

ConPaaS internals: Creating new ConPaaS services

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1 Introduction

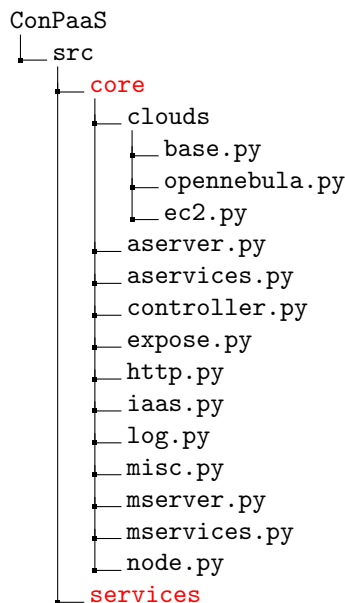
A ConPaaS service may consist of three main entities: the manager, the agent and the frontend. The (primary) manager resides in the first VM that is started by the frontend when the service is created and its role is to manage the service by providing supporting agents, maintaining a stable configuration at any time and by permanently monitoring the service's performance. An agent resides on each of the other VMs that are started by the manager. The agent is the one that does all the work. Note that a service may contain one manager and multiple agents, or multiple managers that also act as agents.

To implement a new ConPaaS service, you must provide a new manager service, a new agent service and a new frontend service (we assume that each ConPaaS service can be mapped on the three entities architecture). To ease the process of adding a new ConPaaS service, we propose a framework which implements common functionality of the ConPaaS services. So far, the framework provides abstraction for the IaaS layer (adding support for a new cloud provider should not require modifications in any ConPaaS service implementation) and it also provides abstraction for the HTTP communication (we assume that HTTP is the preferred protocol for the communication between the three entities).

1.1 ConPaaS directory structure

You can see below the directory structure of the ConPaaS software. The *core* folder under *src* contains the ConPaaS framework. Any service should make use of this code. It contains the manager http server, which instantiates the python manager class that implements the required service; the agent http server that instantiates the python agent class (if the service requires agents); the IaaS abstractions and other useful code.

A new service should be added in a new python module under the *ConPaaS/src/services* folder.



that contains configuration files in the INI format and the *scripts* folder that contains executable bash scripts. Some of these files are specific to the cloud, other to the manager and the rest to the agent. These files will be concatenated in a single contextualization script, as described below.

- Files specific to the Cloud:

(1) `$CONPAAS_HOME/config/cloud/cloud_name.cfg`, where *cloud_name* refers to the clouds supported by the system (for now OpenNebula and SC2). So there is one such file for each cloud the system supports. These files are filled in by the administrator. They contain information such as the username and password to access the cloud, the OS image to be used with the VMs, etc. These files are used by the frontend and the manager, as both need to ask the cloud to start VMs.

(2) `$CONPAAS_HOME/scripts/cloud/cloud_name`, where *cloud_name* refers to the clouds supported by the system (for now OpenNebula and EC2). So, as above, there is one such file for each cloud the system supports. These scrips will be included in the contextualization files. For example, for OpenNebula, this file sets up the network.

- Files specific to the Manager:

(3) `$CONPAAS_HOME/scripts/manager/manager-setup`, which prepares the environment by copying the ConPaaS source code on the VM, unpacking it, and setting up the PYTHONPATH environment variable.

(4) `$CONPAAS_HOME/config/manager/service_name-manager.cfg`, which contains configuration variables specific to the service manager (in INI format). If the new service needs any other variables (like a path to a file in the source code), it should provide an annex to the default manager config file. This annex must be named *service_name-manager.cfg* and will be concatenated to default-manager.cfg

(5) `$CONPAAS_HOME/scripts/manager/service_name-manager-start`, which starts the server manager and any other programs the service manager might use.

(6) `$CONPAAS_HOME/sbin/manager/service_name-cpsmanager` (will be started by the *service_name-manager-start* script), which starts the manager server, which in turn will start the requested manager service.

