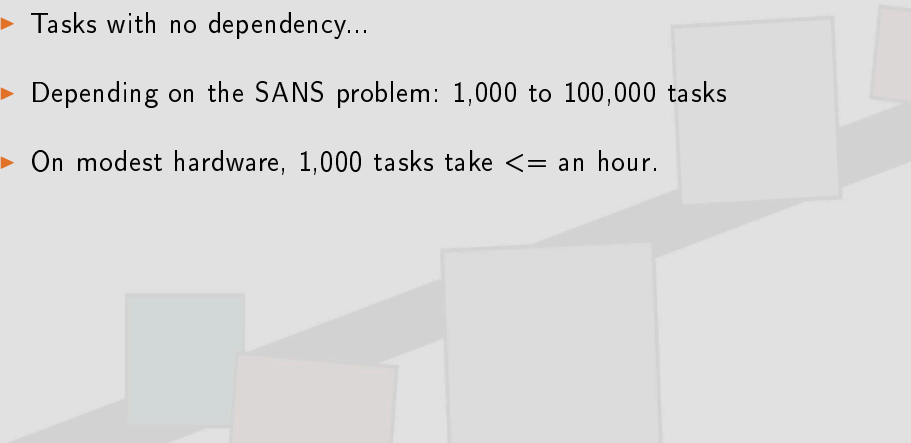
What for...

- ▶ To determine the molecular structure of biological samples
 - ▶ Common method to study proteins in biology
 - ▶ To make better soaps!
- 
- A decorative graphic at the bottom of the slide shows a grey path leading upwards and to the right. Along the path are several rectangular blocks of different colors: a light blue block, a pink block, a light grey block, and a white block. The path and blocks are slightly blurred, giving a sense of depth and movement.

How does it work?

- ▶ Need to find models that fit SANS data
- ▶ Does that molecule look like a sphere? or a cylinder?
- ▶ If so, what diameter fits better? or what height?
- ▶ Long story short, it is parameter sweep problem.
- ▶ <https://pypi.python.org/pypi/pybiosas>

The parameter sweep

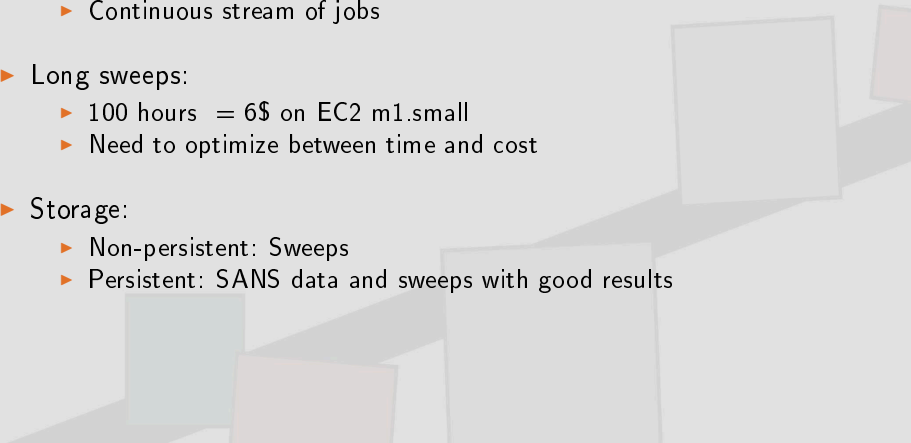
- ▶ Parameter sweeps are sweet!
 - ▶ Tasks with no dependency...
 - ▶ Depending on the SANS problem: 1,000 to 100,000 tasks
 - ▶ On modest hardware, 1,000 tasks take \leq an hour.
- 

The scientist

1. Goes to that big machine and does his experiment
2. Looks at the data
3. Defines the range for parameters
4. Runs the sweep - wait
5. Looks at the result
6. Good? Done. Not good? Go to 3.



Scientist requirements

- ▶ Execution environment
 - ▶ Short sweeps:
 - ▶ Interactiveness is important
 - ▶ Continuous stream of jobs
 - ▶ Long sweeps:
 - ▶ 100 hours = 6\$ on EC2 m1.small
 - ▶ Need to optimize between time and cost
 - ▶ Storage:
 - ▶ Non-persistent: Sweeps
 - ▶ Persistent: SANS data and sweeps with good results
- 
- A decorative graphic in the bottom right corner of the slide. It features a thick, grey diagonal line that runs from the bottom left towards the top right. Several semi-transparent, light-colored squares are scattered around and overlapping this line. The squares are in various shades of light blue, light green, and light orange. Some squares are partially cut off by the edges of the slide.

