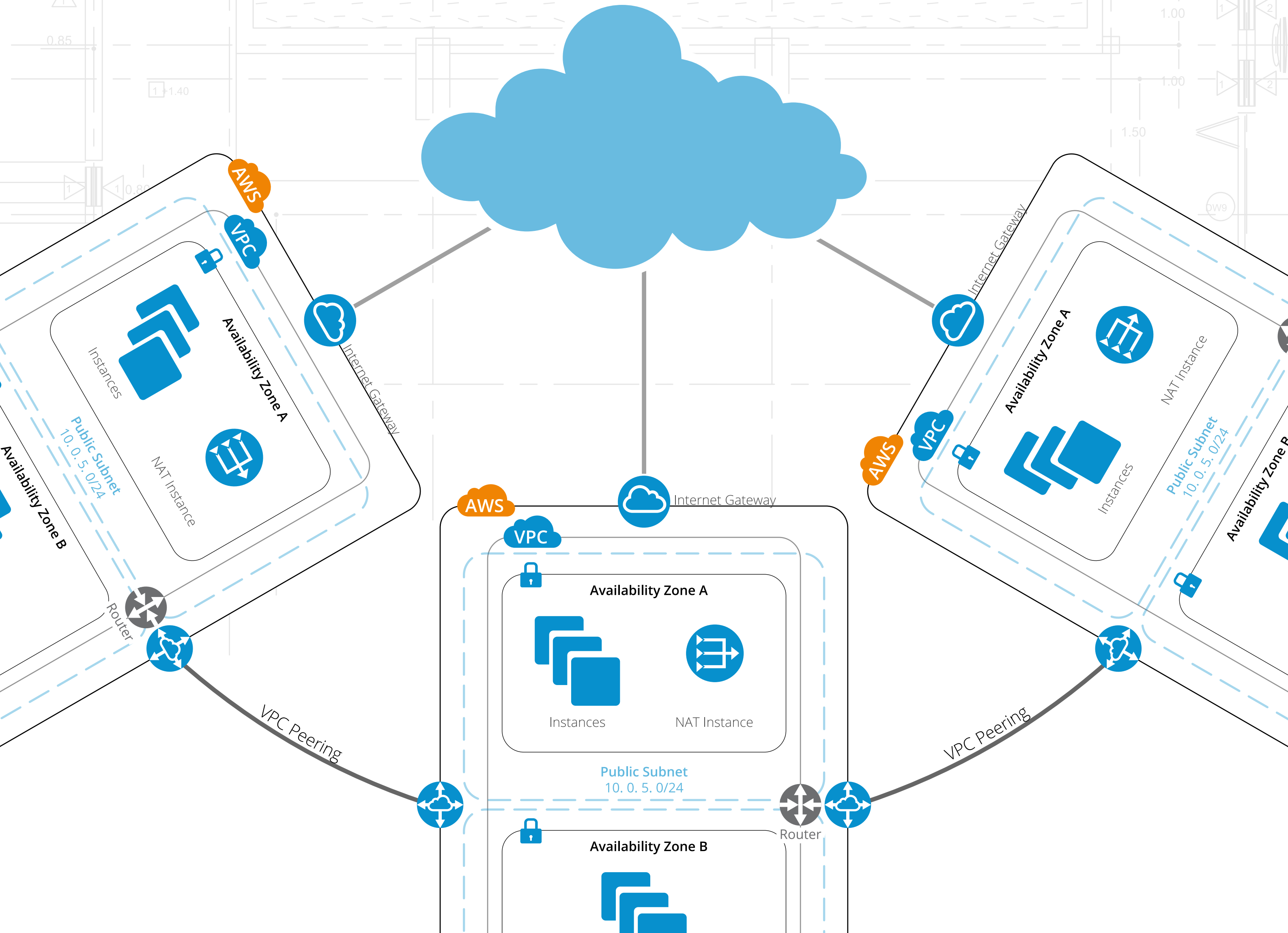
severalnines

DIY Cloud Database on Amazon Web Services: Best Practices



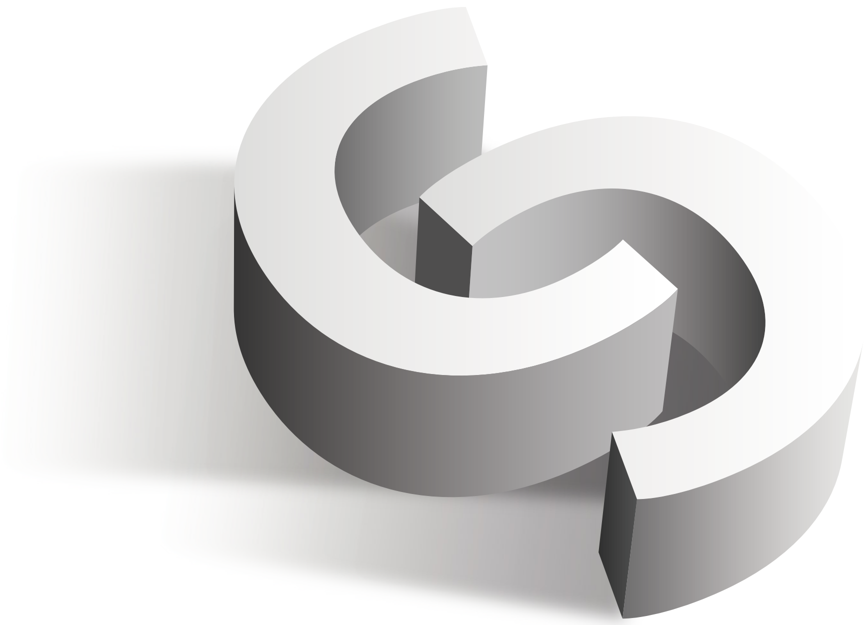


Table of Contents

What is AWS / the Cloud?

Amazon Web Services is an Infrastructure as a Service platform, comprising a large number of independent and semi-independent services. The purpose of Infrastructure as a Service platforms is to offer, on a commodity basis, services that previously required the purchase of capital-intensive infrastructure components such as high-end servers, network routers and switches, and for larger enterprises, even their own datacenters.

1.1. Objectives of this white paper

The purpose of this white paper is to provide a step by step guide to building a deployment environment for your databases on AWS, to detail the configuration of such an environment, and to instruct on important performance considerations.

Why the Cloud?

2.1. Pros

2.1.1. Rapid Deployment/Scalability

Cloud resources, such as virtual machines, containers, serverless compute resources and databases, among others, are available at the click of a button. A full solution can be spun up in a fraction of the time in which it can be deployed on one's own hardware. With the use of auto-scaling technology, new resources can automatically be provisioned depending on such metrics as current or expected traffic load on the existing infrastructure, or when an existing resource fails.

2.1.2. Offsite backup "included"

Massive-scale object stores such as AWS S3 (Simple Storage Service) provide effectively infinite storage capacity for your data, including backups. With advanced S3 functionality such as "lifecycle management", data can be archived for lower cost long-term storage, and can be expired after a user-defined length of time, to automatically manage your use of the service and associated costs.

2.1.3. Low-friction DR capability

With AWS' automation and templating tools, a disaster recovery environment suitable for the full or partial recovery of your company resources can be defined in code, ready for when it is needed, and launched with as much or as little customisation as required for your specific scenario.

2.2. Cons

2.2.1. Security

AWS offers a flexible approach to security, and a variety of methods of securing your data from unauthorised access. Some of these, such as EC2 security groups, provide a simple approach where specific IP addresses and ranges are explicitly allowed and all else is by default rejected, while EC2 instances in the same security group can communicate without security restriction. Others, like S3, take a more complex approach, relying on AWS credential sets, Access Control Lists, and JSON-based policy documents. These disparate methods in the same environment can result in improper security management.

2.2.2. Third Party control of data

One of the primary concerns with Infrastructure as a Service is the necessity of storing your data on third party servers, to which you have no physical access. This necessitates trusting a third party with your data. Mitigating this, Amazon supports encryption at rest for data on many of its services, limiting customers exposure in the event of unauthorised internal or external access.

2.2.3. High cost/Limitations of available HA solutions

While High Availability is built into services such as DynamoDB and S3, and is largely transparent within a single geographical region, your data stored in EC2 and similar services is not automatically redundant. It is up to you to design appropriate levels of redundancy into your solutions. While AWS provides the resources to enable you to do this, additional costs will be incurred. It is therefore beneficial to evaluate your data prior to deployment, to ascertain whether High Availability or Redundancy are required, or indeed if archival storage will suffice.

Deploying on AWS

As a commodity cloud IaaS platform, AWS is very diverse and caters for a wide variety of use cases. Cost and complexity can be increased or decreased according to user requirements, but certain rules should be observed for all production deployments:

1. **Design for failure:** Unlike traditional datacentre-based solutions, commodity cloud environments rely heavily on this principle. No service or solution should be dependent upon a single node, as nodes are virtual resources and are replaced rather than repaired in case of failure, and all data should be stored in more than one location. In AWS, it is advisable to store data backups in more than one geographical region for full redundancy. AWS S3 and Glacier provide effectively unlimited storage and archival storage respectively, including the functionality to replicate data to more than one geographic region.
2. **Security:** It is a common misconception that data in the cloud is automatically secure, that the cloud itself is inherently secure. IaaS environments such as AWS provide the functionality needed to implement a very high level of security for your data, but the level of security depends largely on your architecture, and on a correct understanding and appropriate configuration of the provided security tools and features. AWS Identity and Access Management (IAM) provides the ability to silo users and permissions, to enhance security. AWS also provides a wealth of other security options integrated into the various products, which can be configured to enhance your security.
3. **Pricing:** Unlike in traditional datacentre architectures, there are no expensive capital acquisitions, no physical space considerations. An increase in compute, memory, storage or bandwidth can be achieved relatively easily in AWS as needed. The result is the ability to build out a system conservatively, rather than over-provisioning for "future-proofing", which is unnecessarily expensive. Consider relatively conservative resource usage from the outset, and you can scale out and up as your use requires.