Scripts (1), (2), (3), (4) and (5) will be used by the frontend to generate the contextualization script for the manager VM. After this scripts executes, a configuration file containing the concatenation of (1) and (4) will be put in `$ROOT_DIR/config.cfg` and then (6) is started with the config.cfg file as a parameter that will be forwarded to the new service.

Examples:

Listing 1: Script (1) - ConPaaS/config/cloud/opennebula.cfg

```
[ iaas ]
DRIVER = OPENNEBULA

# The URL of the OCCI interface at OpenNebula. Note: ConPaaS ↔
  currently
```

```

# supports only the default OCCI implementation that comes ↵
#   together
# with OpenNebula. It does not yet support the full OCCI-0.2 and ↵
#   later
# versions.
URL =

# Your OpenNebula user name
USER =

# Your OpenNebula password
PASSWORD =

# The image ID (an integer). You can list the registered ↵
#   OpenNebula
# images with command "oneimage list" command.
IMAGE_ID =

# OCCI defines 4 standard instance types: small medium large and ↵
#   custom. This
# variable (an integer) should choose one of these. (Note please ↵
#   use numbers
# from 1 to 4, where 4 means the custom instance)
INST_TYPE =

# The network ID (an integer). You can list the registered ↵
#   OpenNebula
# networks with the "onevnet list" command.
NET_ID =

# The network gateway through which new VMs can route their ↵
#   traffic in
# OpenNebula (an IP address)
NET_GATEWAY =

# The DNS server that VMs should use to resolve DNS names (an IP ↵
#   address)
NET_NAMESERVER =

```

Listing 2: Script (2) - ConPaaS/scripts/cloud/opennebula

```

#!/bin/bash
# Copyright (C) 2010-2011 Contrail consortium.
#
# This file is part of ConPaaS, an integrated runtime environment
# for elastic cloud applications.
#
# ConPaaS is free software: you can redistribute it and/or modify
# it under the terms of the GNU General Public License as ↵
#   published by
# the Free Software Foundation, either version 3 of the License, ↵
#   or
# (at your option) any later version.
#
# ConPaaS is distributed in the hope that it will be useful,
# but WITHOUT ANY WARRANTY; without even the implied warranty of
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# GNU General Public License for more details.
#
# You should have received a copy of the GNU General Public ↵
#   License
# along with ConPaaS. If not, see <http://www.gnu.org/licenses↵
#   />.
#
# This is part of the contextualization script
# for the VMs started on Opennebula.
# The rest is generated by the frontend.

if [ -f /mnt/context.sh ]; then
. /mnt/context.sh
fi

```

```
/sbin/ifconfig eth0 $IP_PUBLIC
/sbin/ip route add default via $IP_GATEWAY
echo "nameserver $NAMESERVER" > /etc/resolv.conf
```

Listing 3: Script (3) - ConPaaS/scripts/manager/manager-setup

```
#!/bin/bash

# This script is part of the contextualization file. It
# copies the source code on the VM, unpacks it, and sets
# the PYTHONPATH environment variable.

# Is filled in by the frontend
FRONTEND=%FRONTEND_URL%
SOURCE=$FRONTEND/download
ROOT_DIR=/root
CPS_HOME=$ROOT_DIR/ConPaaS

wget -P $ROOT_DIR/ $SOURCE/ConPaaS.tar.gz
tar -zxvf $ROOT_DIR/ConPaaS.tar.gz -C $ROOT_DIR/
export PYTHONPATH=$CPS_HOME/src/:$CPS_HOME/contrib/
```

