Windows PowerShell Desired State Configuration (DSC) on the AWS Cloud: Quick Start Reference Deployment

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Table of Contents

What We'll Cover

This Quick Start Reference Deployment includes architectural considerations and configurations used to build a highly available Windows PowerShell Desired State Configuration (PowerShell DSC) "pull server" environment on the Amazon Web Services (AWS) cloud. We discuss how to use the necessary AWS services, such as Amazon Elastic Compute Cloud (Amazon EC2), Amazon Elastic Load Balancing (Amazon ELB) and Amazon Virtual Private Cloud (Amazon VPC) together with PowerShell DSC to deploy a highly available enterprise application across separate AWS Availability Zones.

The intent with this guide is to give you a point of reference for implementing your own configuration management solution using the PowerShell DSC platform, and to provide and understanding of the following key topics:

- How to use AWS CloudFormation and PowerShell DSC to bootstrap your servers and applications from scratch
- How to deploy a highly available PowerShell DSC pull server environment using AWS resources
- How to make sure that your instances are resilient to configuration drift once your application stack has been deployed

This guide explores the deployment and management of an internal enterprise web application infrastructure running on the AWS cloud. You can use the patterns in this guide to deploy your own application stack in a similar fashion. You can also deploy automatically the environment outlined in this guide in order to test a fully configured PowerShell DSC pull server infrastructure.

To launch the PowerShell DSC Pull Server infrastructure AWS CloudFormation template into the US West (Oregon) region, **launch the Quick Start**. This stack takes approximately one hour to create.

Note
You are responsible for all the cost related to your use of any AWS services used while running this Quick Start Reference Deployment. The cost for creating and running the template with default settings is approximately $3.50 an hour. See the pricing pages of the AWS services you will be using for full details.

After deploying this Quick Start with the default input parameters, you will have built the following PowerShell DSC pull server environment on the AWS cloud:

