ASCETiC Whitepaper

Motivation

The increased usage of ICT, together with growing energy costs and the need to reduce greenhouse gases emissions call for energy-efficient technologies that decrease the overall energy consumption of ICT. So far, efforts in eco-efficiency have mainly targeted hardware and data center technologies. Less attention has been given to software eco-efficiency. Although it has a direct impact on system's energy consumption; software usually controls how computing equipment is utilized. Covering the full service life cycle, from application design, development, deployment and operation, as ASCETiC ambitions to do, is crucial to determine and optimize the energy usage of the complete system, considering software and hardware as an interrelated mechanisms.

Approach

ASCETiC project focuses on issues of energy efficient computing, specifically on design, construction, deployment and operation of Cloud services. It proposes novel methods and development tools to support software developers in monitoring and optimizing (minimizing it) the energy consumption resulting from developing and deploying software in Cloud environments.

ASCETiC primary goal is to characterize the factors which affect energy efficiency in software development, deployment and operation. The approach focuses firstly on the identification of the missing functionalities to support energy efficiency across all cloud layers, and secondly on the definition and integration of explicit measurements of energy requirements into the design and development process for software to be executed on a Cloud platform. Therefore, the more detailed objectives of ASCETiC are:

Objective 1: To extend existing development models for green software design, supporting sustainability at all stages of software development and execution.

Objective 2: To develop and evaluate a framework with identified energy efficiency parameters and metrics for Cloud services.

Objective 3: Develop methods for measuring, analyzing and evaluating energy use in software development and execution.

Objective 4: To integrate energy efficiency into service construction, deployment and operation leading to an Energy Efficiency Embedded Service Lifecycle.

ASCETiC Toolbox Business Goals

ASCETiC Toolbox is developed taking into account the following list of business goals and objectives for both Cloud customers and providers:

Greener ICT: The ASCETiC Toolbox has to provide the appropriate tools to support software developers in monitoring the carbon footprint of their applications and in optimising the total energy efficiency from the design, development and deployment of the software in Cloud environments.

Ecological and Economically Sustainable Ecosystem: ASCETiC energy models, profiles/footprints of Cloud platforms and the real-time monitoring mechanisms have to make possible the creation of new pricing schemes that will charge users based on their actual consumption and encouraging more efficient use of energy in Cloud resources.

Cost-effective Corporate social responsibility: ASCETiC aims to support organisations in addressing increasingly important efforts to be more socially responsible corporate citizens while at the same time optimize cost-cutting efforts, by being able to assess and reduce Cloud services energy consumption.

Transparency for the customer: The ASCETiC methods and tools to eco-efficiently manage the life cycle of Cloud services from requirements to runtime through construction, deployment and operation consider transparency for the user in all decisions that affect final cost. This means consideration of energy metrics for SLA and monitoring, but also visibility in a provider's resources consumption and in policies applied for its optimization.

Support for Cost and Energy reduction: ASCETiC tools and methods support providers in achieving their ambition of reducing costs in services provision and operation.

Use of de-facto (market) standards: The ASCETiC solution maintains interoperability with and use of existing widely used solutions as part of the entire service lifecycle.

Features

ASCETiC Toolbox functionalities consider three layers: SaaS layer facilitates the modelling, design and construction of Cloud applications; PaaS layer provides middleware functionality for a Cloud application and facilitates the energy-aware deployment and operation of the application as a whole; IaaS layer considers the admission, allocation and management of virtual resources.

SaaS Layer

The main goal of the Software-as-a-Service Layer is to provide means to a SaaS development team to measure energy consumption data for elements of a SaaS service or application, at components, sub-system or feature level. The following capabilities are offered:

– Capture of energy monitoring goals and KPI through a UML profile that can be use both for designing new Cloud application or migrating existing application to the Cloud.
– Set of monitoring probes for generic application monitoring of Java, C# or OS specific binaries
– Efficient energy data gathering, aggregation and visualization at the SaaS level, including relating them to specified energy goals.
– Automated deployment of probes on the energy aware ASCETiC Cloud stack and easy to deploy on Cloud environment supporting Chef or automatically when using the ASCETiC PM.
– Specify as a requirement in the ASCETiC Programming Model (PM) when the application must be executed with the objective of reducing energy consumption.