Listing 4: Script (4) - ConPaaS/config/manager/default-manager.cfg

```
[manager]

# Service TYPE will be filled in by the frontend
TYPE = %CONPAAS_SERVICE_TYPE%

BOOTSTRAP = $SOURCE
MY_IP = $IP_PUBLIC

# These three are used by the manager to instruct the frontend to
# decrement the number of credits the user has.
# They are used when a VM ran more than 1 hour.
# Everything will be filled in by the frontend
FE_SERVICE_ID = %CONPAAS_SERVICE_ID%
FE_CREDIT_URL = %FRONTEND_URL%/callback/decrementUserCredit.php
FE_TERMINATE_URL = %FRONTEND_URL%/callback/terminateService.php

# This directory structure already exists in the VM (with ROOT = ↵
# '' ) - see
# the 'create new VM script' so do not change ROOT unless you ↵
# also modify
# it in the VM. Use these files/directories to put variable data ↵
# that
# your manager might generate during its life cycle
ROOT =
LOG_FILE = %(ROOT)s/var/log/cpsmanager.log
ETC = %(ROOT)s/etc/cpsmanager/
VAR_TMP = %(ROOT)s/var/tmp/cpsmanager/
VAR_CACHE = %(ROOT)s/var/cache/cpsmanager/
VAR_RUN = %(ROOT)s/var/run/cpsmanager/
CODE_REPO = %(VAR_CACHE)s/code_repo

CONPAAS_HOME = $CPS_HOME

# Add below other config params your manager might need and save ↵
# a file as
# %service_name%-manager.cfg
# Otherwise this file will be used by default
```

Listing 5: Script (5) - ConPaaS/scripts/manager/default-manager-start

```
#!/bin/bash
```

```
# This script is part of the contextualization file. It
# starts a python script that parses the given arguments
# and starts the manager server, which in turn will start
# the manager service.

# This file is the default manager-start file. It can be
# customized as needed by the service.

$CPS_HOME/sbin/manager/default-cpsmanager -p 80 -c $ROOT_DIR/↵
config.cfg 1>$ROOT_DIR/manager.out 2>$ROOT_DIR/manager.err &
manager_pid=$!
echo $manager_pid > $ROOT_DIR/manager.pid
```

Listing 6: Script (6) - ConPaaS/sbin/manager/default-cpsmanager

```
#!/usr/bin/python
'''
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OF THE USE OF THIS SOFTWARE, EVEN IF ADVISED OF THE
POSSIBILITY OF SUCH DAMAGE.

Created on Jul 4, 2011

@author: ielhelw
'''
from os.path import exists
from conpaas.core.mserver import ManagerServer

if __name__ == '__main__':
    from optparse import OptionParser
    from ConfigParser import ConfigParser
    import sys

    parser = OptionParser()
    parser.add_option('-p', '--port', type='int', default=80, dest='↵
port')
    parser.add_option('-b', '--bind', type='string', default='↵
0.0.0.0', dest='address')
    parser.add_option('-c', '--config', type='string', default=None↵
, dest='config')
```

```

options, args = parser.parse_args()

if not options.config or not exists(options.config):
    print >>sys.stderr, 'Failed to find configuration file'
    sys.exit(1)

config_parser = ConfigParser()
try:
    config_parser.read(options.config)
except:
    print >>sys.stderr, 'Failed to read configuration file'
    sys.exit(1)

"""
Verify some sections and variables that must exist in the
configuration file
"""
config_vars = {
    'manager': ['TYPE', 'BOOTSTRAP', 'LOG_FILE',
               'FE_CREDIT_URL', 'FE_TERMINATE_URL', '←
               FE_SERVICE_ID'],
    'iaas': ['DRIVER'],
}
config_ok = True
for section in config_vars:
    if not config_parser.has_section(section):
        print >>sys.stderr, 'Missing configuration section "%s"' % ←
        (section)
        print >>sys.stderr, 'Section "%s" should contain variables ←
        %s' % (section, str(config_vars[section]))
        config_ok = False
        continue
    for field in config_vars[section]:
        if not config_parser.has_option(section, field)\
        or config_parser.get(section, field) == '':
            print >>sys.stderr, 'Missing configuration variable "%s" ←
            in section "%s"' % (field, section)
            config_ok = False
if not config_ok:
    sys.exit(1)

"""
Start the manager server
"""
print options.address, options.port
d = ManagerServer((options.address, options.port),
                  config_parser,
                  reset_config=True)
d.serve_forever()

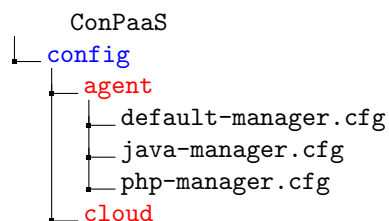
```

