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Orchestrating the Deployment of High Availability Services on Multi-zone and Multi-cloud Scenarios

R. Moreno-Vozmediano · R. S. Montero · E. Huedo · I. M. Llorente

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Abstract Cloud computing has become one of the most used platforms to deploy High Availability (HA) solutions for its flexibility, on-demand provisioning, and elasticity. However, although many providers offer specific tools for HA support, like floating IPs and load balancing, the analysis of downtime at public cloud providers in previous years shows that a combination of several availability zones or cloud providers is required to achieve "five nines" availability. Besides reducing the chances of failure, the use of multiple availability zones and geographically distributed clouds may additionally bring performance and cost benefits. However, the orchestration, in an efficient and adaptive way, of HA multi-tier services in multi-zone and multi-cloud environments brings several challenges. This paper presents a novel orchestration method to automate the deployment and management of high availability multi-tier services on multiple availability zones, by introducing new affinity mechanisms, such as *VM to location* and *role to role* affinity/anti-affinity rules. Furthermore, we also extend this solution to multi-cloud scenarios, based on the replication or distribution of the service components among various clouds, along with their corresponding affinity rules.

Keywords High-availability · Multi-tier services and applications · Multi-zone and multi-cloud orchestration · Affinity and anti-affinity mechanisms

R. Moreno-Vozmediano · R. S. Montero · E. Huedo (✉) · I. M. Llorente
Computer Science Faculty, Universidad Complutense de Madrid, Madrid, Spain
e-mail: ehuedo@fdi.ucm.es

I. M. Llorente
FAS Research Computing, Harvard University, Cambridge, USA

1 Introduction

High Availability (HA) is the ability for a service, such as clusters or multi-tier applications, to continue functioning after failure of one or more of the hardware or software resources supporting its execution. This ultimately means that there is no single point of failure and the service does not go down and continues serving requests even if a system component fails. Typically, HA is achieved by incorporating specific features to reduce service downtime, such as redundancy for failover and replication for load balancing.

Cloud computing is becoming one of the most used platforms to deploy HA configurations and deliver superior uptime and service. Many cloud providers and cloud management platforms offer specific tools for HA, such as built-in load balancing mechanisms, floating IP addresses, and instance placement and host affinity policies. To avoid service disruption in case of hardware failure, many cloud providers also allow service components to run in different physical hosts

within the same datacenter. However, these solutions fail in case of datacenter outage.

Availability is calculated as the percentage of time an application and its services are available, given a specific time interval. HA is achieved when the service is down less than 5.25 minutes per year, meaning at least 99.999% of availability [44]. As it is shown in Section 5, the cloud with the best uptime in 2015 was Amazon Web Services, with a downtime of 150 minutes, far from the also named "five nines" availability. To achieve more than "five nines" availability, it could be necessary to deploy HA services using a combination of two availability zones (multi-zone HA), which are isolated locations within a cloud infrastructure, or even two different cloud providers (multi-cloud HA).

The automatic deployment of the service components in a distributed infrastructure is usually performed through affinity and anti-affinity rules [7], which define specific placement constraints to the scheduler or broker. Several virtualization platforms and cloud managers support VM-VM affinity and VM-host affinity rules to define if several virtual machines (VMs) can be deployed in the same physical host or should be deployed in a specific host. However, these systems do not support zone-based affinity/anti-affinity rules to enable a given VM or VM group be deployed on a specific availability zone.

This paper proposes a new flexible and adaptive method to orchestrate the deployment of multi-tier HA services on multi-zone scenarios, by extending the existing affinity mechanisms to deal with availability zones and groups of related VMs, called *roles* (e.g. a group of VMs belonging to the same service tier that must be deployed with specific location constraints). We introduce new affinity policies, such as *role to role* and *VM to location* affinity/anti-affinity rules, where the term *location* can represent a host, a group of hosts, or an availability zone. Furthermore, we present a matchmaking-based scheduling mechanism to make placement decisions based on the previous affinity constraints.

In addition, we also extend the deployment of HA services to multi-cloud scenarios, based on the replication of the service components among two or more clouds. It is important to observe that, when using multiple cloud providers, each cloud runs its own and independent scheduler, which is responsible for deciding the placement of each VM within the cloud, according to the placement constraints (affinity rules) defined by the user. Hence, the simplest way to orchestrate the multi-cloud deployment of a HA service is to manually replicate or distribute the service components among the various clouds, and to provide each cloud scheduler with the description of the service components that must be deployed on this site, along with their corresponding affinity rules. However, the deployment of multi-cloud HA services involves some other challenges, such as the inclusion of global load balancing and failover mechanisms, and the management of cross-cloud private networks.

The rest of this paper is structured as follows. Section 2 describes the techniques for support HA in datacenter, clouds and multi-cloud environments, and the previous related work. Section 3 explores and compares different deployments of HA services using single and multiple cloud setups. Section 4 proposes the new method and scheduling algorithm to orchestrate HA services across multiple zones. In Section 5, we describe how the framework can be used in an Example of HA Service Deployment. We conclude with a summary of our results and an outline of our plans for continuing research in Section 6.

2 Related Work

HA techniques [23] have been broadly used to guarantee IT business continuity by ensuring a certain level of operational performance in case of system failure (e.g. server, network, or storage failure) or scheduled downtime (e.g. for maintenance). HA is often achieved by providing the system with failure tolerance, which usually involves the inclusion of redundant instances for critical system components, so avoiding single points of failure.

2.1 HA Clustering

HA clustering [9] is one of the most common solutions to provide HA in many application environments, such as database servers [5, 11, 15], web application servers [4, 37, 40], datacenters [32, 43] or cloud infrastructures [8, 12, 30]. A HA cluster consists of several redundant computer systems running critical service components, with different alternative configurations such as active-passive or active-active setups. In an active-passive configuration, also called failover configuration, there is a master or primary cluster node