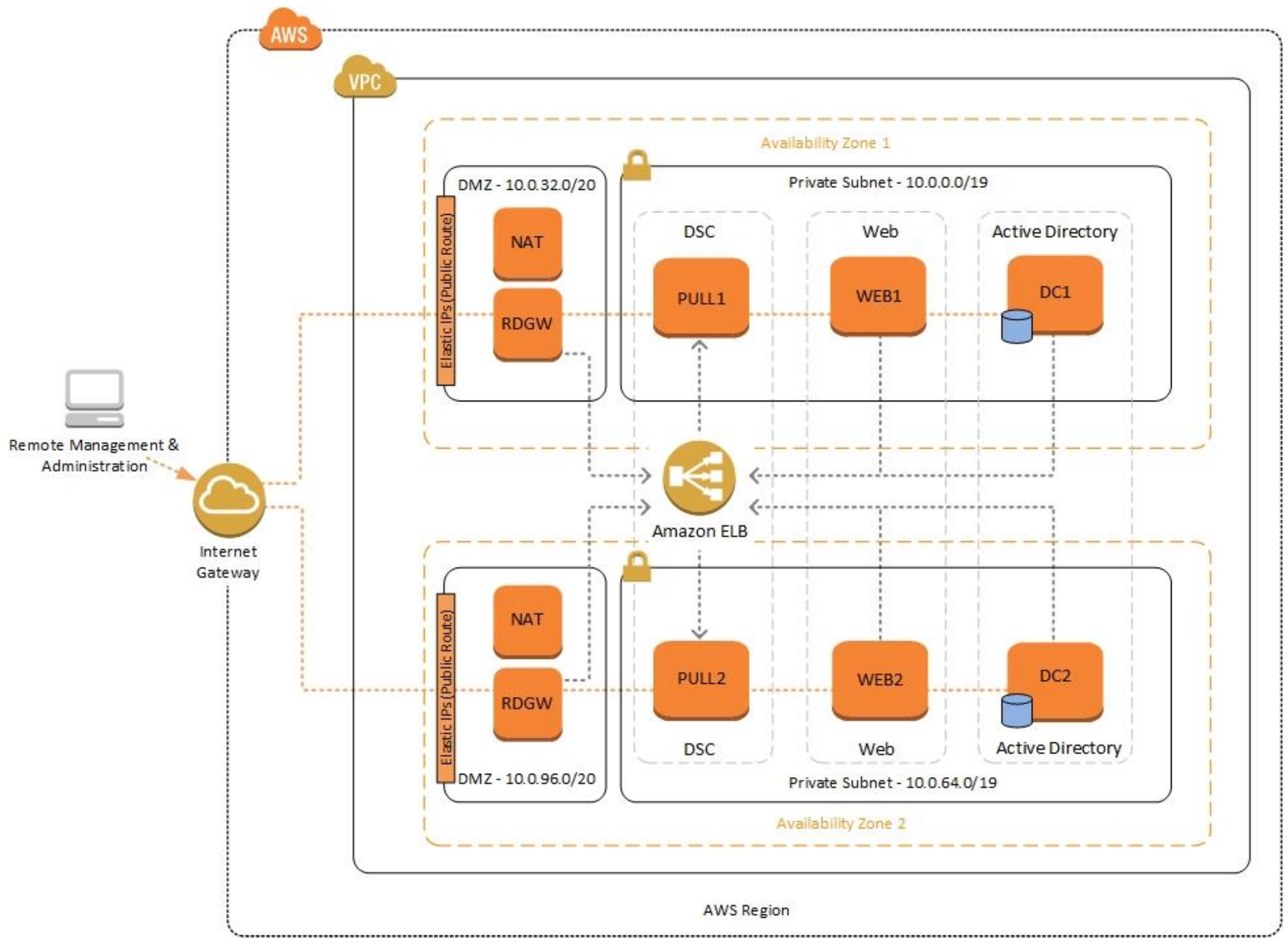


Figure 1: Highly Available PowerShell DSC Pull Server Infrastructure on AWS

Architecture Overview

The core AWS components used by this reference include the following AWS services:

- **Amazon VPC** – the Amazon Virtual Private Cloud service lets you provision a private, isolated section of the AWS cloud where you can launch AWS services and other resources in a virtual network that you define. You have complete control over your virtual networking environment, including selection of your own IP address range, creation of subnets, and configuration of route tables and network gateways.

- **Amazon EC2** – the Amazon Elastic Compute Cloud service allows you to launch virtual machine instances with a variety of operating systems. You can choose from existing Amazon Machine Images (AMIs) or import your own virtual machine images.

- **Amazon ELB** – the Amazon Elastic Load Balancing service automatically distributes incoming traffic across multiple Amazon EC2 instances. It enables you to achieve greater levels of fault tolerance in your applications.

- **Amazon S3** – the Amazon Simple Storage Service provides highly durable and available cloud storage for a variety of content, ranging from web applications to media files. It allows you to offload your entire storage infrastructure onto the cloud.

When deploying a Windows-based environment on the AWS cloud, we recommend an architecture that supports the following requirements:

- Critical workloads should be placed in a minimum of two Availability Zones to provide high availability.

- Internal application servers and other non-Internet facing servers should be placed in private subnets to prevent direct access to these instances from the Internet.

- Remote Desktop Gateways should be deployed into public subnets in each Availability Zone for remote administration. Other components, such as reverse proxy servers, can also be placed into these public subnets if needed.

A Very Brief Overview of Windows PowerShell DSC

If you are new to PowerShell DSC, we highly recommend that you consult the additional resources at the end of this guide for a deeper look at the topic. For now, we'll quickly cover what PowerShell DSC is and how it works.

PowerShell DSC was introduced in Windows Management Framework 4.0. It provides a configuration management platform native to Windows Server 2012 R2 and Windows 8.1, and available to Windows Server 2008 R2, Windows 7, and Linux. PowerShell DSC allows you to express the desired state of your systems using declarative language syntax instead of configuring servers with complex imperative scripts. If you've worked with configuration management tools like Chef or Puppet, you'll notice that PowerShell DSC provides a familiar framework.