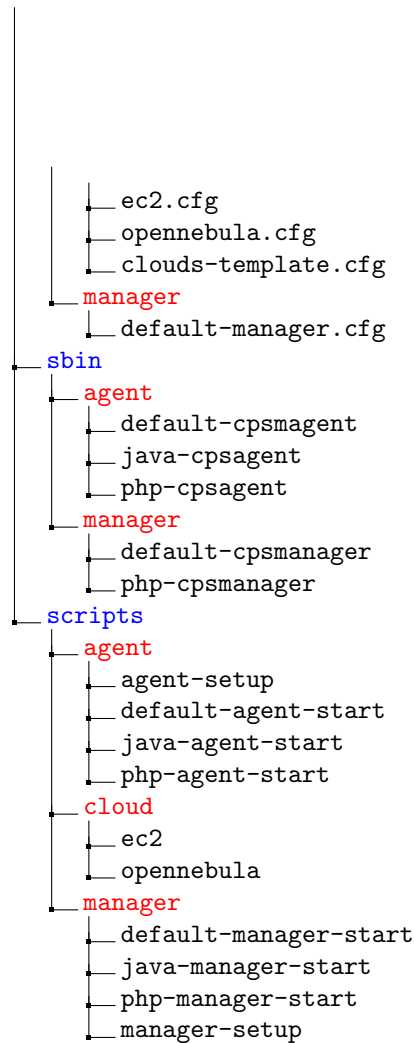
- Files specific to the Agent

They are similar to the files described above for the manager, but this time the contextualization file is generated by the manager.

3.1 Scripts and config files directory structure

Bellow you can find the directory structure of the scripts and configuration files described above.





4 Implementing a new ConPaaS service

In this section we describe how to implement a new ConPaaS service by providing an example which can be used as a starting point. The new service is called *helloworld* and will just generate helloworld strings. Thus, the manager will provide a method, called `get_helloworld` which will ask all the agents to return a 'helloworld' string (or another string chosen by the manager).

We will start by implementing the agent. We will create a class, called `HelloWorldAgent`, which implements the required method - `get_helloworld`, and put it in `conpaasservices/helloworld/agent/agent.py` (Note: make the directory structure as needed and providing empty `__init__.py` to make the directory be recognized as a module path). As you can see in Listing 7, this class uses some functionality provided in the `conpaas.core` package. The `conpaas.core.expose` module provides a python decorator (`@expose`) that can be used to expose the http methods that the agent server dispatches. By using this decorator, a dictionary containing methods for http requests GET, POST or UPLOAD is filled in behind the scenes. This dictionary is used by the built-in server in the `conpaas.core` package to dispatch the HTTP requests. The module `conpaas.core.http` contains some useful methods, like `HttpJsonResponse` and `HttpErrorResponse` that are used to respond to the HTTP request dispatched to the corresponding method. In this class we also implemented a method called `startup`, which only changes

the state of the agent. This method could be used, for example, to make some initializations in the agent. We will describe later the use of the other method, `check_agent_process`.

