TEST REPORT

Eco4Cloud Proof of Concept Test for

Introduction

Eco4Cloud is a spin-off from the Institute for High-Performance Computing and Networking of Italy's National Research Council (CNR) and has researched/developed/engineered an innovative and effective solution to optimize the consolidation of virtual machines (VM) in highly-virtualized data centers yielding significant reductions of the relevant **energy bills** and related **Carbon emissions**, as well as additional benefits in terms of DC **SLA assurance**, **capacity planning**, **orchestration optimization**, **risk monitoring/mitigation**.

In fact Eco4Cloud's technology is based on an innovative bio-inspired probabilistic algorithm which consolidates the maximum number of virtual machines on the minimum number of physical servers in a data center, enabling the switch-off/hibernation of those freed-up, making them dynamically available as additional capacity for incremental workloads.

The resulting CapEx and OpEx reductions are tangible and this document reports the outcomes of a Proof of Concept test carried out at Herning Kommune's data centers, between January 16st and Jan 23rd 2015.

Summary

The Proof of Concept of Eco4Cloud at Herning Kommune was performed on a testbed of 18 ESX hosts.

With specific reference to Workload Consolidation, the testbed was restricted to 12 hosts. The test results show that Eco4Cloud Workload Consolidation is able to switch-off 6 hosts, yielding a reduction of powered on hosts of 50% of the testbed, 33% of the whole infrastructure.

Test Description

The test has been performed on 18 hosts running VMWare VSphere virtualization platform. The servers are grouped in 5 clusters containing a number of hosts ranging from 1 to 12 each.

The hosts have the following hardware configurations: These servers hosted 565 virtual machines, which were assigned a number of virtual CPU cores ranging from 1 to 16 and an amount of RAM memory varying from 0.00 GB to 50.00 GB.
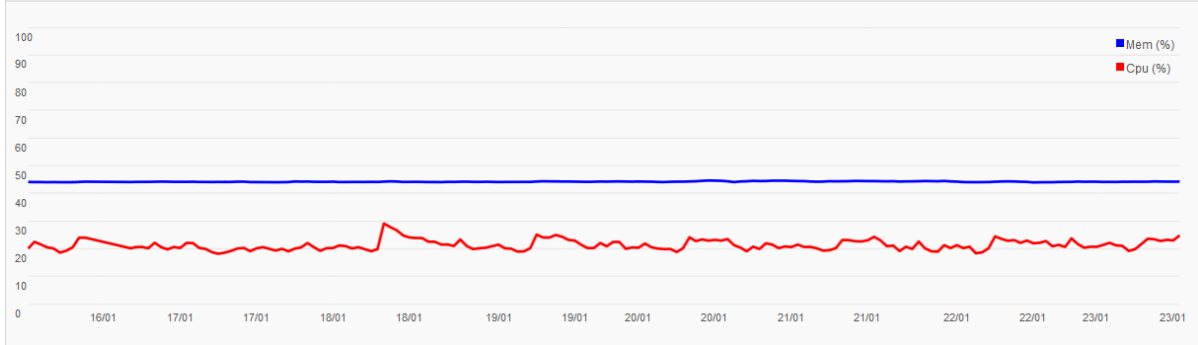
The test is based on collected inventory data and performance metrics of hosts and virtual machines for 7 consecutive days.

Resources utilization without Eco4Cloud

Figure 1 reports the average CPU utilization of the 18 hosts during the monitoring period. The performances metrics show that workload is not perfectly balanced; some servers have low CPU utilization, often lower than 16%. This is an indicator of remarkable inefficiency and excessive energy consumption: it is known in fact that an active server with very low CPU utilization consumes about 70% of the power that the same server consumes when the utilization is close to 100%. The Eco4Cloud Workload Consolidation software can greatly improve efficiency by consolidating the VMs on a lower number of servers and putting some servers in a low power state.

Figure 1 also shows the average RAM allocation (again in percentage with respect to the total amount of RAM) of the 18 servers: the RAM utilization is also unbalanced, between 0 % and 71 %. When Eco4Cloud migrates the VMs and consolidates the load, it must obviously respect the constraints imposed by both CPU and RAM. The use of disk I/O and bandwidth is not reported in this report as these are not significant constraints for this test.

Eco4Cloud srl
Piazza Vermicelli c/o TechNest
87036 Rende (CS) - Italy
www.Eco4Cloud.com | info@eco4cloud.com   Page 2

Figure 1 - Average CPU and RAM utilization of the TOTAL-HOSTS servers before using Eco4Cloud.

