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## Storage solutions for a production-level cloud infrastructure

At INFN-Bari we have set-up an OpenStack-based cloud infrastructure in the framework of a publicly funded project, PRISMA, aimed at implementing a fully integrated PaaS+IaaS platform to provide services in the field of public administration and scientific data analysis. The IaaS testbed currently consists of 25 compute nodes providing in total almost 600 physical cores, 3 TB of RAM, 400 TB of storage (disks). Connectivity is ensured through 10Gbit/s ethernet connection. Both the backend (MySQL database and RabbitMq message broker) and the core services (nova, keystone, glance, neutron, etc.) have been configured in high-availability using HA clustering techniques. The full capacity available in the early 2015 will provide 2000 cores and 8 TB of RAM.

In this work we present the storage solutions that we are currently using as backend for our production cloud services.

Storage-as-service is implemented in Openstack by the Block Storage project, Cinder, and the Object Storage project, Swift. Selecting the right software to manage the underlying backend storage for these services is very important, and decisions can depend on many factors, not only merely technical, but also economic: in most cases they result from a trade-off between performance and costs.

Many operators use separate compute and storage hosts. We have decided not to follow this mainstream trend, aiming at the best cost-performance scenario: for us, it makes sense to run compute and storage on the same machines, since we want to be able to dedicate as many of our hosts as possible to running instances. Therefore, each compute node is configured with a significant amount of disk space and a distributed file system (GlusterFS and/or Ceph) ties the disks from each compute node into a single file-system.

In this case, the reliability and stability of the shared file-system is critical and defines the effort to maintain the compute hosts: tests have been performed to assess the stability of the shared file-systems changing the replica factor. For example, we have tested performance and reliability of GlusterFS in both replica 2 or 3.

We currently use CEPH distributed file system for:

- storage of the running VMs enabling the live migration,
- storage of the virtual images (as primary Glance image store),
- implementation of several of the Cinder backends for block devices.

We have decided to enable Ceph as additional backend of Cinder in order to compare features, reliability and performances of the two solutions.

Our interest in Ceph derives also from the possibility of consolidating the infrastructure overall backend storage into a unified solution. To this aim, we are currently testing Ceph to run Virtual Machines, both using RBD and Ceph-FS protocols, and to implement object storage.

In order to test scalability and performance of the deployed system we used test cases which are derived from the typical pattern of storage utilization.

The testing tools are standard software widely used for this purpose such as: iозone and/or dd for block storage and specific benchmarking tools like Cosbench, swift-bench and sbench for object storage. Using different tools for testing the file-system and comparing their results with the observation of the real test case, is also a good possibility for verifying the reliability of the benchmarking tools.

Throughput tests have been planned and conducted on the two system configurations in order to understand the performance of both storage solutions and their impacts on applications, aiming at achieving the better SLA and end-users experience.

Implementing our cloud platform, we have also focused on providing transparent access to data using standardized protocols (both de-iure and de-facto standards). In particular, Amazon-compliant S3 and CDMI

(Cloud Data Management Interface) interfaces have been installed on top of the Swift Object Storage, in order to promote interoperability at PaaS/SaaS levels also.

Data is important for businesses of all sizes. Therefore, one of the most common user requirement is the possibility to backup data, in order to minimize their loss, stay compliant, and preserve data integrity. Implementing this feature is particularly challenging when the users come from the scientific communities that produce huge quantities of heterogeneous data and/or can have strict constraints.

An interesting feature of the Swift Object Storage is the geographic replica that can be used in order to add a disaster-recovery feature to the set of data and services exposed by our infrastructure.

Also Ceph provides a similar feature: the geo-replication through RADOS gateway.

Therefore, we have installed and configured both a Swift global cluster and a Ceph federated cluster, distributed on three different geographic sites. Results of the performance tests conducted on both clusters are presented along with a description of the parameters tuning that has been performed for optimization. The different replication methods implemented in the two middlewares, Swift and Ceph, are compared in terms of network traffic bandwidth, cpu and memory consumption.

Another important aspect we are taking care of is the QoS (Quality of Service) support, i.e. the capability of providing different levels of storage service optimized wrt the user application profile. This can be achieved defining different tiers of storage and setting parameters like how many I/Os the storage can handle, what limit it should have on latency, what availability levels it should offer and so on.

Our final goal is also to set-up a (semi-)automated system that is able of self-optimising. Therefore we are exploring the cache tiering feature of Ceph, that handles the migration of data between the cache tier and the backing storage tier automatically. Results of these testing activities are shown in this presentation.

In this work we show results achieved in terms of performance and functionalities of INFN-Bari cloud infrastructure while supporting scientific use cases as LHC experiments.

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