Listing 7: `conpaas/services/helloworld/agent/agent.py`

```
from conpaas.core.expose import expose
from conpaas.core.http import JsonResponse, HttpResponse, \
    HttpFileDownloadResponse, HttpRequest, \
    FileUploadField, HttpError, _http_post
from conpaas.core.log import create_logger

class HelloWorldAgent():
    def __init__(self,
                  config_parser, # config file
                  **kwargs):     # anything you can't send in ↔
        config_parser           # (hopefully the new service won't ↔
                               need anything extra)

        self.logger = create_logger(__name__)
        self.state = 'INIT'
        self.gen_string = config_parser.get('agent', 'STRING_TO_GENERATE↔
        ')

    @expose('GET')
    def check_agent_process(self, kwargs):
        """Check if agent process started — just return an empty ↔
        response"""
        if len(kwargs) != 0:
            return HttpResponse('ERROR: Arguments unexpected')
        return JsonResponse()

    @expose('POST')
    def startup(self, kwargs):
        self.state = 'RUNNING'
        self.logger.info('Agent started up')
        return JsonResponse()

    @expose('GET')
    def get_helloworld(self, kwargs):
        if self.state != 'RUNNING':
            return HttpResponse('ERROR: Wrong state to get_helloworld↔
            ')
        return JsonResponse({'result': self.gen_string})
```

Let's assume that the manager wants each agent to generate a different string. The agent should be informed about the string that it has to generate. To do this, we could either implement a method inside the agent, that will receive the required string, or specify this string in the configuration file with which the agent is started. We opted for the second method just to illustrate how a service could make use of the config files and also, maybe some service agents/managers need some information before having been started.

Therefore, we will provide the *helloworld-agent.cfg* file (see Listing 8) that will be concatenated to the *default-manager.cfg* file. It contains a variable (`$STRING`) which will be replaced by the manager.

Listing 8: `ConPaaS/config/agent/helloworld-agent.cfg`

```
STRING_TO_GENERATE = $STRING
```

Now let's implement an http client for this new agent server. See Listing 9. This client will be used by the manager as a wrapper to easily send requests to

the agent. We used some useful methods from `conpaas.core.http`, to send json objects to the agent server.

Listing 9: `conpaas/services/helloworld/agent/client.py`

```
from conpaas.core.http import _jsonrpc_get, _jsonrpc_post, _http_post
import httplib, json

def _check(response):
    code, body = response
    if code != httplib.OK: raise Exception('Received http response code ←
    %d' % (code))
    data = json.loads(body)
    if data['error']: raise Exception(data['error'])
    else: return data['result']

def check_agent_process(host, port):
    method = 'check_agent_process'
    return _check(_jsonrpc_get(host, port, '/', method))

def startup(host, port):
    method = 'startup'
    return _check(_jsonrpc_post(host, port, '/', method))

def get_helloworld(host, port):
    method = 'get_helloworld'
    return _check(_jsonrpc_get(host, port, '/', method))
```

Next, we will implement the manager in the same manner: we will write the *HelloWorldManager* class and place it in the file `conpaas/services/helloworld/manager/manager.py`. To make use of the IaaS abstractions, we need to instantiate a Controller which controls all the requests to the clouds on which ConPaaS is running. Note the lines:

```
1: self.controller = Controller( config_parser)
2: self.controller.generate_context('helloworld')
```

The first line instantiates a Controller. The controller maintains a list of cloud objects generated from the *config_parser* file. There are several functions provided by the controller which are documented in the doxygen documentation of file *controller.py*. The most important ones, which are also used in the Hello World service implementation, are: *generate_context* (which generates a template of the contextualization file); *update_context* (which takes the contextualization template and replaces the variables with the supplied values); *create_nodes* (which asks for additional nodes from the specified cloud or the default one) and *delete_nodes* (which deletes the specified nodes).

Note that the *create_nodes* function accepts as a parameter a function (in our case *check_agent_process*) that tests if the agent process started correctly in the agent VM. If an exception is generated during the calls to this function for a given period of time, then the manager assumes that the agent process didn't start correctly and tries to start the agent process on a different agent VM.

