ENTICE:
dEcentralized repositories for traNsparent and efficienT vlrтуal maChine opErations

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Project in a Nutshell

- Research and create a novel VM repository and operational environment named **ENTICE** for federated Cloud infrastructures aiming to:
  - Simplify the creation of lightweight and highly optimised VM images tuned for functional descriptions of applications
  - Automatically decompose and distribute VM images based on multi-objective optimisation to meet application runtime requirements
    - performance, economic costs, storage size, QoS needs
  - Elastically auto-scale applications on Cloud resources based on their fluctuating load with optimised VM interoperability across Cloud infrastructures and without provider lock-in
Research Problems

- Manual, tedious and time-consuming VM image creation
- Unoptimised and monolithic (non-decomposable) VM images
- Proprietary unoptimised VM repositories
- Inelastic resource provisioning
- Lack of information to support automated preparation and optimised deployment
Metrics of Success

Software
- Libraries
- Applications
- Components
- Services
- ...

ENTICE optimization

Functional descriptions

Programmers

Objective 1
60% ↑ smaller VMI
30% ↑ faster VM delivery

Objective 2
80% ↑ less storage

Objective 3
20% ↑ faster
10% cheaper, smaller

Objective 4
95% ↑ elastic QoS

Objective 5
25% ↑ faster VMI creation

VM Image synthesis and analysis

QoS + SLA

ENTICE repositories

Software-defined federated networks

Federated Clouds

Objectives

• Creation of lightweight VM images through functional descriptions
  o 60% smaller compared to regular user-created VM images
  o Reduce VM delivery time of VM images by 30%, down to around 10 seconds

• Distributed lightweight VM image storage
  o Reduce storage requirements by more than 80%
  o Reduce time for cross data center deployment by over 20%

• Autonomous multi-objective repository optimization
  o Improve performance of pilot use cases by at least 30%
  o Preserve performance while decreasing costs and storage requirements by at least 25%

• Elastic resource provisioning
  o Improve the QoS elasticity of use cases from their inelastic to elastic

• Information infrastructure for strategic and dynamic reasoning
  o Over 25% of productivity increase in their VM image preparation and deployment time
ENTICE Architecture

ENTICE Environment

User Native Environment

- Build Application
- Run Application

ENTICE federated Cloud and distributed repository

Amazon-Cloud

VM Image Portal

Knowledge Base and Reasoning

VM Mgmt. Template

VM Image Synthesis

VM Image Analysis

VM Mgmt. Template

VM Image Distribution

Online VM Image Assembly

Pareto SLA

Multi-objective Optimization

Functional descriptions

Earth Observation Data (EOD)

- EOD is a Space Data System
- Data collected from in-orbit satellites
  - Optimise ingestion and processing of raw data incoming from ground stations
- Data processing under heavy technical constraints
  - On-demand adaptation of the infrastructure for processing incoming data
- Data storage over many years and in different forms
  - Provisioning of an optimised and cheaper storage service for cataloguing
- Data distribution to many external users all over the world
  - Reduction of the delivery time of products to end users
  - Data rate optimisation between the VMs of whole EOD
- VM startup and auto-scaling optimisation
Cloud Service Provider (CSP)

- Optimise the operational and infrastructure resources used for providing proprietary and third party SaaS to customers
  - VM images creation and storage optimisation
  - VM images configuration procedure optimisation
  - VM deployment optimisation
  - Elimination of dependencies with providers
  - Elasticity improvement for on-demand scaling

- Unified Communications open source framework for enterprises
  - Elasticity, scalability and high availability

- Alfresco
  - Free fully managed enterprise content management solution
  - Optimise of VMI configuration and dependencies with CSP for on-demand scaling on different Clouds

- Redmine
  - Free, open-source web application for project and issue management
  - Optimisation of the VMI configuration procedures
Flexiant Cloud Orchestrator (FCO)

- Cloud management software suite
  - Vendor agnostic supporting multiple hypervisors
  - Customisable platform, flexible interface
  - Integrated metering and billing, resell capabilities and application management

- Limitations
  - Optimised, distributed, interoperable VM storage-as-a-service
  - Different levels of QoS related to performance, cost, and storage
  - Cookbook templates to automatically configure and tune environments for specific applications
  - Secure connectivity between geographically distributed Cloud providers

- FCO advances from ENTICE
  - Multi-Cloud ecosystems and federated Cloud opportunities
  - Bursting into public Cloud from on-premises to cope with spikes in capacity requirements
  - Benefits from economies of scale of multi-tenanted Clouds without compromising on performance, cost, or other QoS to end-users
## Innovation