When using DSC to apply a desired configuration for a system, you create a configuration script with PowerShell that explains what the system should look like. You then generate a Management Object Format (MOF) file using that configuration script, which is then pushed or pulled by a "node" to apply the desired state. PowerShell DSC uses vendor-neutral MOF files to enable cross-platform management, and "nodes" refer to either Windows or Linux systems.

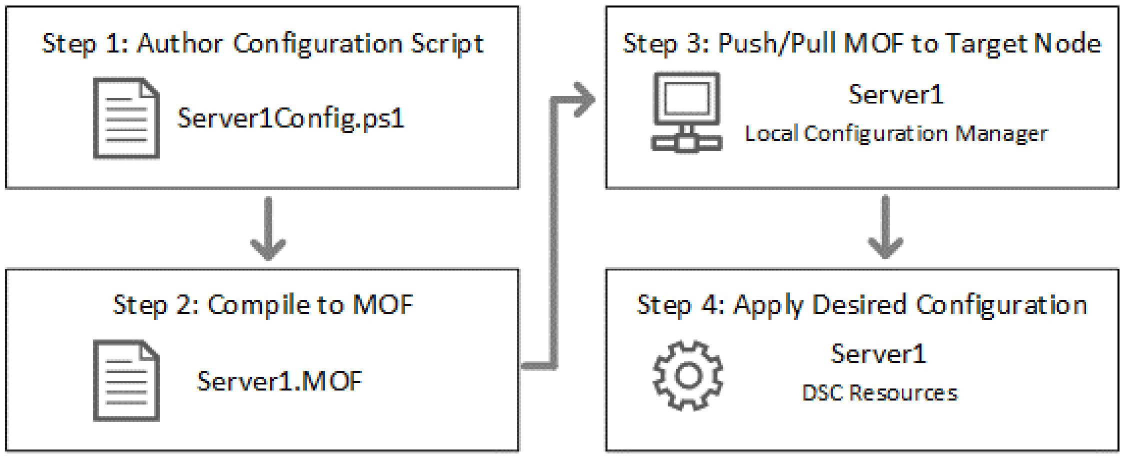
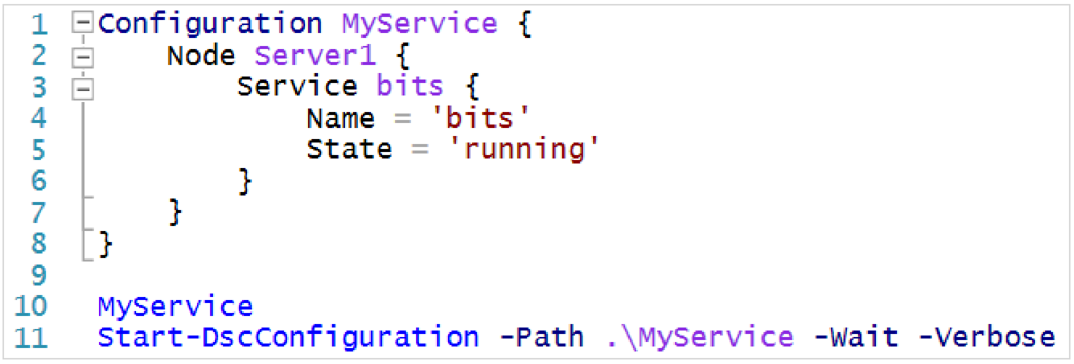

Step 1: Author Configuration Script
Server1Config.ps1
Step 2: Compile to MOF
Server1.MOF
Step 3: Push/Pull MOF to Target Node
Server1
Local Configuration Manager
Step 4: Apply Desired Configuration
Server1
DSC Resources

Figure 2: High Level DSC Architecture

Windows systems running Windows Management Framework 4.0 or later include an engine called the Local Configuration Manager, which acts as a DSC client. The Local Configuration Manager calls the DSC resources required by the configuration defined in the MOF files. These DSC resources perform the work of applying the desired configuration.



```
1   Configuration MyService {
2       Node Server1 {
3           Service bits {
4               Name = 'bits'
5               State = 'running'
6           }
7       }
8   }
9
10  MyService
11  Start-DscConfiguration -Path .\MyService -Wait -Verbose
```

Figure 3: Basic DSC Configuration Script

Figure 3 shows an example of a very simple DSC configuration script that can be used to push a desired configuration to a computer.