Deployment Architecture

This will comprise a dual availability zone deployment using AWS VPC (Virtual Private Cloud) for redundancy and a secure environment. The VPC environment will contain two private subnets, and you will create a node in each zone to host your database servers. This will provide redundant database server hosts in the same region, with low-latency communication between them. Additionally, you will create a second VPC in a different region to securely host another subnet, and another database server, providing geographical redundancy, but at the cost of higher expense and higher latency.

4.1. Deployment Prerequisites

4.1.1. Command Line Tools

You will deploy this environment using the AWS Command Line tools. This is a suite of tools written in the Python programming language, and should be installed before you commence. Instructions are available directly from Amazon here.

4.1.2. IAM (Identity and Access Management) User

In a production environment, we strongly suggest the use of an IAM user. This is a user account subordinate to your AWS "root" login credentials, the permissions of which can be restricted to required tasks. You will use an IAM user account with administrator privileges for the purposes of this whitepaper. With the AWS Command Line tools installed and configured, execute the following commands to create the user:

Action	Command
Create user "whitepaper"	aws iam create-user \ --path "/" \ --user-name "whitepaper"
Grant admin permissions to user "whitepaper"	aws iam put-user-policy \ --user-name "whitepaper" \ --policy-name "AllAccessPolicy" \ --policy-document "{\"Statement\":[{\"Effect\":\"Allow\", \"Action\":\"*\",\"Resource\":\"*\"}]}"
Generate Access Keys for user "whitepaper". **Save** these credentials, and on completion of IAM user configuration reconfigure your Command Line tools to use these instead.	aws iam create-access-key \ --user-name "whitepaper"
Allow AWS Console login at https://*your_account_id*.signin.aws.amazon.com/console/	aws iam create-login-profile \ --user-name "whitepaper" \ --password "yourPassword"

4.1.3. Re-configure your AWS Command Line tools credentials

Log out and reconfigure your AWS Command Line tools to use your new credentials before proceeding. While this is not strictly necessary, it is advisable to use good security practices at all times.

4.2. Create your initial VPC

First you create the VPC itself, a virtual construct identified by a label in the form of *vpc-1a2b3c4d*. Creation of sub-components, such as subnets, requires the VPC ID.

```
user@host:~$ aws ec2 create-vpc --cidr-block 10.0.0.0/16
{
    “Vpc”: {
        “VpcId”: “vpc-d4c3b2a1”,
        ...
        “CidrBlock”: “10.0.0.0/16”,
        “IsDefault”: false
    }
}
```

The *CidrBlock* specified is the IP address range inside which your VPC subnets and hosts will be created. The *IsDefault* parameter defines whether the VPC was manually created or is a *default* VPC, a VPC configured automatically via AWS. As modifying the *default* VPC can have consequences for existing EC2 resources, you have created a new one in which to deploy your resources. To view your new VPC, you can run the *describe-vpcs* command, specifying the VPC ID returned by the *create-vpc* command.

```
user@host:~$ aws ec2 describe-vpcs --vpc-id vpc-d4c3b2a1
```

4.3. Create Subnets

Subnets, when created in VPC, will by default choose an availability zone randomly. A specific availability zone can be specified with the *--availability-zone* parameter. As you can see below, the subnet was automatically created in *eu-central-1c*.

```
user@host:~$ aws ec2 create-subnet --vpc-id vpc-d4c3b2a1
--cidr-block 10.0.1.0/24
{
    “Subnet”: {
        “AvailabilityZone”: “eu-central-1c”,
        “AvailableIpAddressCount”: 251,
        “DefaultForAz”: false,
        “Ipv6CidrBlockAssociationSet”: [],
        “VpcId”: “vpc-d4c3b2a1”,
        “State”: “pending”,
        “MapPublicIpOnLaunch”: false,
        “SubnetId”: “subnet-8e917ac3”,
            "CidrBlock": "10.0.1.0/24",
            "AssignIpv6AddressOnCreation": false
        }
    }
```

Next, you create a subnet in a different availability zone, in this case *eu-central-1b*, for redundancy.

```
user@host:~$ aws ec2 create-subnet --vpc-id vpc-d4c3b2a1
--cidr-block 10.0.5.0/24 --availability-zone eu-central-1b
{
    "Subnet": {
        "AvailabilityZone": "eu-central-1b",
        "AvailableIpAddressCount": 251,
        "DefaultForAz": false,
        "Ipv6CidrBlockAssociationSet": [],
        "VpcId": "vpc-d4c3b2a1",
        "State": "pending",
        "MapPublicIpOnLaunch": false,
        "SubnetId": "subnet-541a302e",
        "CidrBlock": "10.0.5.0/24",
        "AssignIpv6AddressOnCreation": false
    }
}
```

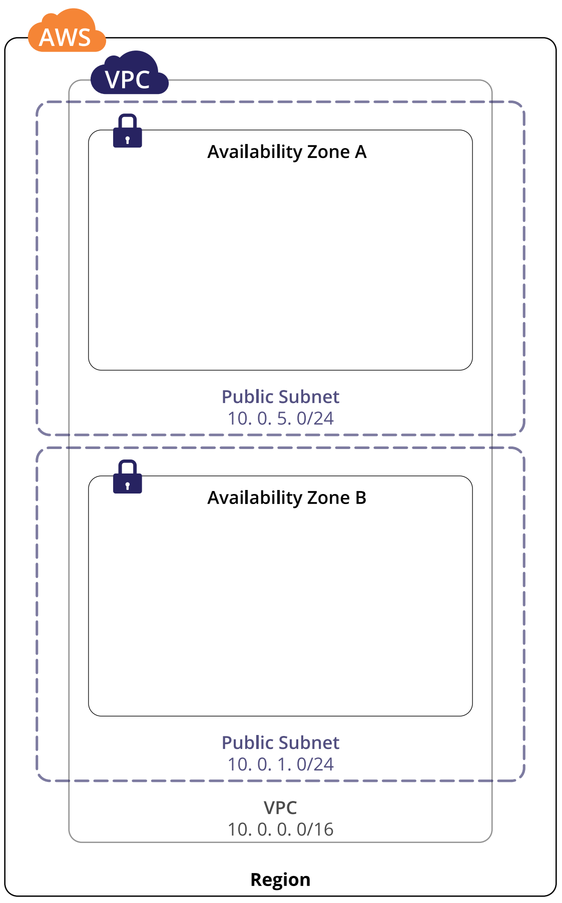


Figure 1. VPC with 2 Private Subnets

4.4. Internet Access

In case access to a node from the Internet is required, as in the case of a webserver, the concept of a *public subnet* exists. A *public subnet* is created from an existing private subnet by virtue of adding an *Internet Gateway* to your VPC, and adding it to the *route table* in the form of a rule directing traffic to wildcard route *0.0.0.0/0* to the *Internet Gateway*, identified in the form *igw-d2b1c3a4*.

In this case, for the purposes of security, it is recommended that the *public subnet* be used only to host instances that must be accessed from the Internet. Database hosts within the *private subnet(s)* will be able to communicate with each other, and the web server/proxy server in the *public subnet* will be able to communicate with them.

To create an Internet Gateway, you execute the following command, and note the *InternetGatewayId* value in the output:

```
user@host:~$ aws ec2 create-internet-gateway
{
    “InternetGateway”: {
        “Tags”: [],
        “Attachments”: [],
        “InternetGatewayId”: “igw-012dca3b”
    }
}
```

Now that you have your Internet Gateway, you must attach it to your VPC, as follows (no output is expected):

```
user@host:~$ aws ec2 attach-internet-gateway --vpc-id
vpc-d4c3b2a1 --internet-gateway-id igw-012dca3b
```

4.5. Route table

To route network traffic, a route table is required, as noted above. The route table, as its name implies, contains network routing information between your subnets and other components of your infrastructure, such as the *Internet Gateway*, and the *Customer Gateway* which we will deal with later.

To create the initial custom route table, you use the following command:

```
user@host:~$ aws ec2 create-route-table --vpc-id vpc-d4c-
3b2a1
{
    “RouteTable”: {
        “Associations”: [],
        “RouteTableId”: “rtb-98fe76dc”,
        “VpcId”: “vpc-d4c3b2a1”,
        “PropagatingVgws”: [],
        “Tags”: [],
        “Routes”: [
            {
```

```
                        "GatewayId": "local",
                        "DestinationCidrBlock": "10.0.0.0/16",
                        "State": "active",
                        "Origin": "CreateRouteTable"
                    }
                ]
            }
}
```

Note the *RouteTableId* as you will use it to add the *Internet Gateway* route to your new route table. The *create-route* command shown here should return *true*, if successful.

```
user@host:~$ aws ec2 create-route --route-table-id rtb-98fe76dc --destination-cidr-block 0.0.0.0/0 --gateway-id igw-012dca3b
{
    "Return": true
}
```

To verify that your route has been added to the route table, you can run *describe-route-tables* as follows:

```
user@host:~$ aws ec2 describe-route-tables --route-table-id rtb-98fe76dc
{
    "RouteTables": [
        {
            "Associations": [],
            "RouteTableId": "rtb-98fe76dc",
            "VpcId": "vpc-d4c3b2a1",
            "PropagatingVgws": [],
            "Tags": [],
            "Routes": [
                {
                    "GatewayId": "local",
                    "DestinationCidrBlock": "10.0.0.0/16",
                    "State": "active",
                    "Origin": "CreateRouteTable"
                },
                {
                    "GatewayId": "igw-012dca3b",
                    "DestinationCidrBlock": "0.0.0.0/0",
                    "State": "active",
                    "Origin": "CreateRoute"
                }
            ]
        }
    ]
}
```