ConPaaS to the rescue



- ▶ Taskfarming service for the parameter sweep
- ▶ XtremFS service for scalable and reliable storage
- ▶ Unified and clean interface for:
 - ▶ Starting/stopping services
 - ▶ Scaling services
 - ▶ Getting status of various services

Taskfarming service in ConPaaS

- ▶ Bag-of-tasks scheduler on VM nodes
- ▶ Parameter sweeps are bags of tasks
- ▶ Sampling/execution phase
- ▶ Optimizes between time and cost¹

¹Oprescu et al. Budget Estimation and Control for Bag-of-Tasks Scheduling in Clouds. Parallel Processing Letters, 2011.

XtreemFS service in ConPaaS

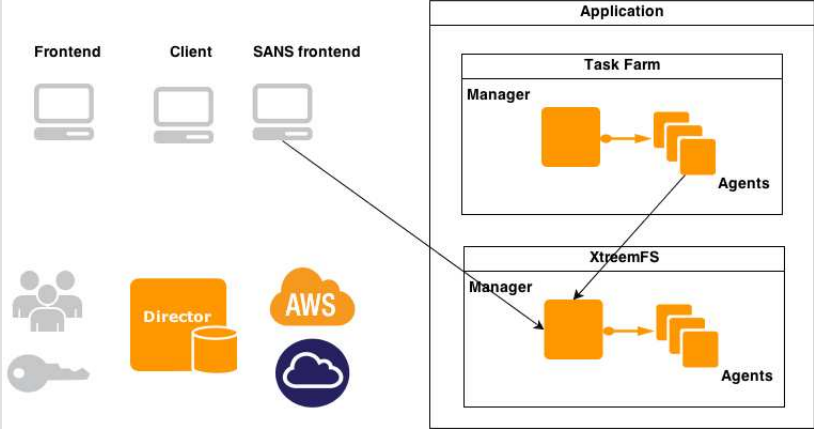
- ▶ Distributed object-based filesystem²
- ▶ Fully-integrated in ConPaaS
- ▶ Can add storage nodes on the fly
- ▶ Currently, only non-persistent storage on VM image disk
- ▶ Work in progress:
 - ▶ Support for scratch disks (more disk space)
 - ▶ Support for persistent storage (e.g. over Amazon EBS)

²Hupfeld et al. XtreemFS - a case for object-based storage in Grid data management. VLDB, 2007.

The ConPaaS director interface

- ▶ A unified interface to run commands on:
 - ▶ ConPaaS director: start/stop services
 - ▶ Services: scale, service status (e.g. tasks done)
- ▶ Users of this interface:
 - ▶ ConPaaS web frontend
 - ▶ ConPaaS client tools
 - ▶ And now: SANS modeling frontend!
- ▶ SANS modeling frontend
 - ▶ Specialized interface
 - ▶ Interactive workflow functionality described earlier
 - ▶ Functionality to analysis results of sweeps (e.g. clustering)
 - ▶ Lacks ConPaaS XtremFS support (uses an external one)

Putting it all together



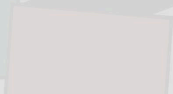
Agenda

Introduction

Architecture

Example application: small-angle neutron scattering

Conclusion



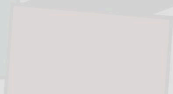
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Conclusion

- ▶ An **integrated** runtime environment for **elastic** cloud **applications**
 - ▶ Standard services can be composed to build cloud applications
 - ▶ Extending ConPaaS with extra services is quite easy
- ▶ Application domains: Web apps, scientific apps
 - ▶ Soon: data stream processing
- ▶ Mature
- ▶ Open-source (BSD licence)

Free trial: <https://online.conpaas.eu>

People behind ConPaaS

Ismail El Helw



Services, Managers, Agents

People behind ConPaaS

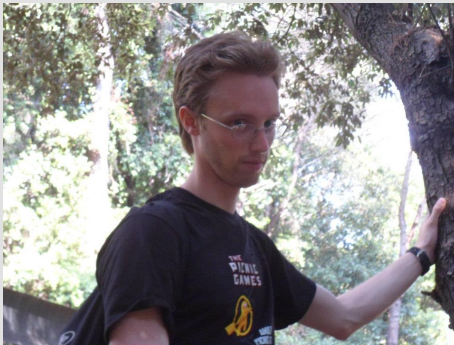
Adriana Szekeres



Security

People behind ConPaaS

Francesco Allertsen



Applications, Manifest

People behind ConPaaS

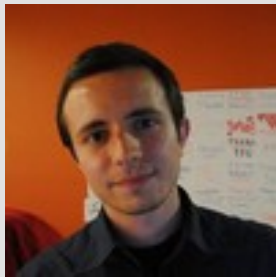
Emanuele Rocca



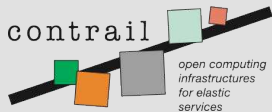
Director, IPOP integration

People behind ConPaaS

Claudiu Gheorghe



Frontend



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Area: Internet of Services, Software & Virtualization
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Project reference: FP7-IST-257438

Total cost: 11.29 million euro

EU contribution: 8.3 million euro

Execution: From 2010-10-01 till 2013-09-30

Duration: 36 months

Contract type: Collaborative project (generic)