- **Line 1** – We use the Configuration keyword to define a name (MyService) for the configuration.
- **Line 2** – The node keyword is used to define the desired state for a server named “Server1.”
- **Lines 3 through 6** – We’re creating an instance of the Service resource called “bits.” As you can see, within the resource, we’re declaring that the service actually named “bits” should be in a running state.
- **Line 10** – The configuration is executed, which generates a MOF file called Server1.mof in a folder called MyService.
- **Line 11** – The Start-DscConfiguration cmdlet is used to push the MOF file in the MyService folder to the computer Server1. When doing this interactively, it’s useful to use the -Wait and -Verbose parameters to get detailed information

As we will see later in this guide, the configuration scripts used to deploy the reference architecture will include several resources for each server in the topology. Some of those will be native to the operating system, some of them will be additional resources provided by Microsoft, and others will be custom written resources to fill in the gaps.

Note
Keep in mind that this guide is not a complete tutorial on DSC. It’s simply a reference architecture for how systems can be deployed and configured in tandem with DSC and AWS CloudFormation. For a complete understanding of the mechanics of DSC pull servers and writing custom DSC resources, we highly recommend consulting the supplemental reading at the end of this guide.

How We'll Use Windows PowerShell DSC on AWS

PowerShell DSC clients can pull their configurations from a server or have their configurations pushed to them either locally or from a remote system. In this guide, we've provided two AWS CloudFormation templates that deploy the reference environment using both the pull and push models. In this section, we'll discuss the differences between these two methods and how they will be used to deploy our stack on AWS.

DSC in Pull Mode

To deploy our reference architecture using DSC in pull mode, we'll use AWS CloudFormation to create the Amazon VPC and required network elements. Then we'll launch servers to act as DSC pull servers. On these servers we'll install a web service which will allow the Local Configuration Manager on client nodes to pull their configuration via HTTPS. To do this, we'll use a master configuration script to generate MOF files for each node in our deployment. As each server is bootstrapped by AWS CloudFormation, we'll configure the Local Configuration Manager to retrieve its configuration from the pull server and the desired state will be applied.

Once the stack is built successfully, we'll have a distributed enterprise application deployment that maintains its desired state and is resistant to configuration drift.

DSC in Push Mode

Our second example will deploy the same reference architecture in DSC push mode. In this scenario, there will be no requirement for DSC pull servers, and each server in the environment will "push" a configuration document to itself.

Again, we'll utilize AWS CloudFormation to orchestrate the build process. After creating the Amazon VPC and required network elements, each server instance will be launched and bootstrapped. Since there will be no pull servers in this scenario, each instance will download its own configuration script, generate the MOF document, and apply the desired state using the Start-DSCConfiguration cmdlet.

Things That Won't be Handled by DSC

Most Windows-specific tasks will be handled by PowerShell DSC. However, there are a few things that we'll do using helper scripts called from AWS CloudFormation cfn-init in order to start the bootstrapping process.

- **Renaming the Computer** – We'll simply use the Rename-Computer cmdlet before invoking a DSC push or pull operation. This allows us to use each server's hostname when using the "node" keyword in the DSC configuration scripts.

- **Installing Certificates** – For the sake of demonstration, we'll utilize self-signed certificates to secure the DSC pull server's HTTPS endpoint and to encrypt credentials when using DSC resources that require authentication. Self-signed certificates will be installed on each instance in the environment to support these scenarios. For production environments, we recommend utilizing an internal PKI or commercial SSL certificate provider.