Finally, to associate the route table with the appropriate subnet, you'll call *associate-route-table*:

```
user@host:~$ aws ec2 associate-route-table  --subnet-id sub-
net-541a302e --route-table-id rtb-6912fa02
{
    "AssociationId": "rtbassoc-dea5e9b5"
}
```

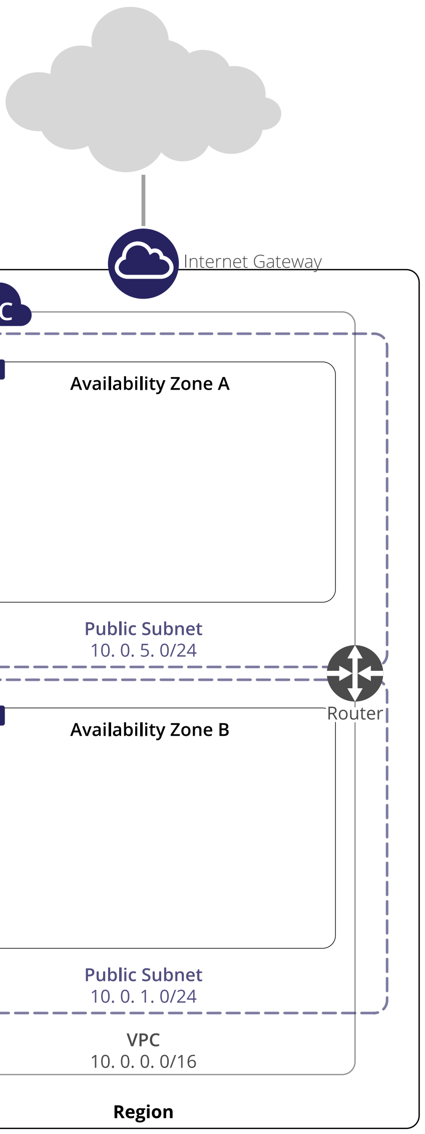


Figure 2. VPC with Public & Private Subnets, Internet Gateway and Virtual Router/Route table

As shown in Figure 2, above, you have built out a complete VPC network at this point. Before you approach launching your hosts and configuring the various resources needed to support them, let's recap what has been done so far.

1. Using the ***create-vpc*** command, you first created your new Virtual Private Cloud, and associated the IPv4 address range 10.0.0.0/16 with it. This is an isolated network, that cannot communicate with the outside world.
2. Next, you created two individual subnets, with the *create-subnet* command, within the 10.0.0.0/16 range in your VPC, 10.0.1.0/24 and 10.0.5.0/24. Note here

that AWS reserves certain IP addresses in your VPC subnet. These are the IP addresses ending in .0, .1, .2, .3, .255. The first and last of these are the network address and broadcast address respectively, and as expected. The other 3 IP addresses are reserved for AWS functionality as follows:
    a. 10.0.x.1: Subnet gateway IP address
    b. 10.0.x.2: AWS DNS Server. Allows for name resolution through the gateway
    c. 10.0.x.3: Subnet DHCP Services

3. To facilitate access from the Internet, you added an Internet Gateway with *create-internet-gateway* and attached it to a subnet with *attach-internet-gateway*. You will be able to attach publicly routable IP addresses – or in AWS terms *Elastic IP Addresses* – to hosts in this subnet to make them accessible on the Internet. You can run services such as web servers in this subnet. Note that any host without an Elastic IP Address in this subnet is still unable to be accessed directly via the Internet and security remains intact.
4. To complete your Internet configuration, you added a route table, using *create-route-table* and using *create-route* you added a route to the 0.0.0.0/0 wildcard network address via the *Internet Gateway*. This means that all traffic destined for external addresses will be routed via the *Internet Gateway*.

4.6. VPC Gateway

The VPC Gateway is an IPsec-secured gateway into your VPC. It exists to facilitate VPN connections from your remote location to the VPC. It works in conjunction with another component, the Customer Gateway, which is the virtual device your VPN router connects to. To configure a VPC Gateway, you will use the *create-vpn-gateway* command. Note that the type specified, *ipsec.1*, is currently the only available option.

```
user@host:~$ aws ec2 create-vpn-gateway --type ipsec.1
{
    “VpnGateway”: {
        “State”: “available”,
        “Type”: “ipsec.1”,
        “VpnGatewayId”: “vgw-9a4cacf3”,
        “VpcAttachments”: []
    }
}
```

Now that you have a VPC Gateway, it should be attached to the VPC itself. This is achieved by means of the *attach-vpn-gateway* command.

```
user@host:~$ aws ec2 attach-vpn-gateway --vpc-id vpc-d4c-
3b2a1 --vpn-gateway-id vgw-9a4cacf3
{
    “VpcAttachement”: {
        “State”: “attaching”,
        “VpcId”: “vpc-d4c3b2a1”
    }
}
```

To connect your router to the VPC, you will need a *Customer Gateway*, which you set up with the *create-customer-gateway-command*. The public IP address specified in the command should be the IP address of the Northbound interface of your VPN router, and the BGP-ASN should be the BGP Autonomous Systems Number of your internet segment, if applicable. When configuring dual redundant connections to your VPC, BGP provides superior link failure detection. If you do not have a BGP ASN, you can use **65534**.

```
user@host:~$ aws ec2 create-customer-gateway --type ipsec.1 
--public-ip 1.1.1.1 --bgp-asn 65534
{
    “CustomerGateway”: {
        “CustomerGatewayId”: “cgw-0e11f167”,
        “IpAddress”: “1.1.1.1”,
        “State”: “available”,
        “Type”: “ipsec.1”,
        “BgpAsn”: “65534”
    }
}
```

You cannot create more than one customer gateway with the same VPN type, IP address, and BGP ASN parameter values. If you run an identical request more than one time, the first request creates the customer gateway, and subsequent requests return information about the existing customer gateway. The subsequent requests do not create new customer gateways.

Finally, to configure your device, you should refer to the AWS Network Administrator Guide for detailed information, and a list of officially supported devices.

4.7. Host Dependencies

Now that you have configured your network, it is time to add hosts. You will first create host dependencies, such as the *Key Pair* required for *ssh* login to the hosts, and the *Security Group* that provides basic firewall functionality for your hosts. You will also create a *NAT Instance*, a device which allows your hosts to communicate outbound with Internet hosts, to facilitate such functionality as operating system updates.

First, let’s create the *Key Pair*. As you can see, the output of this command is redirected to a file, *YourKey*.pem. This file is your *ssh key*. You should ensure you keep a backup of this key, as without it you will be unable to log in to your hosts. Note also that *ssh* will not allow you to use a key that has open permissions. Linux/UNIX permission mode 400 is recommended.

```
user@host:~$ aws ec2 create-key-pair --key-name YourKey 
--query ‘KeyMaterial’ --output text > YourKey.pem
user@host:~$ chmod 400 YourKey.pem
```

AWS facilitates the creation of up to 5,000 *Key Pairs* per region, but it is important to note that only the *Key Pair* with which an AWS instance is launched can be used to log in directly to that instance.

Now you need your Security Group. The Security Group controls access to your host or hosts, and in VPC can also be used to block outgoing traffic. Make sure to note your security group *GroupId* for the next stage.

```
user@host:~$ aws ec2 create-security-group --group-name SSH-Access --description “SSH Access” --vpc-id vpc-d4c3b2a1
{
    “GroupId”: “sg-29362c42”
}
```

Now that you have created a security group, you’re going to add a rule to it. This rule allows unfettered *ssh* access by means of the wildcard network IP address 0.0.0.0/0. In practice however, you should use a more restrictive range or specific IP address, to limit access to your hosts’ *ssh* port.

```
user@host:~$ aws ec2 authorize-security-group-ingress --group-id sg-29362c42 --protocol tcp --port 22 --cidr 0.0.0.0/0
```

You are almost ready to launch your instances, but before you can proceed to this step, you will need to choose an AMI, or Amazon Machine Image, which is the operating system image that you wish to launch. AWS provide instructions for finding a suitable AMI here. Note that AMIs are specific to the region in which they are provided. For the purposes of this exercise, we will use a community-provided CentOS Linux 7 AMI in the EU-CENTRAL-1 region: ami-fa2df395

You will also need to decide on the type of AWS Instance that you wish to launch. The instance type dictates the number of CPU cores, the amount of RAM memory, its network performance, and availability of *ephemeral* storage, a data store included with some instance types. The *ephemeral* data storage, while benefiting from performance improvement due to direct attachment to the instance, unlike the persistent network-attached EBS (Elastic Block Storage), disappears when an instance is shutdown, and the data is irretrievable. For use cases that need high performance disk and that can survive data loss on shutdown, ephemeral is very useful.

AWS instance types can be reviewed here. You should spend some time reviewing this document, as it explains in detail the storage options available. Pay particular attention to Provisioned IOPS EBS storage, persistent network-attached storage with prescribed fixed performance characteristics. It is a good idea to test your environment with different levels of disk performance, as higher performance will also result in increased costs.

