An Approach to Support Automated Deployment of Applications on Heterogeneous Cloud-HPC Infrastructures

Elisabetta Di Nitto, Jesus Gorronogoitia, Indika Kumara, Georgios Meditskos, Dragan Radolovic, Karthee Sivalingamk, and Roman Sosa Gonzlez
An example of complex application

The goal is to exploit publicly available images to obtain a water availability indicator.
A closer look - multiple configurations

Chron jobs calling the other components through a pipe & filter approach
A closer look - multiple configurations

Data processing

- Skyline Extractor
- 360 panorama generator
- Panorama Alignment
- Snow Mask computation
- Snow Index computation

ML training

Best on HPC

Best on Cloud, on multiple VMs
The problem

How expensive is for a non-IT intensive company
- to handle the deployment of such application and
- to make the process replicable?
The realm of DevOps tools
Towards standard Infrastructure-as-Code

An Application Deployment Topology, i.e., “a graph of physical artefacts that need support for several lifecycle phases (e.g., procurement, installation, configuration, deployment, undeployment, teardown, etc.)”
Towards standard Infrastructure-as-Code

→ **Infrastructure-as-code**, i.e., “a blueprint detailing physical artefacts, all scripts for all lifecycle phases and all artefacts needed for deployment”

**IaC Blueprint**

- Referenced in
- Included in

**IaC Middleware Scripts** (e.g., Chef, Puppet, etc.)

**Deploy artefacts** (e.g., JARs, etc.)

**Infrastructure**
- Host
- Network

**Middleware**
- Apache
- Tomcat
- MySQL

**Application**
- Mod_proxy
- WAR
- Schema
Where Does TOSCA fit into?

- An application topology
- 3 layers
  - Infrastructure (Cloud or DC objects)
  - Platform or Middleware (App containers)
  - Application modules, schemas and configurations
- Relationships between components:
  - What’s hosted on what or installed on what
  - What’s connected to what

Topology and Orchestration Specification for Cloud Applications (TOSCA) - an OASIS standard
• Complexity of the specification
• If special-purpose resources are used, they need to be specified as well (this may be difficult for application experts)
• Different types of resources often offer different APIs and access control mechanisms
  • Sometimes even a different programming style
What SODALITE offers

- Smart creation of deployment models through a textual and graphical DSL
- Editing is supported by an ontology-based reasoning mechanism that
  - Checks the semantic validity of a model
    - E.g., it signals a problem if a requirement of a source node is not satisfied by a capability of the target node
  - Enables the development of decision making tools, e.g.:
    - context-aware assistance of user at design-time
    - model enrichment taking into account domain knowledge
What SODALITE offers

- Automatic discovery and modeling of new infrastructural resources

```yaml
sodalite.nodes.OpenStack.VM:
derived_from: tosca.nodes.Compute
properties:
  name:
  ...
attributes:
  id:
    type: string
description: OpenStack id of the VM
private_address:
  type: string
description: Private ipv4
  ...
```
What SODALITE offers

Support to design time application optimization for HPC
What SODALITE offers

- Supports the identification of bug smells in deployment models
- Identify potentially advantageous reconfigurations in running applications
The SODALITE Deployment

- Operation Manager/App Operations Expert
- Complex App
- IDE
  - Abstract Application Model
  - Abstract Resource Model
- IaC Builder
- TOSCA blueprint
  - Application Optimisation
  - Blueprint Optimisation
  - Optimised blueprint
- Optimised application
- Infrastructure Manager/Resource Expert
- Infrastructure
Three case studies from three different domains:

- A computationally-intensive scientific workflow aiming at simulating the behavior of a screw-rod fixation bone implant system on virtual patients – Clinical Trial Simulation
- An adaptive system for acquiring and elaborating information from moving vehicles, able to reconfigure based on privacy preferences and rules holding in specific countries – Vehicle IoT
- A system able to collect images concerning mountains and to compute the quantity of snow and, therefore, of water available in the area – Snow
Conclusion

- SODALITE provides tools to enable simpler and faster development, deployment and execution of heterogeneous apps in HPC, Cloud, Edge, & SW defined computing environments.

- **Future works:**
  - Incorporation of edge resources
  - Dynamic self-adaptation of application deployments
  - Enhancement of the reasoning capabilities to reduce even further the modeling effort by end users