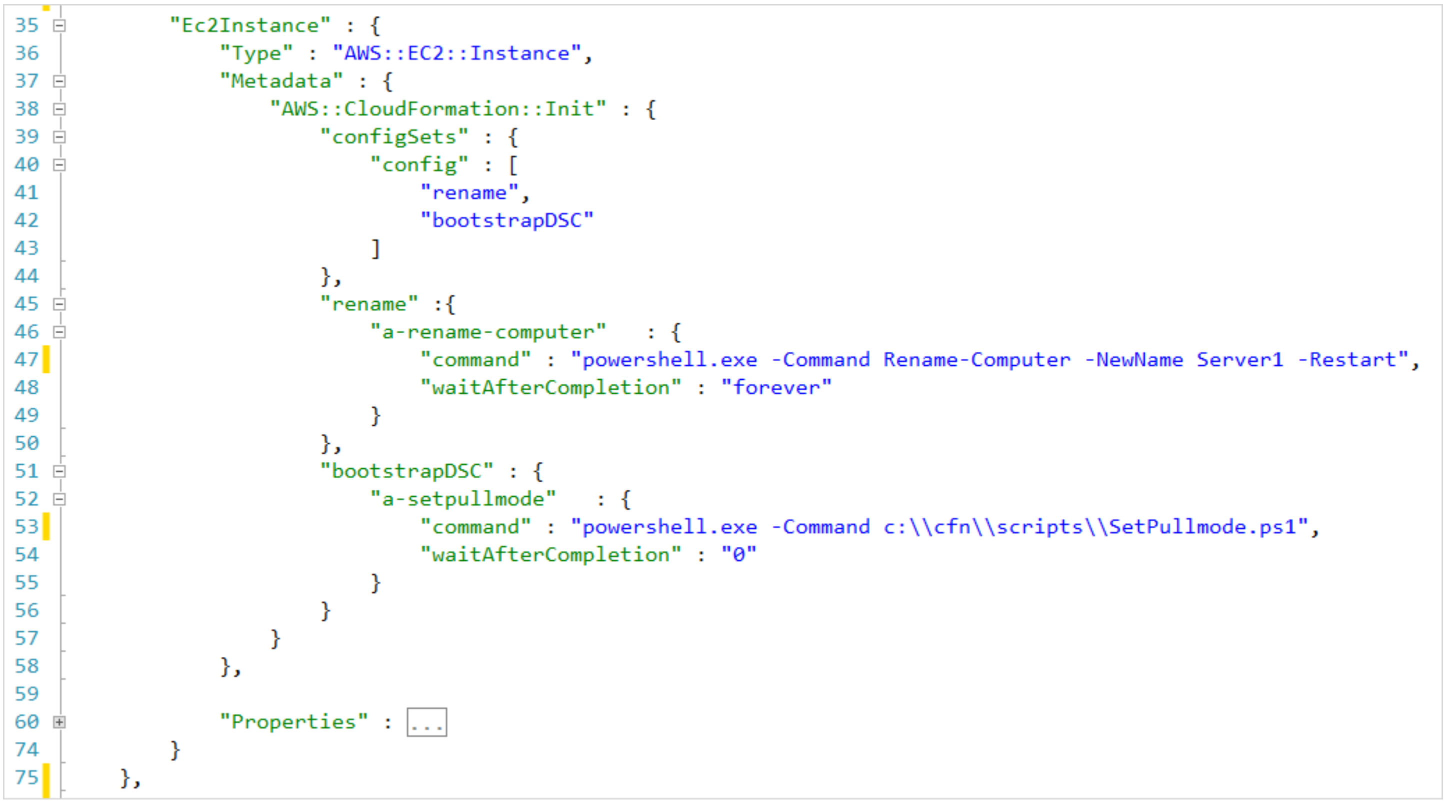
- **Downloading Configurations and Modules** – Configuration scripts and DSC resource modules will be downloaded from a public Amazon S3 bucket. The MOF files will be generated on the fly during the bootstrapping process. This does not apply to servers configured in pull mode, which will obtain their configurations and any required modules from the pull server.