4.8. Launching Hosts

To launch our host, we use the *run-instances* command. The command launches the instance and returns a JSON document with a full description of the instance. From this output, note the *InstanceId*. This is the unique reference that you will use to query the instance and address it via the API or the AWS Command Line tools.

```
user@host:~$ aws ec2 run-instances --image-id ami-fa2df395
--count 1 --instance-type t2.micro --key-name MyKeyPair
--security-group-ids sg-29362c42 --subnet-id subnet-541a302e
```

Using the *InstanceId* we can query the instance and confirm that it is in state "Running". Once the instance is running, we can connect to it via *ssh*. Note that it may take some time to reach the running state, as resources are provisioned.

```
user@host:~$ aws ec2 describe-instances --instance-id
i-0146854b7443af453
```

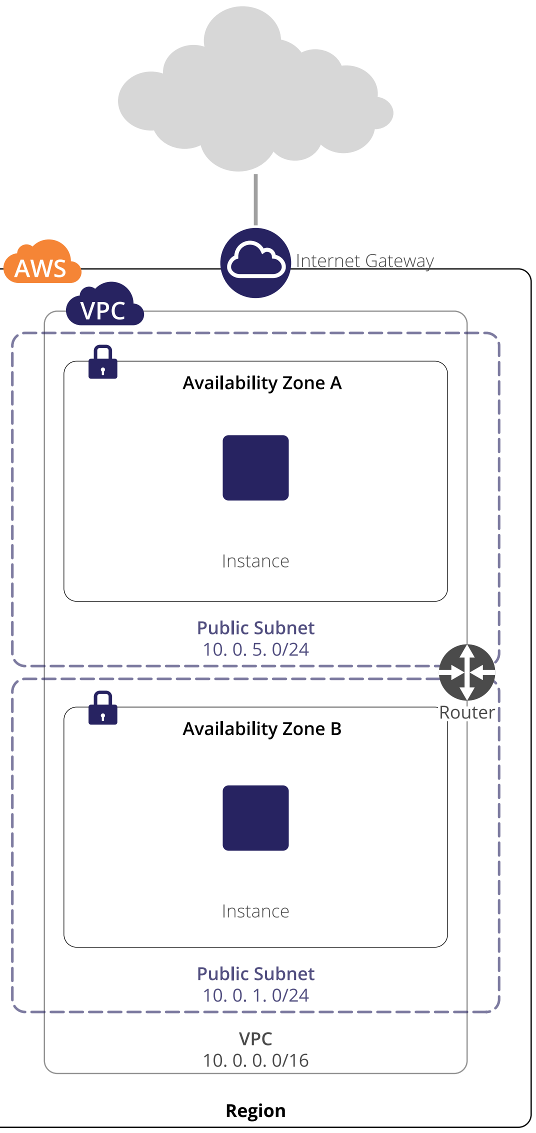


Figure 3. VPC with EC2 instance

4.9. NAT Instances

A *NAT Instance* in your subnet allows your instance to communicate with external services, without exposing the host itself to the Internet, similar to your computers at home, which in general use your cable or DSL modem as a NAT device to access the Internet, but are not themselves directly exposed to it.

In AWS you must create a *NAT Instance* in each subnet in which you wish to give Internet access to hosts. To create a *NAT Instance* you will use the same process of launching an instance as previously, with a new security group, specific to the NAT Instance. You will also need to use an Amazon AMI configured for use as a *NAT Instance*. The following command will list appropriate AMIs.

```
user@host:~$ aws ec2 describe-images --filter Name=”own-
er-alias”,Values=”amazon” --filter Name=”name”,Values=”amzn-
ami-vpc-nat*”
```

To create the security group, you will use the same process previously documented, and associate with the appropriate subnet. The security group should be configured with the following rules:

Inbound			
Source	Protocol	Port Range	Note
Private Subnet Network Address e.g. 10.0.1.0/24	TCP	80	Allow inbound HTTP traffic from servers in the private subnet
Private Subnet Network Address e.g. 10.0.1.0/24	TCP	443	Allow inbound HTTPS traffic from servers in the private subnet
Public IP address range of your remote network.	TCP	22	Allow inbound SSH access to the NAT instance from your remote network (over the Internet gateway)
Outbound			
Destination	Protocol	Port Range	Note
0.0.0.0/0	TCP	80	Allow outbound HTTP access to the Internet
0.0.0.0/0	TCP	443	Allow outbound HTTP access to the Internet

Note that in terms of security, hosts launched within a single security group have, by default, unfettered communication with each other, with no need for additional security rules, other than for external access.

AWS also offers a fully redundant ***NAT Gateway*** option, a more complex premium option, on which you can find details here. The ***NAT Gateway*** can facilitate high volumes of traffic, with bursts of up to 10Gbps.

4.10. Geographical Redundancy

You now have an ostensibly complete VPC deployment, complete with EC2 host. The instructions provided can be used to deploy additional hosts as needed. For geographical redundancy, but with the previously noted increase in latency and AWS bandwidth charges that this will incur, you can use the previous process to create a second VPC in a second region. Due to AWS' ***VPC Peering*** functionality, it is possible to connect your VPCs securely and protect traffic between the two VPCs.

To peer your VPCs, use the ***create-vpc-peering-connection*** command with your two VPC IDs:

```
user@host:~$ aws ec2 create-vpc-peering-connection --vpc-id
<VPC ID> --peer-vpc-id <2nd VPC ID>
```

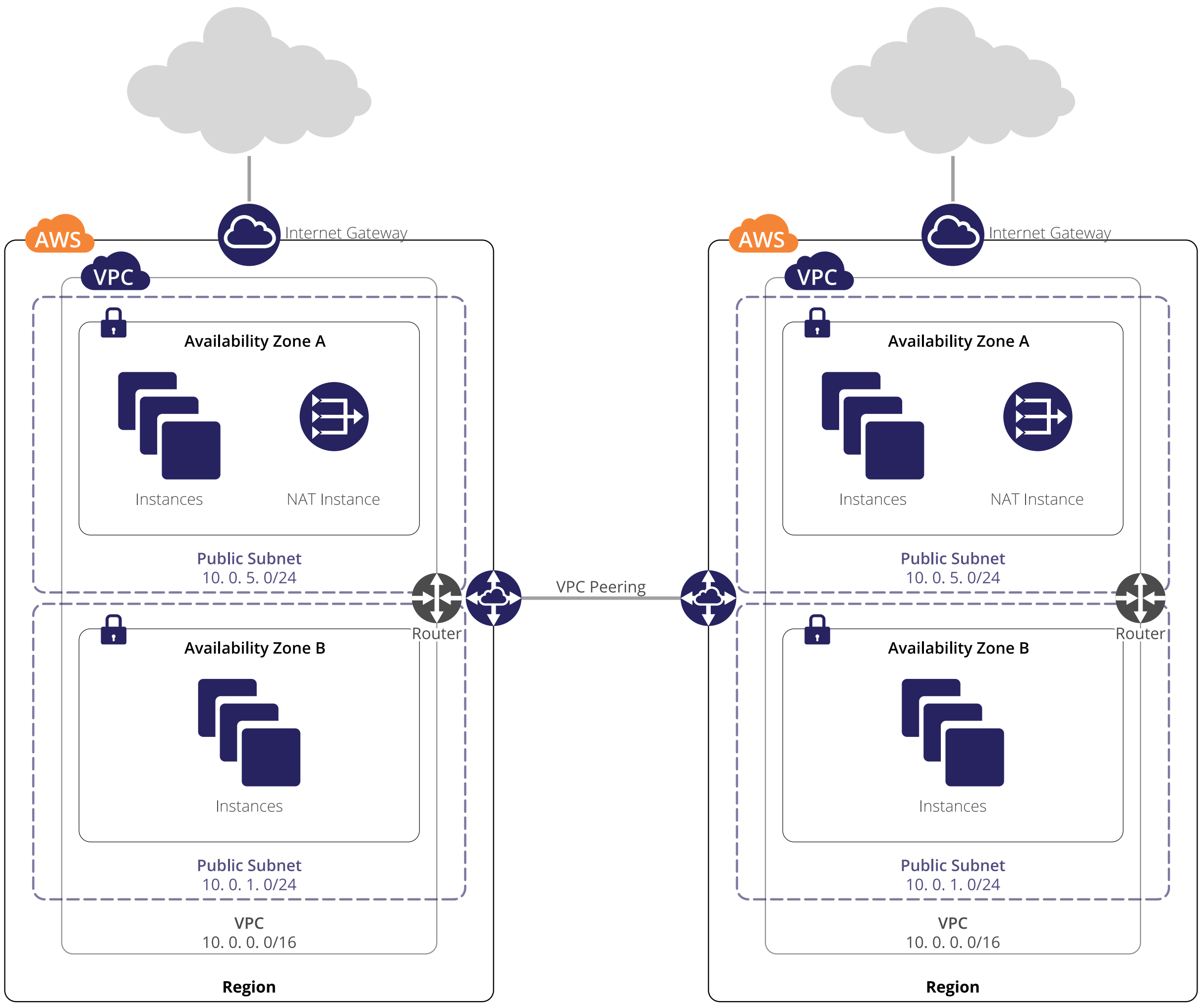


Figure 4. Geographically Redundant VPC Environment

4.11. Deployment Summary

At this point, using an IAM user, you have deployed a geographically redundant and secure network environment, hosting multiple virtual servers. Within the environment, your servers can be completely isolated from the Internet, can make outbound Internet requests only, or can be accessed directly from the Internet on ports of your choosing. You are up and running in the Cloud, in a secure environment, and are familiar with the use of the AWS Command Line tools. If you are not familiar with the AWS Console, it is recommended that you familiarise yourself with it, and with the CloudWatch monitoring functionality it offers. While basic, CloudWatch offers visibility into metrics associated with your AWS resources. These include CPU Usage, Network Usage, and Disk Usage, as well as Instance and System Health Check.

4.12. Database in the Cloud Considerations

As alluded to earlier, when deploying Cloud servers, important considerations include Instance Type, Instance Storage, and Network Performance. Here we will go into more depth on these topics.