Listing 10: `conpaas/services/helloworld/manager/manager.py`

```
from threading import Thread, Lock, Timer, Event

from conpaas.core.expose import expose
from conpaas.core.controller import Controller
from conpaas.core.http import JsonResponse, HttpResponse, \
```

```

        HttpFileDownloadResponse, HttpRequest, \
        FileUploadField, HttpError, _http_post
from conpaas.core.log import create_logger
from conpaas.services.helloworld.agent import client

class HelloWorldManager(object):

    # Manager states - Used by the frontend
    S_INIT = 'INIT' # manager initialized but not yet started
    S_PROLOGUE = 'PROLOGUE' # manager is starting up
    S_RUNNING = 'RUNNING' # manager is running
    S_ADAPTING = 'ADAPTING' # manager is in a transient state - <-
        frontend will keep # polling until manager out of transient <-
        state
    S_EPILOGUE = 'EPILOGUE' # manager is shutting down
    S_STOPPED = 'STOPPED' # manager stopped
    S_ERROR = 'ERROR' # manager is in error state

    def __init__(self,
                  config_parser, # config file
                  **kwargs): # anything you can't send in <-
        config_parser
        # (hopefully the new service won't <-
        need anything extra)

        self.config_parser = config_parser
        self.logger = create_logger(__name__)
        self.logfile = config_parser.get('manager', 'LOG_FILE')
        self.nodes = []
        # Setup the clouds' controller
        self.controller = Controller(config_parser)
        self.controller.generate_context('helloworld')
        self.state = self.S_INIT

    @expose('POST')
    def startup(self, kwargs):
        self.logger.info('Manager started up')
        self.state = self.S_RUNNING
        return HttpResponse()

    @expose('POST')
    def shutdown(self, kwargs):
        self.state = self.S_EPILOGUE
        Thread(target=self._do_shutdown, args=[]).start()
        return HttpResponse()

    def _do_shutdown(self):
        self.controller.delete_nodes(self.nodes)
        self.state = self.S_STOPPED
        return HttpResponse()

    @expose('POST')
    def add_nodes(self, kwargs):
        self.controller.update_context(dict(String='helloworld'))
        if self.state != self.S_RUNNING:
            return HttpResponse('ERROR: Wrong state to add.nodes' <-
                                )
        if not 'count' in kwargs:
            return HttpResponse('ERROR: Required argument doesn\' <-
                                t exist')
        if not isinstance(kwargs['count'], int):
            return HttpResponse('ERROR: Expected an integer value <-
                                for "count"')
        count = int(kwargs.pop('count'))
        self.state = self.S_ADAPTING
        Thread(target=self._do_add_nodes, args=[count]).start()
        return HttpResponse()

    def _do_add_nodes(self, count):
        node_instances = self.controller.create_nodes(count, \
                                                         client.check_agent_process, <-
                                                         5555)

        self.nodes += node_instances
        # Startup agents

```

```

        for node in node_instances:
            client.startup(node.ip, 5555)
        self.state = self.S_RUNNING
        return JsonResponse()

    @expose('GET')
    def list_nodes(self, kwargs):
        if len(kwargs) != 0:
            return HttpResponse('ERROR: Arguments unexpected')
        if self.state != self.S_RUNNING:
            return HttpResponse('ERROR: Wrong state to list_nodes')
        return JsonResponse({
            'helloworld': [ node.vmid for node in self.nodes ],
        })

    @expose('GET')
    def get_service_info(self, kwargs):
        if len(kwargs) != 0:
            return HttpResponse('ERROR: Arguments unexpected')
        return JsonResponse({'state': self.state, 'type': 'helloworld'})

    @expose('GET')
    def get_node_info(self, kwargs):
        if 'serviceNodeId' not in kwargs:
            return HttpResponse('ERROR: Missing arguments')
        serviceNodeId = kwargs.pop('serviceNodeId')
        if len(kwargs) != 0:
            return HttpResponse('ERROR: Arguments unexpected')
        serviceNode = None
        for node in self.nodes:
            if serviceNodeId == node.vmid:
                serviceNode = node
                break
        if serviceNode is None:
            return HttpResponse('ERROR: Invalid arguments')
        return JsonResponse({
            'serviceNode': {
                'id': serviceNode.vmid,
                'ip': serviceNode.ip
            }
        })

    @expose('POST')
    def remove_nodes(self, kwargs):
        if self.state != self.S_RUNNING:
            return HttpResponse('ERROR: Wrong state to remove_nodes')
        if not 'count' in kwargs:
            return HttpResponse('ERROR: Required argument doesn\'t exist')
        if not isinstance(kwargs['count'], int):
            return HttpResponse('ERROR: Expected an integer value for "count"')
        count = int(kwargs.pop('count'))
        self.state = self.S_ADAPTING
        Thread(target=self._do_remove_nodes, args=[count]).start()
        return JsonResponse()

    def _do_remove_nodes(self, count):
        for i in range(0, count):
            self.controller.delete_nodes([self.nodes.pop(0)])
        self.state = self.S_RUNNING
        return JsonResponse()

    @expose('GET')
    def get_helloworld(self, kwargs):
        if self.state != self.S_RUNNING:
            return HttpResponse('ERROR: Wrong state to get_helloworld')
        # Just get_helloworld from all the agents
        for node in self.nodes:
            data = client.get_helloworld(node.ip, 5555)