Eco4Cloud is able to collect hosts power consumption data. 17 hosts are compliant with the power consumption monitoring feature. Figure 2 reports the overall power consumption of these 17 physical hosts in the data center. The observed variations are due to the corresponding variations of the overall workload. The overall energy consumption is equal to 4532 Wh per host per day.

**Figure 2 - Average power consumption of each server**

For the evaluation of the quality of service, VMWare suggests to compute two indices:

- the CPU ready time;
- the amount of ballooned memory.

VMWare has set two thresholds for the CPU ready time of a VM: 5% is a warning threshold, while 10% represents an alert. In these tests, the CPU ready time sometimes exceeded 10% for up to 177 VMs out of 565 (see fig. 3). Moreover, VMWare specifies that the presence of ballooned memory should be avoided, even if a small presence of memory ballooning is not a sign of serious memory contention. In these tests, up to 22 VMs out of 565 had memory ballooning (see fig. 4).

Figure 3 - CPU ready time
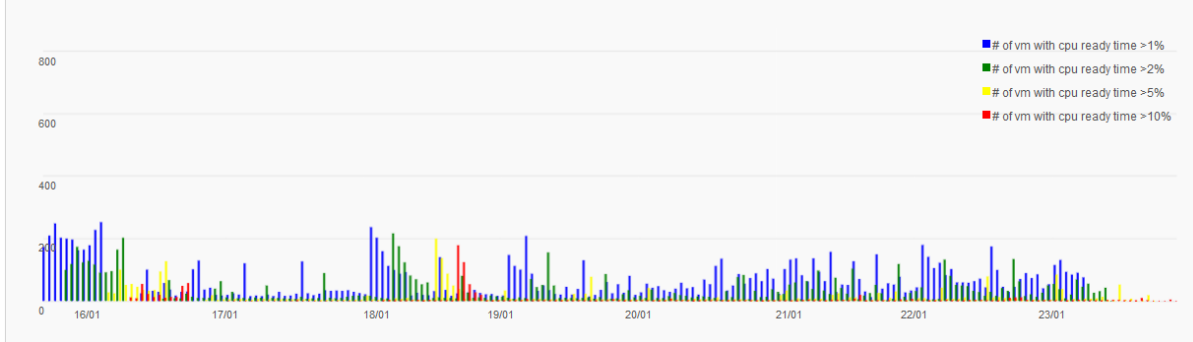
Figure 4 - Ballooned memory
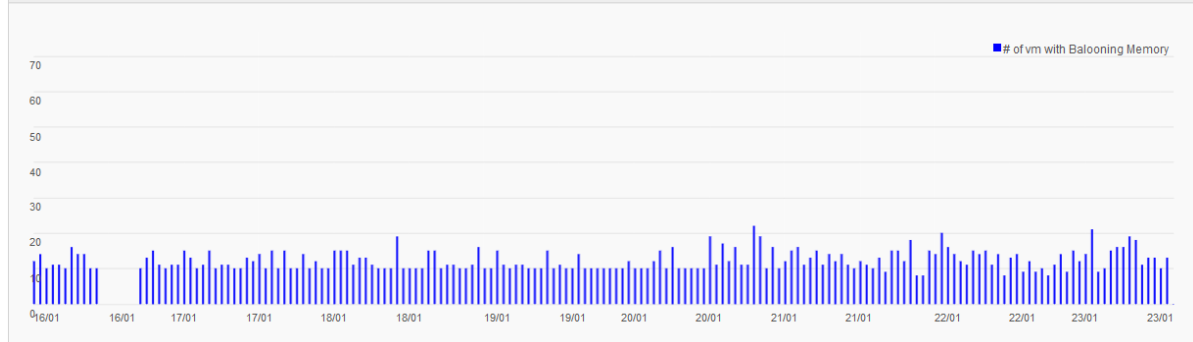
Resources utilization using Eco4Cloud

Figure 5 reports the number of active servers, with and without the use of Eco4Cloud:

- before using Eco4Cloud, the load spanned across 18 active hosts;
- with Eco4Cloud, VM migrations allow this number to decrease from 18 to 12.