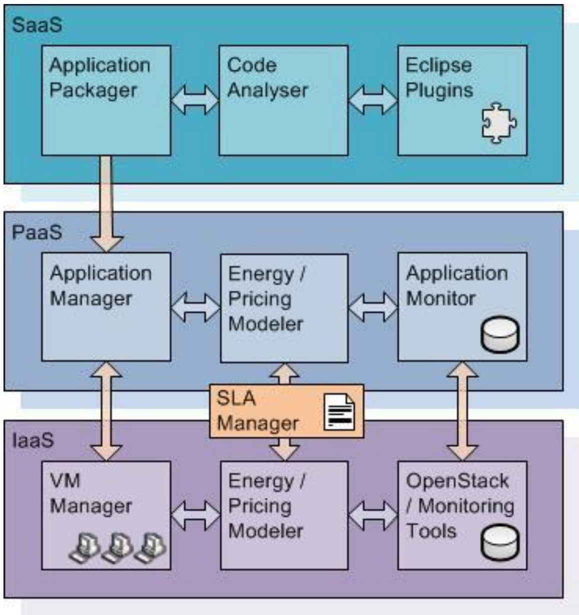
In addition, the SaaS layer also supports enhancement of code development by providing:

– Static analysis of Java code focusing on energy efficiency
– Knowledge management of good practices in energy efficiency for Cloud applications, in relation with existing frameworks such as Cloud Patterns.

PaaS Layer

Platform-as-a-Service layer provides the means for deployment and operation of energy aware applications. The following list specifies the provided features:

– Application deployment management taking into account specific user's deployment requirements.
– Negotiation and management of SLAs for diverse providers making use of energy-aware cost estimation and energy consumption predictions to assess the most suitable provider in which to execute an application.
– Injection of energy measurement probes to the deployment application transparently to the user.
– Real-time Application Monitoring of resources that are used by a given application.
– Support functions to enable migration of applications among providers, such as VM formats transformation.



IaaS Layer

Infrastructure-as-a-Service Layer is concentrated in providing the virtual infrastructure management capabilities:

– Deployment and operation of Virtual Machines according to multi-objective criteria: price minimization, energy-efficiency maximization, Quality of Service maximization.
– Real time energy monitoring at Virtual Machine level based on advanced energy-models that decompose hardware metrics into Virtual Machine metrics.

- A pricing model that incentivizes energy-efficient scheduling and management of the resources.
- Service-Level Agreement analysis and enforcement during negotiation and operation stages.
- State-of-the-art, OpenStack-based Cloud Infrastructure management.

ASCETIC Reference Architecture

ASCETiC proposed architecture is composed of the previously introduced three distinct layers and follows the standard Cloud deployment model. It concentrates on delivering energy awareness in all system components. Monitoring and metrics information are measured at IaaS level and propagated through the various layers of the Cloud stack (PaaS, SaaS) considering static energy profiles.

In the *SaaS layer* a set of components interact to facilitate the modelling, design and construction of a Cloud application. The components aid in evaluating energy consumption of a Cloud application during its construction. A number of plug-ins are provided for a frontend Integrated Development Environment (IDE) as a means for developers to interact with components within this layer. A number of packaging components are also made available to enable provider-agnostic deployment of the constructed cloud application, while also maintaining energy awareness. The *PaaS layer* provides middleware functionality (service and sla management) for a Cloud application and facilitates the deployment and operation of the application as a whole. Components within this layer are responsible for selecting the most energy appropriate provider for a given set of energy requirements and tailoring the application to the selected provider's hardware environment. Application level monitoring is also accommodated for, in addition to support for Service Level Agreement (SLA) negotiation. In the *IaaS layer* the admission, allocation and management of virtual resources are performed through the orchestration of a number of components. Energy consumption is monitored, estimated and optimized using translated PaaS level metrics. These metrics are gathered via a monitoring infrastructure and a number of software probes.

Future versions of the architecture will support adaptation with regard to energy efficiency and focus on the addition of capabilities required to achieve dynamic energy management for each of the Cloud layers, in other words local layer adaptation, as well as flux of steering information and decisions among Cloud layers for inter-layer adaptation.