4.12.1. Instance Type

There are a number of different types of AWS Instances. In broad categories, these are General Purpose, Compute Optimised, Memory Optimised, Accelerated Computing & Storage Optimised instances. The full list of instance types can be reviewed here. Instance characteristics to pay specific attention to when choosing a suitable instance type for your database host are the following, each of which are explained in details in the Instance Types list:

- **Number of CPU cores:** each virtual CPU core is a single hyperthread of a physical CPU. Depending on your CPU requirements, you may therefore need to allocate double or quadruple the number of CPUs you would use on a physical host for the same performance.
- **RAM:** When using an EBS-backed instance, it is possible to stop your instance and start it again as a different instance type. This means that it is possible to be conservative in your RAM requirements during your evaluation stage, reducing your costs, as nothing is lost by changing your instance type. *Note that, as discussed earlier, if you are using ephemeral storage on your instance, data here will not survive a stop and start of an instance.*
- **EBS Optimisation:** EBS-optimised instances offer significantly improved disk read/write performance. You should strongly consider taking advantage of this feature to reduce disk read and write latency.
- **Enhanced Networking:** Using Placement Groups (logical groups of EC2 instances within an Availability Zone), you can avail of Enhanced networking options that facilitate up to 10 Gbps for single-flow and 25 Gbps for multi-flow traffic in each direction (full duplex). Network traffic outside a cluster placement group (e.g. to the Internet) is limited to 5 Gbps (full duplex).

4.12.2. Instance Storage

When planning your database deployment, it is important to be aware of the different storage options available to EC2 instances, and the limitations and benefits of each.

Many instance types, except for the most basic, include what is known as *ephemeral* storage. Ephemeral storage is also known as *local* storage. It is storage that is local to your instance, i.e. served by the same physical server on which your instance runs. Because it is local, it offers low latency and high performance. As it is included with the instance, it also lowers your costs; there is no additional cost for your use of ephemeral storage. Some larger instances offer multiple ephemeral volumes, which you can stripe your data across to further increase performance. However, precisely because this is local rather than network storage, it is not possible to snapshot these volumes for backup purposes, as with EBS volumes. In addition, as stopping and starting an EC2 instance results in movement to a new physical server, all data in the ephemeral storage is lost when doing so. Note that it is not possible to recover data in an ephemeral data store when an instance is moved.

The other instance storage that is offered by Amazon is EBS or *Elastic Block Storage*. This is network-attached persistent storage. Volumes can be attached to and detached from running instances, other than the root volume, and all volumes can be backed via the EC2 snapshot method. New volumes can be created directly from a snapshot, even in another availability zone. Snapshots can also be migrated to another AWS region, which is a convenient way to move large volumes of data.

Standard EBS Storage performance is heavily impacted by network traffic to and from your instance, as well as to and from any other instances hosted on the same physical server as you. As this is not ideal for applications requiring high and/or consistent disk performance, such as databases, Amazon introduced the concept of *pIOPS*, or provisioned I/O operations per second, to guarantee certain performance levels. Note that pIOPS is performance constrained by the size of the volume for which it is being provisioned, i.e. EBS Provisioned IOPS Maximum IOPS:GB ratio is 30:1, therefore to obtain a throughput of 3,000 I/O operations per second, your volume size would need to be a minimum of 100GB in size.

Finally, as you will have noticed in the Instance Types matrix, some instance types include the *EBS Optimised* feature. EBS-optimized instances deliver dedicated throughput between Amazon EC2 and Amazon EBS, with options between 500 and 4,000 Megabits per second (Mbps) depending on the instance type used. The dedicated throughput minimizes contention between Amazon EBS I/O and other traffic from your EC2 instance, resulting in significantly increased read/write performance.

4.12.3. Network Performance

In addition to the network performance points discussed above, relating to disk performance, every instance has a defined level of network throughput support. In the AWS Instance Types Guide, these levels are defined as Low, Low-to-Moderate, Moderate, High, 10 Gigabit, 25 Gigabit. No specific guarantees are provided by Amazon for throughput levels below the 10 Gigabit level. It is therefore important to benchmark instance network performance for critical applications prior to a production deployment. As a rough guideline, an AWS RDS MySQL instance at Amazon's minimum recommended specification has "High" network performance. These instances are similar to the m3.xlarge instance type. This instance type also supports EBS Optimisation.

4.13. ClusterControl: Automating Database Management in the Cloud

You've deployed your VPC, carefully chosen and benchmarked your production EC2 instances, allocated high-performing data disks. Now what?

Database management has traditionally been complex and time-consuming. Deployment, with the headaches of security, complex networking, backup planning and implementation, and monitoring, has been a headache. Scaling out your database cluster has been a major undertaking. In a world where 24/7 availability and rapid disaster recovery is expected, managing even a single database cluster can be a full-time job. We have endeavoured to address infrastructure components of this earlier, but now it's time to focus on the database server itself.

Severalnines' ClusterControl is a database deployment and management tool that addresses the above, facilitating rapid deployment of redundant, secure database clusters or nodes, including advanced backup and monitoring functionality. With plugins supporting Nagios, PagerDuty, and Zabbix, among others, ClusterControl integrates well with existing infrastructure and tools to help you manage your database servers with confidence.

4.14. Controlling and automating MongoDB in the Cloud

MongoDB is the leading NoSQL database server in the world today. Using ClusterControl, you're now going to deploy a MongoDB Replica Set with three data nodes in a single region, and look at some of the features of the ClusterControl application.

First, you will need to deploy four AWS instances. For a production platform, the instance type should be carefully chosen based on the guidelines we have previously discussed, but for our purposes instances with 2 virtual CPUs and 4GB RAM will be sufficient. One of these nodes will host ClusterControl, the others will be used to deploy the three database nodes.

Begin by creating your database nodes' security group, allowing inbound traffic on port 27017. There is no need to restrict outbound traffic, but should you wish to do so, allow outbound traffic on ports 1024-65535 to facilitate outbound communication from the database servers.

Next create the security group for your ClusterControl node. Allow inbound traffic on ports 22, and 80. Add this security group ID to your database nodes security group, and allow unrestricted TCP communication. This will facilitate communication between the two security groups, without allowing *ssh* access to the database nodes from external clients.

Launch the instances into their respective security groups, choosing for each instance a KeyPair for which you have the *ssh* key. For the purposes of this task, use the same KeyPair for all instances. If you have lost the *ssh* key for your KeyPair, you will have to create a new KeyPair. When launching the instances, do not choose the default Amazon Linux image, instead choose an AMI based on a supported operating system listed here. As I am using AWS region EU-CENTRAL-1, I will use community AMI **ami-fa2df395**, a CentOS 7 image, for this purpose.

Use the *describe-instances* command detailed previously to confirm that your instances are running, and when confirmed, log in to the ClusterControl instance via *ssh*.

Copy the public key file you downloaded when creating your KeyPair to the ClusterControl instance. You can use the *scp* command for this purpose. For now, let's leave it in the default */home/centos* directory, the home directory of the centos user. I have called mine s9s.pem.

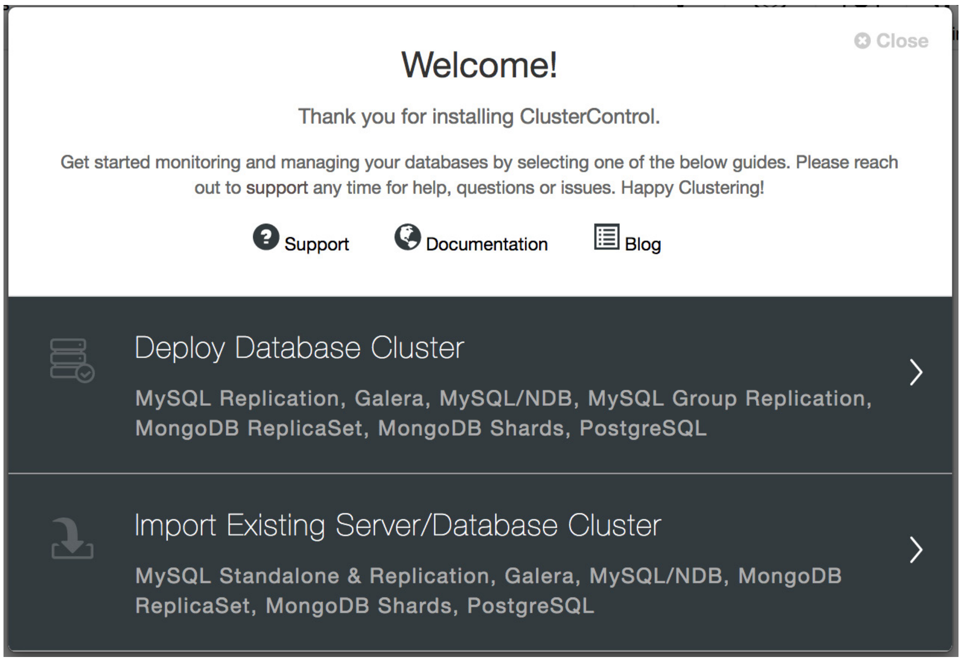
To install ClusterControl, run the following commands:

```
$ wget http://www.severalnines.com/downloads/cmon/install-cc
$ chmod +x install-cc
$ ./install-cc   # as root or sudo user
```

The installation will walk you through some initial questions, after which it will take a few minutes to retrieve and install dependencies using your operating system's package manager.

When installation is complete, point your your web browser to http://<address of your ClusterControl instance>. You can find the external facing address of the instance using the *describe-instances* command.

Once you have successfully logged in, you will see the following screen, and can continue to deploying your MongoDB Replica Set.


Welcome!

Thank you for installing ClusterControl.

Get started monitoring and managing your databases by selecting one of the below guides. Please reach out to support any time for help, questions or issues. Happy Clustering!