Bootstrapping with AWS CloudFormation

AWS CloudFormation allows you to define a set of resources needed to run an application in the form of a declarative JSON (JavaScript Object Notation) template. The resources within the template can include Amazon EC2 instances, Elastic Load Balancers, and more. AWS CloudFormation takes care of provisioning all of your AWS resources, and there are a number of techniques that can be used to bootstrap applications running on your Amazon EC2 instances. The instances in this Quick Start Reference Deployment are partially bootstrapped using the AWS CloudFormation helper process called cfn-init, which allows us to download scripts and define initialization commands. Once the instance is up and running, we'll rely on PowerShell DSC for the Windows and application-specific configuration.

AWS CloudFormation Metadata and cfn-init

You can attach metadata to any resource in your AWS CloudFormation template. The cfn-init helper script retrieves and interprets the resource metadata to create and download files, start services, and define commands that should be executed on the instance. Figure 4 shows a simple example of the techniques used in this Quick Start Reference Deployment to bootstrap instances using AWS CloudFormation.



```
        "Ec2Instance" : {
            "Type" : "AWS::EC2::Instance",
            "Metadata" : {
                "AWS::CloudFormation::Init" : {
                    "configSets" : {
                        "config" : [
                            "rename",
                            "bootstrapDSC"
                        ]
                    },
                    "rename" :{
                        "a-rename-computer"   : {
                            "command" : "powershell.exe -Command Rename-Computer -NewName Server1 -Restart",
                            "waitAfterCompletion" : "forever"
                        }
                    },
                    "bootstrapDSC" : {
                        "a-setpullmode"   : {
                            "command" : "powershell.exe -Command c:\\cfn\\scripts\\SetPullmode.ps1",
                            "waitAfterCompletion" : "0"
                        }
                    }
                }
            },

            "Properties" : ...
        }
    },
```

Figure 4: Simplified Example of Bootstrapping a DSC Client Instance using AWS CloudFormation

When cfn-init runs on the instance, it looks for resource metadata rooted in the AWS::CloudFormation::Init metadata key. The metadata is organized into config keys, which you can optionally group into configsets. Using configsets allows you to organize a sequence of commands into individual groups, and cfn-init will process each configset in order. Please note the following aspects of this process as depicted in Figure 4:

- **Lines 41 and 42** – Two configsets are defined: one that will rename and reboot the computer, and another to bootstrap the DSC client upon rebooting.
- **Line 47** – The single PowerShell command in the "rename" configset which renames and reboots the computer. Keep in mind that we can have numerous sections within each configset. Each can create its own set of files, start services, or run commands.
- **Line 48 –** The waitAfterCompletion key specifies how long to wait (in seconds) after a command has finished in case the command causes a reboot. The default value is 60 seconds and a value of "forever" directs cfn-init to exit and resume only after the reboot is complete.
- **Line 53** – The SetPullMode.ps1 script runs after the reboot to bootstrap the PowerShell DSC client.

Bootstrapping applications with AWS CloudFormation is a broad topic, and there are several other techniques that can be useful depending on your requirements. We recommend that you review Bootstrapping Applications via AWS CloudFormation for more details.

Deployment with a Pull Server Infrastructure

In this section, we will cover the process of using a single PowerShell DSC configuration script along with an AWS CloudFormation template to deploy our sample architecture.

DSC Configuration Script Overview

Our pull server infrastructure uses a single DSC configuration script that applies to all of the servers in the deployment. The configuration script ensures the systems implement the following changes:

- Create the Active Directory Forest and Domain and build a Domain Controller in the first Availability Zone
- Configure the Active Directory Site Topology
- Join each node to the domain
- Promote another server to a Domain Controller in the second Availability Zone
- Install Remote Desktop Gateway Services on the Remote Desktop Gateways in public subnets
- Deploy IIS and our sample web page on servers in each Availability Zone

Many of these tasks involved in creating this infrastructure use DSC resources that are not native to the operating system. Microsoft has made a number of additional and experimental DSC resources available for download in "DSC Resource Kit Waves." We've used several of these to configure the state of the systems in this architecture. Additionally, we've created custom DSC resources in order to configure certain aspects of the environment that are not currently supported by Microsoft's provided DSC resources.