<table>
<thead>
<tr>
<th>Domain</th>
<th>EU-funded state-of-the-art</th>
<th>Innovation</th>
<th>Measurable metric</th>
</tr>
</thead>
<tbody>
<tr>
<td>VM synthesis</td>
<td>Guidelines for image creation and publication(^{12} 13 14)</td>
<td>Automated image creation with focus on optimised image delivery operations</td>
<td>60% smaller, 30% faster delivery</td>
</tr>
<tr>
<td>VM analysis</td>
<td>Partial VM image caching within a single Cloud(^{15} [38])</td>
<td>Cross-Cloud image fragment identification optimised for storage size and functionality</td>
<td>80% less storage, 20% faster deployment</td>
</tr>
<tr>
<td>Optimisation</td>
<td>Single-objective (time, utilisation)(^{15}), application, resource-centric</td>
<td>Pareto multi-objective (performance, cost, storage), VM repository-centric</td>
<td>30% faster, 25% cheaper and smaller</td>
</tr>
<tr>
<td>Performance</td>
<td>Time, speedup, efficiency, QoS(^{16} 15)</td>
<td>Elasticity metric</td>
<td>Percentage of QoS change higher than percentage of resource scaleup/down</td>
</tr>
<tr>
<td>Semantics</td>
<td>Semantic Web, Linked Data(^{17}), Cloud ontology(^{10})</td>
<td>Semantic interoperability in federated Clouds</td>
<td>25% productivity increase</td>
</tr>
<tr>
<td>SLA</td>
<td>SLA@SOI templates(^{11})</td>
<td>Pareto SLA templates</td>
<td>Pareto SLA model of 25% faster Cloud federation</td>
</tr>
</tbody>
</table>
Workpackage Structure

WP2: Requirements and Overall Project Design (DEIMOS)

WP3: Interoperable and decentralized VM image synthesis, analysis, and storage (SZTAKI)

WP4: Federated multi-objective VM image repository optimization (UIBK)

WP5: Knowledge-based and Pareto-SLA modelling (UL)

WP6: Integration, Testing, and Use Cases (WT)

WP1: Project Management (UIBK)  WP7: Dissemination and Exploitation (Flexiant)
WP3: Interoperable and decentralized VM image synthesis, analysis and storage

- VM image synthesis
- VM image decomposition analysis
- Federated VM image storage interoperability
WP4: Federated multi-objective VM image repository optimization

• Research of multi-objective optimisation framework and heuristics considering performance, cost, and storage as conflicting objectives

• Optimised VM image distribution placement, deployment and instantiation

• Design of VM management templates for online optimised VM image discovery and assembly

• Design and deployment of federated network overlay capabilities for optimised VM image migration, deployment and instantiation
WP5: Knowledge-based modelling and reasoning

• Modelling and matching QoS requirements to federated Cloud environments

• Elasticity analysis

• Knowledge base and reasoning

• Pareto-SLA design and management

• Decision making process and reasoning
## Progress

**WP1: Coordination and project management**
- **T1.1:** Overall project management, Consortium Agreement maintenance and meetings
- **T1.2:** Reporting
- **T1.3:** Scientific coordination and technical supervisory control
- **T1.4:** EU financial and administrative coordination
- **T1.5:** Quality control, project document repository, and knowledge management

**WP2: Requirements and overall project design**
- **T2.1:** Common requirements specification
- **T2.2:** EN'TICE environment and system design
- **T2.3:** Revision of the EN'TICE requirements and environment design

**WP3: Interoperable and decentralized VM image synthesis, analysis and storage**
- **T3.1:** VM image synthesis
- **T3.2:** VM image decomposition analysis
- **T3.3:** Federated VM image storage interoperability

**WP4: Federated multi-objective VM image repository optimization**
- **T4.1:** Multi-objective optimization framework and heuristic algorithm
- **T4.2:** Image distribution and placement
- **T4.3:** Online VM image discovery and assembly
- **T4.4:** Federated network overlay capabilities for optimized VM image migration, deployment and instantiation

**WP5: Knowledge-based modelling and reasoning**
- **T5.1:** Modelling and matching QoS requirements to federated Cloud environments
- **T5.2:** Elasticity analysis
- **T5.3:** Knowledge base and reasoning
- **T5.4:** Pareto-SLA specification and management
- **T5.5:** Decision making process and reasoning

**WP6: Integration, testing and use cases**
- **T6.1:** Testbed deployment and management
- **T6.2:** Preparation of pilot use cases
- **T6.3:** Integration of EN'TICE environment and pilot use cases
- **T6.4:** Testing, evaluation and tuning of EN'TICE environment with the pilot use cases

**WP7: Dissemination and exploitation**
- **T7.1:** Website and social media
- **T7.2:** Dissemination
- **T7.3:** Exploitation and standardization
- **T7.4:** Impact reporting
- **T7.5:** Intellectual property rights
- **T7.6:** Data management

**MS1:** Specification and design of EN'TICE environment
**MS2:** First prototype of EN'TICE environment and pilot use cases
**MS3:** Final EN'TICE environment and pilot use cases
**MS4:** Tested, evaluated and tuned EN'TICE environment; project completion

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Thank you