Deploy Database Cluster

MySQL Replication, Galera, MySQL/NDB, MySQL Group Replication, MongoDB ReplicaSet, MongoDB Shards, PostgreSQL

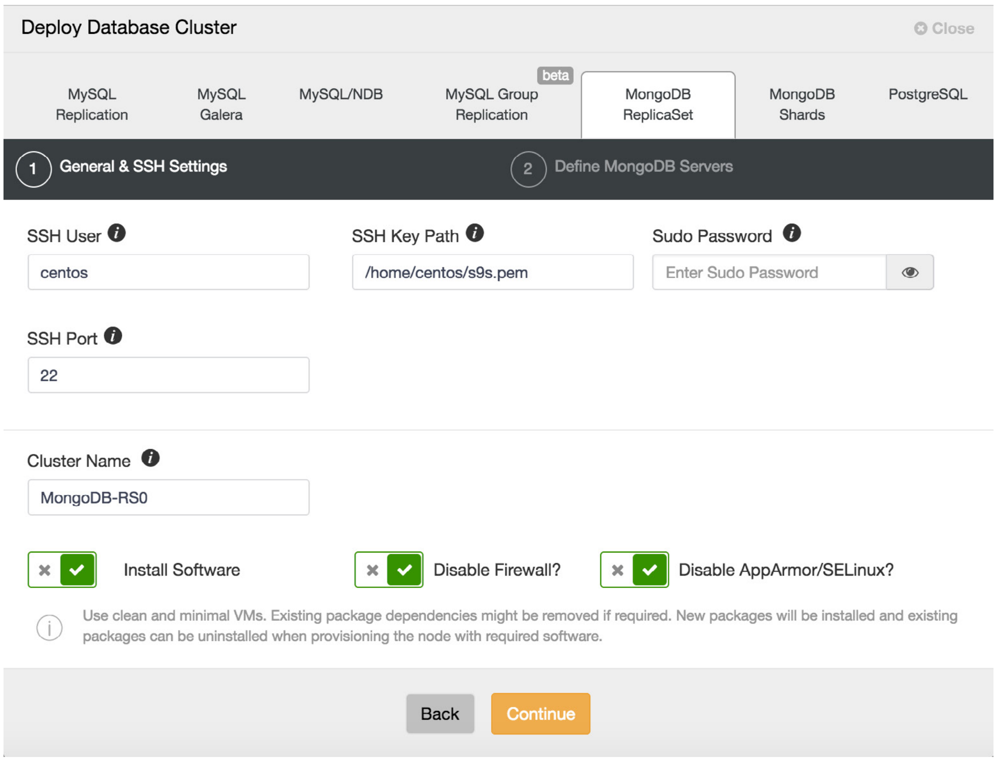
Import Existing Server/Database Cluster

MySQL Standalone & Replication, Galera, MySQL/NDB, MongoDB ReplicaSet, MongoDB Shards, PostgreSQL

Figure 5: Welcome to ClusterControl!

As you can see, ClusterControl can also import existing database clusters, allowing it to manage your existing infrastructure as easily as new deployments.

For our purposes, you are going to click *Deploy Database Cluster*. On the next screen you will see the selection of database servers and cluster types that ClusterControl supports. Click the tab labelled *MongoDB ReplicaSet*, to go to this tab. Here the values with which you are concerned are *SSH User*, *SSH Key Path*, and *Cluster Name*. The port should already be *22*, the default ssh port, and the AMI we are using does not require a *Sudo Password*.


Deploy Database Cluster

Close

MySQL Replication | MySQL Galera | MySQL/NDB | MySQL Group Replication (beta) | MongoDB ReplicaSet | MongoDB Shards | PostgreSQL

1 General & SSH Settings — 2 Define MongoDB Servers

SSH User: centos

SSH Key Path: /home/centos/s9s.pem

Sudo Password: Enter Sudo Password

SSH Port: 22

Cluster Name: MongoDB-RS0

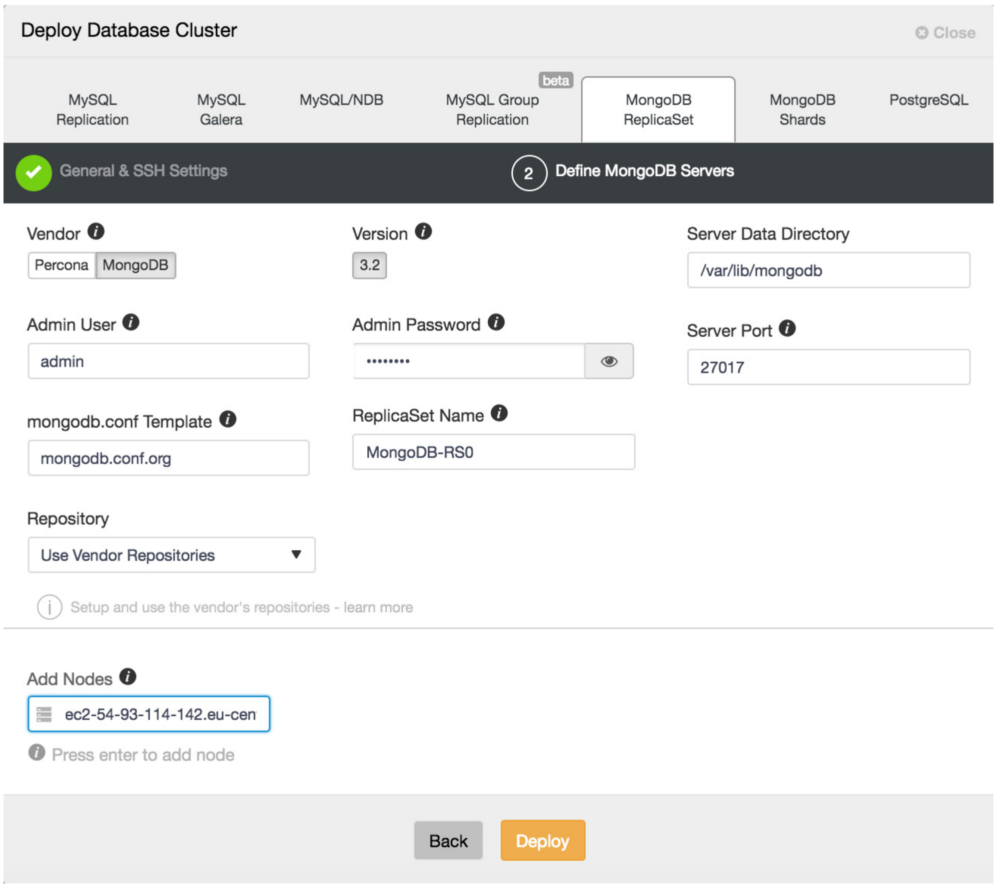
✓ Install Software ✓ Disable Firewall? ✓ Disable AppArmor/SELinux?

Use clean and minimal VMs. Existing package dependencies might be removed if required. New packages will be installed and existing packages can be uninstalled when provisioning the node with required software.

Back | Continue

Figure 6: Deploying a MongoDB Replica Set

The ssh user for the CentOS 7 AMI is *centos*, and the *SSH Key Path* is /home/centos/s9s.pem, or the appropriate path depending on your own Key file name. Let's use MongoDB-RS0 as the *Cluster Name*. Accepting the default options, we click *Continue*.


Deploy Database Cluster

Close

MySQL Replication | MySQL Galera | MySQL/NDB | MySQL Group Replication (beta) | MongoDB ReplicaSet | MongoDB Shards | PostgreSQL

✓ General & SSH Settings — 2 Define MongoDB Servers

Vendor: Percona [✓ MongoDB]

Version: 3.2

Server Data Directory: /var/lib/mongodb

Admin User: admin

Admin Password: ••••••••

Server Port: 27017

mongodb.conf Template: mongodb.conf.org

ReplicaSet Name: MongoDB-RS0

Repository: Use Vendor Repositories

Setup and use the vendor's repositories - learn more

Add Nodes: ec2-54-93-114-142.eu-cen

Press enter to add node

Back | Deploy

Figure 7: Configuring your deployment

Here we can choose between the MongoDB official build, and a Percona build. Select whichever you prefer, and supply an admin user and password with which to configure MongoDB securely. *Note that ClusterControl will not let you proceed unless you provide these details.* Make a note of the credentials you have supplied, you will need them to log in to the deployed MongoDB database, if you wish to later use it. Now choose a Replica Set name, or accept the default. We are going to use the vendor repositories, but be aware that you can configure ClusterControl to use your own repositories or those of a third party, if you prefer.

Add your database nodes, one at a time. You can choose to use the external IP address, but if you provide the hostname, which is generally recommended, ClusterControl will record all network interfaces in the hosts, and you will be able to choose the interface on which you would like to deploy. Once you have added your three database nodes, click *Deploy*. ClusterControl will now deploy your MongoDB Replica Set. Click *Full Job Details* to observe as it carries out the configuration of your cluster. When the job is complete, go to the *Database Clusters* screen and see your cluster.

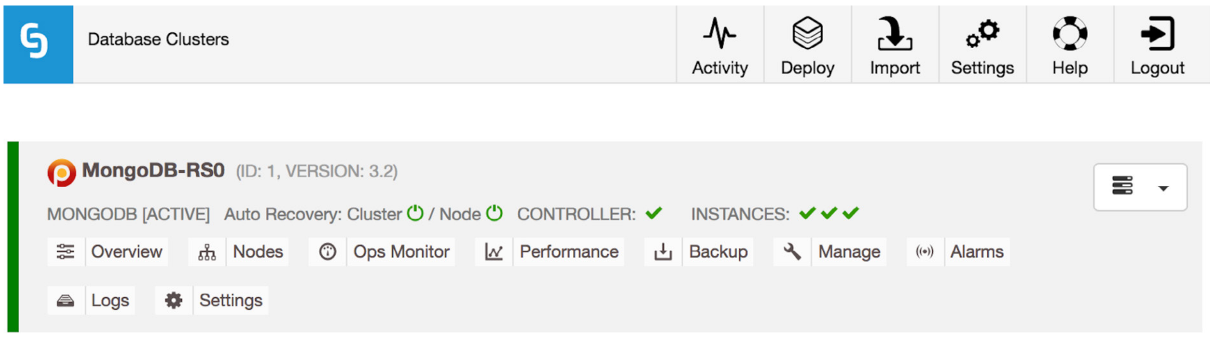


Figure 8: MongoDB deployed

Your MongoDB Replica Set is deployed, and you can connect to it remotely with the admin credentials you chose. Now, let's take a look at the ClusterControl interface. In this view, the Database Clusters view, you can see all of the clusters you are managing. You see the cluster name you've chosen, followed by the software version; in this case you deployed MongoDB 3.2.