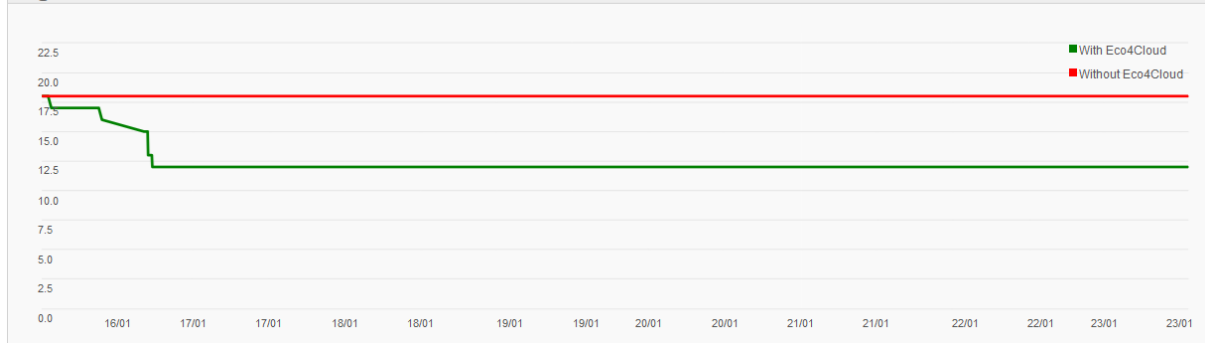Figure 5 - Number of active servers with and without Eco4Cloud.

Figure 6 reports the number of migrations per hour in the whole data center during the week of simulated Eco4Cloud operations. It is noticed that several workload consolidation migrations are performed in the first hours in order to unload one server and then put it in stand-by.

_____

Eco4Cloud srl
Piazza Vermicelli c/o TechNest
87036 Rende (CS) - Italy
www.Eco4Cloud.com | info@eco4cloud.com   Page 4

It may be useful to recall that "overload prevention migrations" of VMs are performed when the CPU utilization or RAM allocation exceed the respective thresholds - in order to prevent QoS degradation - while "workload consolidation migrations" are performed to unload under-utilized servers and possibly switch-off such servers.


Figure 6 - Number of overload prevention and workload consolidation migrations per hour

Smart Ballooning

Along with Workload Consolidation, the scenario includes Smart Ballooning. Smart Ballooning is an Eco4Cloud product that reduces the memory consumption of virtual machines, making it available for further consolidation. The scenario is composed of 76 virtual machines, with 1962 of configured memory, using an average of 252 of active memory, and 1738 of consumed memory. The memory chart below points out how Smart Ballooning is able to reduce consumed memory by 5.08 %, making it available to ESX/ESXi for further consolidation.

Figure 7 - # of VMs affected by Smart Ballooning
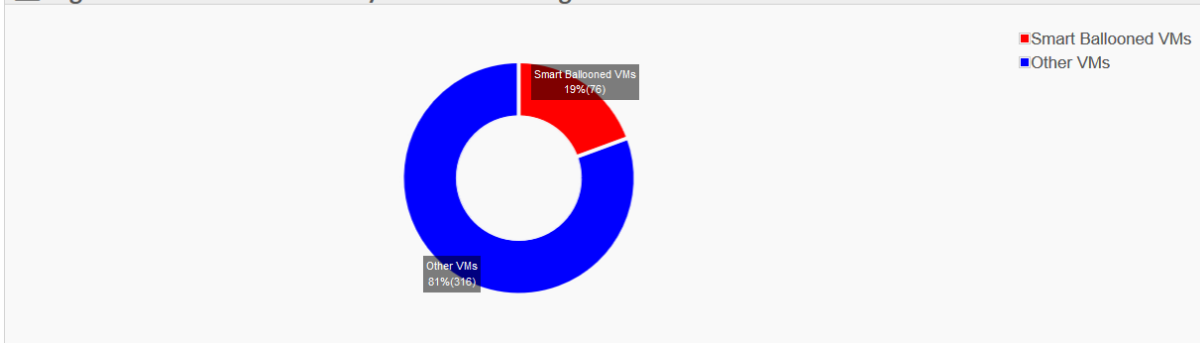
The second chart shows the amount of virtual machines affected by Smart Ballooning. In fact, Smart Ballooning will not reclaim memory from every virtual machines, but only in specific cases, for example idle VMs or over-provisioned VMs.

Eco4Cloud srl
Piazza Vermicelli c/o TechNest
87036 Rende (CS) - Italy
www.Eco4Cloud.com | info@eco4cloud.com   Page 5

Figure 8 - Datacenter memory comparison with and without Smart Ballooning

_____