Use Cases

ASCETiC Toolbox is demonstrated through two industrial use cases provided by two industrial partners in the project: ATC and GPF that illustrate the ASCETiC architecture usage, and the possible energy gains it will provide to the applications it operates. The aim of the Multimedia cross-channel solution use case will be to adapt existing data-intensive software called NewsAsset and make it suitable for an energy-aware Cloud environment. The Green Building Design use case is to adapt the existing computationally intensive software and make it suitable for an energy-aware Cloud environment.

Multimedia cross-channel solution

News as an Asset (NewsAsset) is an innovative management solution, positioned in the news production environment, for handling large volumes of information, hence offering a complete and secure electronic environment for storage, management and delivery of sensitive information (e.g. text, pictures, graphics, audio, videos, and stories) in the news production environment.

In the current business model, NewsAsset system is offered to large and small customers that pay the license fee and host the NewsAsset system on their premise. To address the need of its customers, NewsAsset's team vision is to develop a service in the Cloud where the business model would switch from a license fee and hardware purchase to a single service fee. A service that will be able to leverage on a shared Cloud infrastructure for several agencies in order to be purchased at a more attractive cost and increase the conversion rate of customers. At the same time, NewsAsset's team wants to study the economic viability and the customers' acceptance of various Cloud developments. Besides the provisioning of NewsAsset on a community Cloud, the team wants to study the perspective of purchasing their own infrastructure and hosting NewsAsset-as-a-Service offering on it. For this reason, it is not only concerned with the ability of NewsAsset to behave adequately on traditional functional and non-functional aspects but also on the energy efficiency and energy consumption effectiveness of NewsAsset as a Service.

For realizing NewsAsset case, the first step for ASCETiC Toolbox is focusing on the software re-engineering by means of its SaaS layer tools. In this context, ASCETiC Toolbox will be used to firstly determine energy consumption behavior effectiveness of NewsAsset and secondly determine energy efficiency of NewsAsset features and components. NewsAsset engineers will be able to study the energy consumption pattern of various parts of the NewsAsset software product to determine what part of NewsAsset as a Service should be run on private premise and what part should be run in public Clouds. They will be able to express the need to measure and monitor the energy performance of an application feature on a UML use case diagram and additionally of a component (software or hardware) on a deployment diagram. Once the desired energy consumption is known, based on how frequently a feature is called or how much volume of data must be handled by a component, the NewsAsset development team will be able to make an informed decision on where to focus their refactoring effort and to what level of priority. Finally, in terms of visualization and considering the initial phase of its development it is envisioned that the ASCETiC toolbox will expose data in a dashboard form focusing on identifying one-shot refactoring effort that is, refactoring effort where energy consumption will always yield an improvement. Later on, behavior where variability is found will also be highlighted and recommendation on software design patterns to use to implement the variable behavior so as to save energy will also be exposed.

Green Building Design

The current research and development at GreenPrefab (GPF) focuses on green building design tools incorporating full life-cycle assessment into the design process. The tools provide the GPF's users vast amount of computing power through cloud computing. Although energy use at the design stage accounts for only a small share of the life-cycle energy consumption of buildings, being "green" itself is nevertheless an important credential for the GPF tools. For this reason adopting a green cloud infrastructure is crucial.

The GPF use case will take full advantage of the ASCETiC development by porting the current simulation engine (jEPlus) to the Programming model, therefore utilizing the ASCETiC Toolbox at PaaS and IaaS levels. In use, jEPlus generate hundreds and thousands of design scenarios to be investigated by simulation, taking into account the specific design context and requirements for the building. The simulations will then be executed on the ASCETiC-enabled cloud, in a timely and energy efficient manner. The anticipated outcome is a highly scalable and energy-aware simulation service platform, adding value directly to the life cycle assessment tools for building designers.

More specifically, the aims of the GPF use case include:

- create a flexible online tool based on green cloud computing to support the design of green buildings;
- help designers improve the "greenness" of buildings by reducing their impact on the environment;
- provide a scalable and energy-aware simulation platform for a plethora of software applications for design, operation and training purposes;
- demonstrate the advantage of the ASCETiC toolbox and encourage applications in other engineering fields.

Benefits and Adoption path

ASCETIC main benefit is to provide Cloud customers and providers with the ability to determine and optimize the relationship between energy consumed by an application, and its delivered benefit. This enables to determine gained value per each unit of energy spent in IT, and to correlate energy consumed to the beneficial work for which that energy is spent.