```

```

        self.logger.info('Received %s from %s', data, node.vmid)
    return JsonResponse({
        'helloworld': [ node.vmid for node in self.nodes ],
    })

@expose('GET')
def getLog(self, kwargs):
    if len(kwargs) != 0:
        return HttpResponse('ERROR: Arguments unexpected')
    try:
        fd = open(self.logfile)
        ret = ''
        s = fd.read()
        while s != '':
            ret += s
            s = fd.read()
            if s != '':
                ret += s
        return JsonResponse({'log': ret})
    except:
        return HttpResponse('Failed to read log')

```

We can also implement a client for the manager server (see Listing 11). This will allow us to use the command line interface to send requests to the manager, if the frontend integration is not available.

Listing 11: conpaas/services/helloworld/manager/client.py

```

import httplib, json
from conpaas.core.http import HttpError, _jsonrpc_get, _jsonrpc_post, ↵
    _http_post, _http_get

def _check(response):
    code, body = response
    if code != httplib.OK: raise HttpError('Received http response code ↵
        %d' % (code))
    data = json.loads(body)
    if data['error']: raise Exception(data['error'])
    else: return data['result']

def get_service_info(host, port):
    method = 'get_service_info'
    return _check(_jsonrpc_get(host, port, '/', method))

def get_helloworld(host, port):
    method = 'get_helloworld'
    return _check(_jsonrpc_get(host, port, '/', method))

def startup(host, port):
    method = 'startup'
    return _check(_jsonrpc_post(host, port, '/', method))

def add_nodes(host, port, count=0):
    method = 'add_nodes'
    params = {}
    params['count'] = count
    return _check(_jsonrpc_post(host, port, '/', method, params=params))

def remove_nodes(host, port, count=0):
    method = 'remove_nodes'
    params = {}
    params['count'] = count
    return _check(_jsonrpc_post(host, port, '/', method, params=params))

def list_nodes(host, port):
    method = 'list_nodes'
    return _check(_jsonrpc_get(host, port, '/', method))

```

The last step is to register the new service to the conpaas core. One entry must be added to files *conpaas/core/mservices.py* and *conpaas/core/aservices.py*, as

it is indicated in Listing 12 and Listing 13. Because the java and php services use the same code for the agent, there is only one entry in the agent services (*aservices.py*), called *web* which is used by both the webservices.