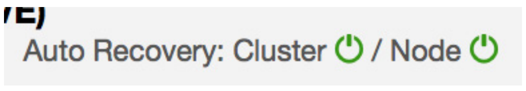
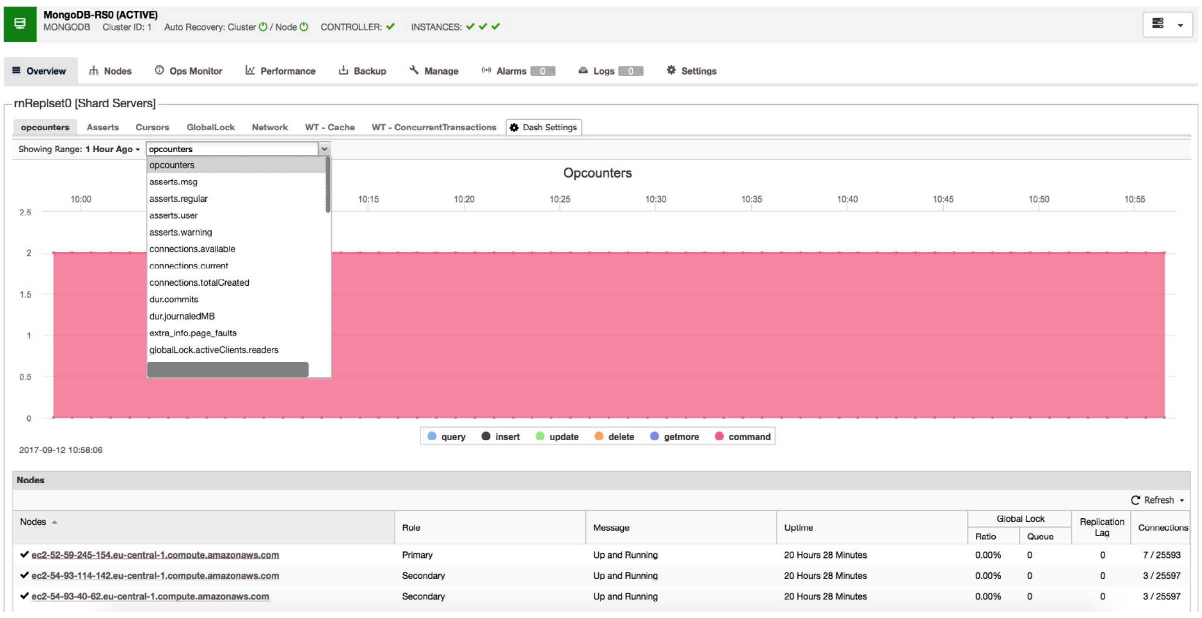


Figure 9: Auto Recovery

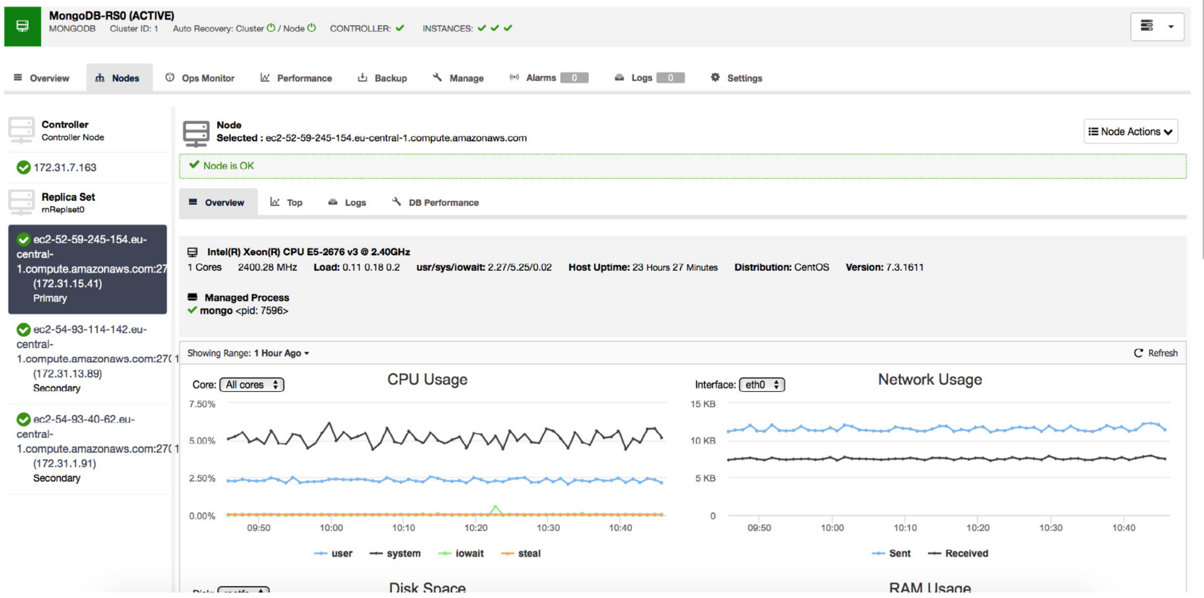
Taking a closer look, you can see that Auto Recovery is enabled at both a cluster and a node level; in the case of failures, ClusterControl will attempt to recover your cluster or the individual node having an issue. The green tick beside each node also displays the cluster's health status at a glance.



Nodes	Role	Message	Uptime	Global Lock		Replication Lag	Connections
				Ratio	Queue		
✓ ec2-52-59-245-154.eu-central-1.compute.amazonaws.com	Primary	Up and Running	20 Hours 28 Minutes	0.00%	0	0	7 / 25593
✓ ec2-54-93-114-142.eu-central-1.compute.amazonaws.com	Secondary	Up and Running	20 Hours 28 Minutes	0.00%	0	0	3 / 25597
✓ ec2-54-93-40-62.eu-central-1.compute.amazonaws.com	Secondary	Up and Running	20 Hours 28 Minutes	0.00%	0	0	3 / 25597

Figure 10: Overview tab

Overview provides a high level overview of the cluster as a whole, covering the core MongoDB metrics, as well as Network, Locking, and Wired Tiger engine-specific performance metrics.


MongoDB-RS0 (ACTIVE)
MONGODB Cluster ID: 1 Auto Recovery: Cluster / Node CONTROLLER: ✓ INSTANCES: ✓ ✓ ✓
Overview
Nodes
Ops Monitor
Performance
Backup
Manage
Alarms 0
Logs 0
Settings
Controller
Controller Node
172.31.7.163
Replica Set
rnReplset0
ec2-52-59-245-154.eu-central-1.compute.amazonaws.com:27 (172.31.15.41) Primary
ec2-54-93-114-142.eu-central-1.compute.amazonaws.com:27((172.31.13.89) Secondary
ec2-54-93-40-62.eu-central-1.compute.amazonaws.com:27((172.31.1.91) Secondary
Node Actions
Top
Logs
DB Performance
Showing Range: 1 Hour Ago
Refresh
CPU Usage
Core: All cores
user
system
iowait
steal
Network Usage
Interface: eth0
Sent
Received
Disk Space
RAM Usage

Node
Selected : ec2-52-59-245-154.eu-central-1.compute.amazonaws.com

✓ Node is OK

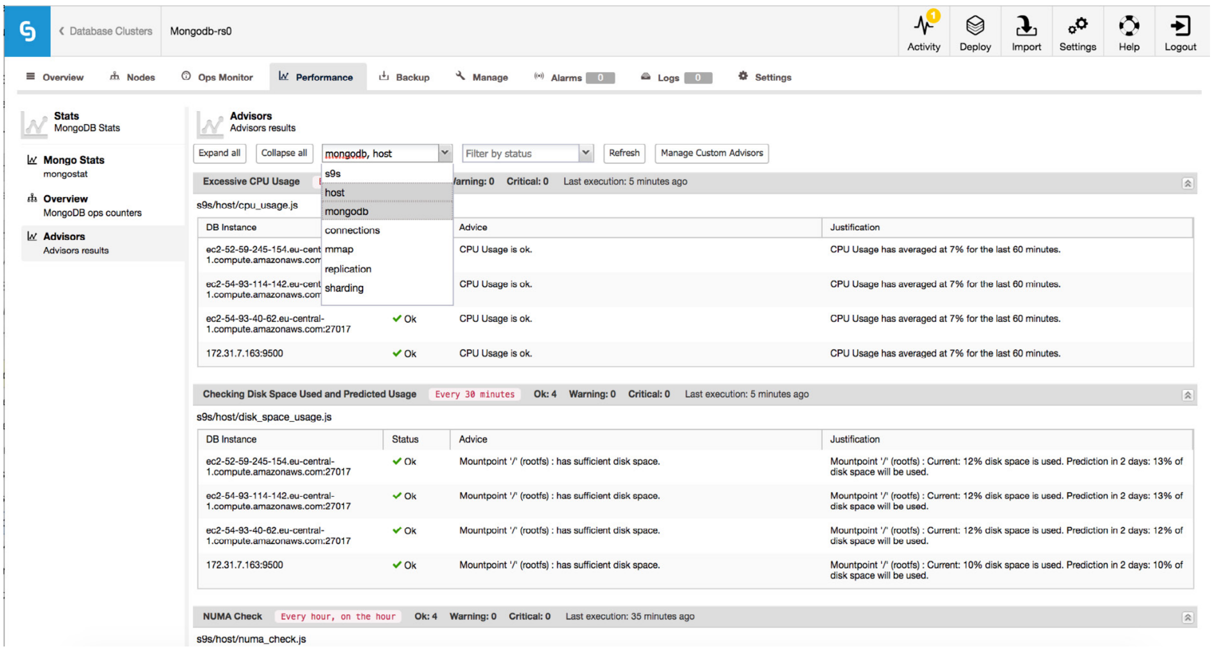
Intel(R) Xeon(R) CPU E5-2676 v3 @ 2.40GHz
1 Cores 2400.28 MHz **Load:** 0.11 0.18 0.2 **usr/sys/iowait:** 2.27/5.25/0.02 **Host Uptime:** 23 Hours 27 Minutes **Distribution:** CentOS **Version:** 7.3.1611

Managed Process
✓ **mongo** <pid: 7596>

Figure 11: Nodes tab

Nodes shows a host by host view, showing host and database performance metrics as well as logs local to the host and top command output. Hosts are managed from this view, with functionality including *maintenance mode* accessible from the *Node Actions* menu in the upper right of the screen, which also offers the options to *Step down*, *Restart*, *Freeze*, or *Stop* a Node, or to reboot the host on which it resides.