This drives into more detailed benefits per actor:

Cloud providers

- Cost reduction: Current rising of energy costs seems a trend set to continue, so decrease costs of operation is highly relevant for Cloud providers reliant and of increasing magnitude.
- Revenue increase: Lower energy consumption can be used as a credential to generate sales from niche market segments. The green-aware segment of the consumer market is growing and this will propagate up the value chain as consumer providers (B2C) attempt to source greener supplies (B2B) to differentiate from their competition.

Cloud providers & Users

- Improved corporate image: Corporate and Social responsibility act as a means of offer

differentiation especially for the European Market, where political support for Sustainability initiatives is higher than in other areas of world.
- Adherence to green legislation: Increasingly organizations are under pressure to demonstrate and optimize energy consumption and emissions all over its productive life-cycle, including ICT usage.

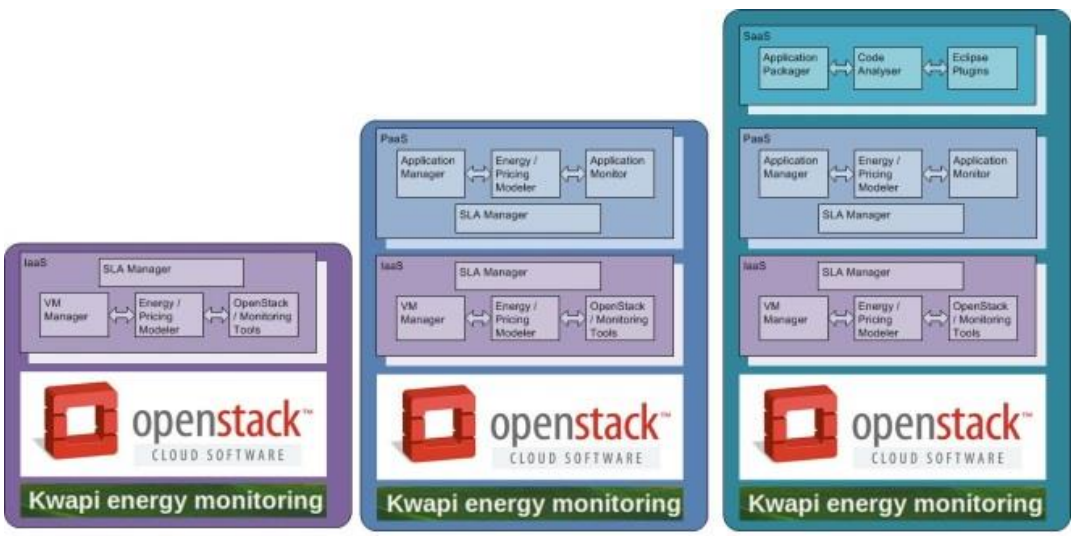
ASCETiC Toolbox adoption for Cloud providers propagates from bottom to top of the Cloud stack. PaaS features rely on the IaaS layer capabilities and metrics, while SaaS tools require PaaS layer tools adoption. ASCETiC Toolbox builds on top of state-of-the-art tools. These include Open Stack VM Manager and Kwapi library, for interfacing Energy Meters at the IaaS layer. Based on these together with the ASCETiC IaaS layer tools, a IaaS Cloud provider can become an ASCETiC-enabled IaaS provider. Building on top of IaaS tools, providers can move upper in the Cloud stack by adopting increasingly PaaS and SaaS tools.

Conclusions and Next steps

Current version of the ASCETiC Toolbox focuses on delivering energy awareness in all system components. Monitoring and metrics information are measured at IaaS level and propagated through the various layers of the Cloud, from IaaS to PaaS and SaaS while considering static energy profiles.

The toolbox will be available for download in www.ascetic.eu in October 2014. This site contains detailed information about the toolbox components including source code access and installation and use instructions. In order to simplify the process of installation and set-up of components though the website we also make available a set of virtual machines with preinstalled software. Please provide us with your feedback in our support mailing list.

ASCETiC advances to requirements, architectures and even software components will be constantly updated through the ASCETiC project website (www.ascetic-project.eu)



ASCETiC Enabled IaaS provider | ASCETiC Enabled PaaS provider | ASCETiC Enabled SaaS provider

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