Listing 12: conpaas/core/mservices.py

```
'''
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CONTRIBUTORS BE LIABLE FOR ANY DIRECT, INDIRECT, INCIDENTAL,
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BUT NOT LIMITED TO, PROCUREMENT OF SUBSTITUTE GOODS OR
SERVICES; LOSS OF USE, DATA, OR PROFITS; OR BUSINESS
INTERRUPTION) HOWEVER CAUSED AND ON ANY THEORY OF LIABILITY,
WHETHER IN CONTRACT, STRICT LIABILITY, OR TORT
(INCLUDING NEGLIGENCE OR OTHERWISE) ARISING IN ANY WAY OUT
OF THE USE OF THIS SOFTWARE, EVEN IF ADVISED OF THE
POSSIBILITY OF SUCH DAMAGE.

This file contains all the available manager services
implementations.
'''

services = {'php' : {'class' : 'PHPManager',
                    'module': 'conpaas.services.webservers.manager←
                        .internal.php'},
            'java' : {'class' : 'JavaManager',
                    'module': 'conpaas.services.webservers.manager←
                        .internal.java'},
            'scalaris' : {'class' : 'ScalarisManager',
                    'module': 'conpaas.services.scalaris.manager.←
                        manager'},
            'hadoop' : {'class' : 'MapReduceManager',
                    'module': 'conpaas.services.mapreduce.manager.←
                        manager'},
            'helloworld' : {'class' : 'HelloWorldManager',
                    'module': 'conpaas.services.helloworld.manager←
                        manager'},
            'mysql' : {'class' : 'MySQLManager',
                    'module': 'conpaas.services.mysql.manager.←
                        manager'}
}
```

Listing 13: conpaas/core/aservices.py

```

'''
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CONTRIBUTORS BE LIABLE FOR ANY DIRECT, INDIRECT, INCIDENTAL,
SPECIAL, EXEMPLARY, OR CONSEQUENTIAL DAMAGES (INCLUDING,
BUT NOT LIMITED TO, PROCUREMENT OF SUBSTITUTE GOODS OR
SERVICES; LOSS OF USE, DATA, OR PROFITS; OR BUSINESS
INTERRUPTION) HOWEVER CAUSED AND ON ANY THEORY OF LIABILITY,
WHETHER IN CONTRACT, STRICT LIABILITY, OR TORT
(INCLUDING NEGLIGENCE OR OTHERWISE) ARISING IN ANY WAY OUT
OF THE USE OF THIS SOFTWARE, EVEN IF ADVISED OF THE
POSSIBILITY OF SUCH DAMAGE.

    This file contains all the available services
implementations.
'''

services = { 'web' : { 'class' : 'WebServersAgent',
                      'module' : 'conpaas.services.webservers.↵
                              agent.internals'},
              'scalaris' : { 'class' : 'ScalarisAgent',
                             'module' : 'conpaas.services.scalaris.agent↵
                              .agent'},
              'mapreduce' : { 'class' : 'MapReduceAgent',
                              'module' : 'conpaas.services.mapreduce.↵
                              agent.agent'},
              'helloworld' : { 'class' : 'HelloWorldAgent',
                                'module' : 'conpaas.services.helloworld.↵
                                agent.agent'},
              'mysql' : { 'class' : 'MySQLAgent',
                          'module' : 'conpaas.services.mysql.agent.↵
                          internals'}
    }

```

5 Integrating the new service with the frontend

So far there is no easy way to add a new frontend service. Each service may require distinct graphical elements. In this section we explain how the Hello World frontend service has been created.

5.1 Manager states

As you have noticed in the Hello World manager implementation, we used some standard states, e.g. INIT, ADAPTING, etc. By calling the *get_service_info* function, the frontend knows in which state the manager is. Why do we need these standardized states? As an example, if the manager is in the ADAPTING state, the frontend would know to draw a loading icon on the interface and keep polling the manager.

5.2 Files to be modified

```
frontend
├── www
│   ├── create.php
│   └── lib
│       ├── service
│       └── factory
│           └── __init__.php
```

Several lines of code must be added to the two files above for the new service to be recognized. If you look inside these files, you'll see that knowing where to add the lines and what lines to add is self-explanatory.

5.3 Files to be added

```
frontend
├── www
│   └── helloworld.php
├── lib
│   ├── service
│   │   ├── helloworld
│   │   │   └── __init__.php
│   ├── ui
│   │   ├── instance
│   │   │   ├── helloworld
│   │   │   │   └── __init__.php
│   └── images
│       └── helloworld.png
```