Ops Monitor allows you to view and interacts with operations currently running on the cluster.



Excessive CPU Usage — Warning: 0 Critical: 0 Last execution: 5 minutes ago

s9s/host/cpu_usage.js

DB Instance	Status	Advice	Justification
ec2-52-59-245-154.eu-cent 1.compute.amazonaws.com		CPU Usage is ok.	CPU Usage has averaged at 7% for the last 60 minutes.
ec2-54-93-114-142.eu-cent 1.compute.amazonaws.com		CPU Usage is ok.	CPU Usage has averaged at 7% for the last 60 minutes.
ec2-54-93-40-62.eu-central-1.compute.amazonaws.com:27017	✓ Ok	CPU Usage is ok.	CPU Usage has averaged at 7% for the last 60 minutes.
172.31.7.163:9500	✓ Ok	CPU Usage is ok.	CPU Usage has averaged at 7% for the last 60 minutes.

Checking Disk Space Used and Predicted Usage `Every 30 minutes` Ok: 4 Warning: 0 Critical: 0 Last execution: 5 minutes ago

s9s/host/disk_space_usage.js

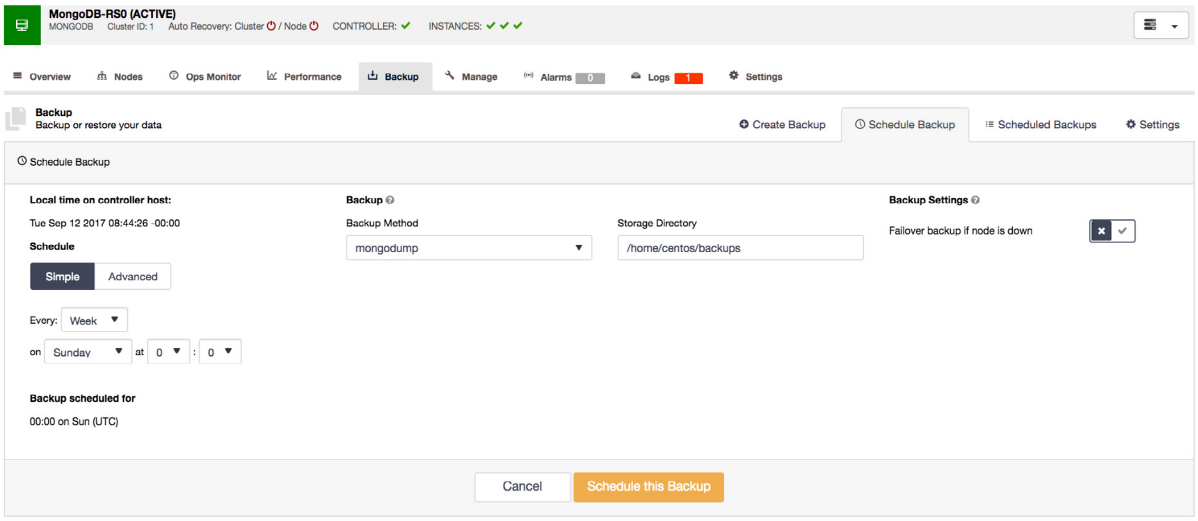
DB Instance	Status	Advice	Justification
ec2-52-59-245-154.eu-central-1.compute.amazonaws.com:27017	✓ Ok	Mountpoint '/' (rootfs) : has sufficient disk space.	Mountpoint '/' (rootfs) : Current: 12% disk space is used. Prediction in 2 days: 13% of disk space will be used.
ec2-54-93-114-142.eu-central-1.compute.amazonaws.com:27017	✓ Ok	Mountpoint '/' (rootfs) : has sufficient disk space.	Mountpoint '/' (rootfs) : Current: 12% disk space is used. Prediction in 2 days: 13% of disk space will be used.
ec2-54-93-40-62.eu-central-1.compute.amazonaws.com:27017	✓ Ok	Mountpoint '/' (rootfs) : has sufficient disk space.	Mountpoint '/' (rootfs) : Current: 12% disk space is used. Prediction in 2 days: 12% of disk space will be used.
172.31.7.163:9500	✓ Ok	Mountpoint '/' (rootfs) : has sufficient disk space.	Mountpoint '/' (rootfs) : Current: 10% disk space is used. Prediction in 2 days: 10% of disk space will be used.

NUMA Check `Every hour, on the hour` Ok: 4 Warning: 0 Critical: 0 Last execution: 35 minutes ago

s9s/host/numa_check.js

Figure 12: Advisors

A key feature, found under *Performance*, is ClusterControl's *Advisors*. These are individual monitors that track key aspects of your clusters, warning you of potentially performance impacting conditions. While a detailed selection of Advisors is provided, covering everything from host metrics to detailed database server-specific features, there is also the option to add your own Advisors.



Local time on controller host: Tue Sep 12 2017 08:44:26 -00:00

Schedule: [✓ Simple] Advanced

Every: Week

on Sunday at 0 : 0

Backup scheduled for: 00:00 on Sun (UTC)

Backup

Backup Method: mongodump

Storage Directory: /home/centos/backups

Backup Settings

Failover backup if node is down: ✗

Figure 13: Scheduling Backups

The last feature we will cover here is Backups. ClusterControl provides a backup feature that allows a full cluster consistent backup, or simply a standard *mongodump* backup if you prefer. It also provides the facility to create scheduled backups to run periodically to a schedule of your choosing. Backup retention is also handled, with the option to retain backups for a limited period, avoiding storage issues.

In Conclusion

Over the course of this paper, we have covered the details of AWS infrastructure deployment, considerations for deploying your database server(s) in the cloud, and finished with an overview of how to automate the deployment and management of a MongoDB cluster using ClusterControl from Severalnines.

You are now equipped to deploy your database clusters in a redundant, scalable, cloud infrastructure, and manage them with ClusterControl.

About ClusterControl

ClusterControl is the all-inclusive open source database management system for users with mixed environments that removes the need for multiple management tools. ClusterControl provides advanced deployment, management, monitoring, and scaling functionality to get your MySQL, MongoDB, and PostgreSQL databases up-and- running using proven methodologies that you can depend on to work. At the core of ClusterControl is it's automation functionality that let's you automate many of the database tasks you have to perform regularly like deploying new databases, adding and scaling new nodes, running backups and upgrades, and more. Severalnines provides automation and management software for database clusters. We help companies deploy their databases in any environment, and manage all operational aspects to achieve high-scale availability.

About Severalnines

Severalnines provides automation and management software for database clusters. We help companies deploy their databases in any environment, and manage all operational aspects to achieve high-scale availability.

Severalnines' products are used by developers and administrators of all skills levels to provide the full 'deploy, manage, monitor, scale' database cycle, thus freeing them from the complexity and learning curves that are typically associated with highly available database clusters. Severalnines is often called the "anti-startup" as it is entirely self-funded by its founders. The company has enabled over 12,000 deployments to date via its popular product ClusterControl. Currently counting BT, Orange, Cisco, CNRS, Technicolor, AVG, Ping Identity and Paytrail as customers. Severalnines is a private company headquartered in Stockholm, Sweden with o ces in Singapore, Japan and the United States. To see who is using Severalnines today visit:

https://www.severalnines.com/company

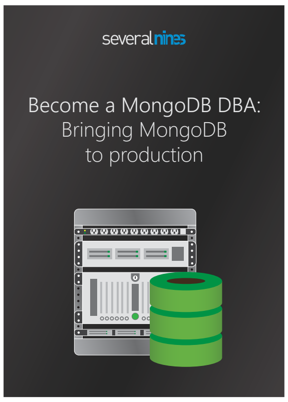
Deploy Manage Monitor Scale

Related Resources from Severalnines

ClusterControl in the Cloud - All Our Resources

You can deploy ClusterControl on premise or in the cloud. This blog describes some of the benefits of the cloud and provides some resources to help you get your databases up and running with ClusterControl.

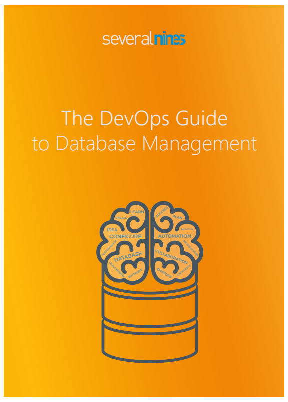
Read the blog



Bringing MongoDB to Production

Learn from our MongoDB experts what it takes to ensure your MongoDB stacks are production-ready. This whitepaper includes tips and tricks that we have collected from our best resources to help you deploy, monitor, manage and scale MongoDB in your environment.

Download whitepaper



The DevOps Guide to Database Management

Relational databases are not very flexible by nature, while DevOps is all about flexibility. This creates many challenges that need to be overcome. This white paper discusses three core challenges faced by DevOps when it comes to managing databases. It also discusses how Severalnines ClusterControl can be used to address these challenges.

Download whitepaper

severalnines

Deploy

Manage

Monitor

Scale