To help ensure that these DSC resources will always be available, we've saved copies of them in an Amazon S3 bucket. This prevents our automated deployment template from being broken if the links suddenly change on the Internet. It also provides the ability to roll back to prior versions of code since the Amazon S3 bucket has versioning enabled.

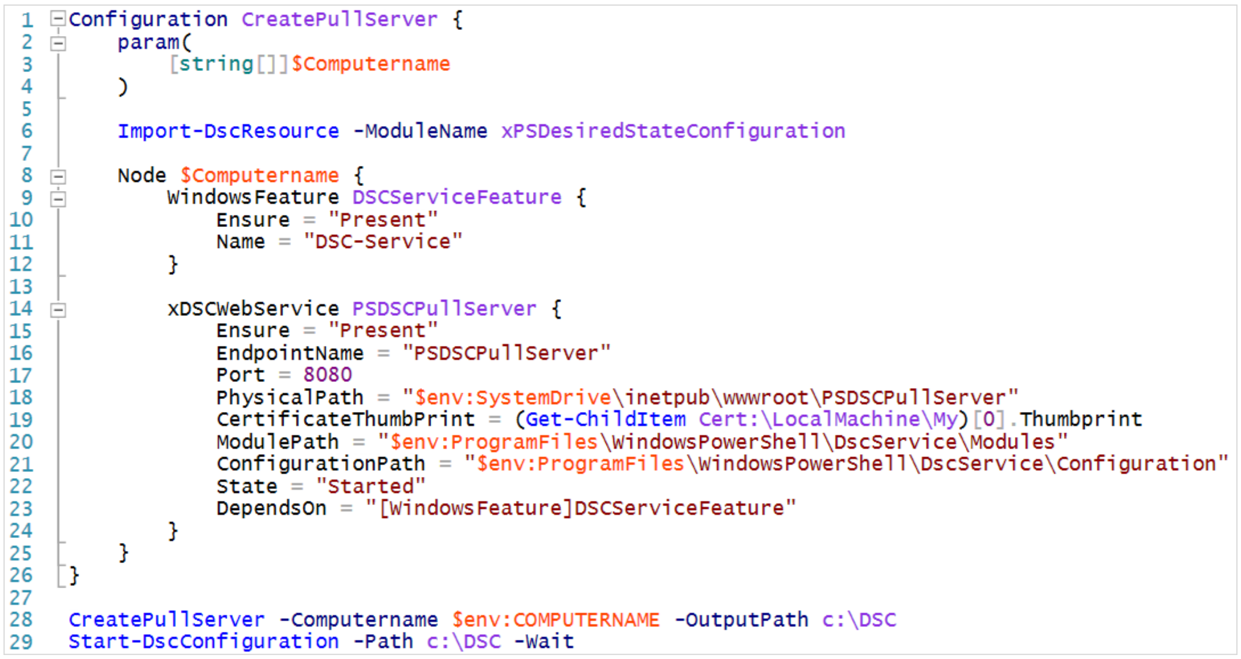
Bootstrapping the PowerShell DSC Pull Server

The bootstrapping sequence for the pull server lays the foundation for building the rest of the environment. As depicted in Figure 1, each client node accesses load balanced pull servers though Elastic Load Balancing. The bootstrapping process for the pull server includes the following:

- **IAM Role** – The pull server launches with an IAM role, allowing the instance to call the DescribeLoadBalancers and DescribeInstances actions. This process allows the pull server to determine the DNS name for the Elastic Load Balancer and to query tags set on each Amazon EC2 instance in the stack.
- **Setup** – Downloads all of the required components, such as the pull server configuration script, the master configuration script, the DSC resource modules, and other helper scripts. These file downloads are completed by the AWS CloudFormation files resource.
- **Self-Signed Certificate** – The pull server creates a self-signed certificate using a helper script. The DNS name of the internal Elastic Load Balancer is obtained from the Get-ELBLoadBalancer cmdlet. The DNS name is used as the common name on the self-signed certificate. This allows client nodes to pull their configurations through the load balanced endpoint using secure HTTPS connections.
- **Bootstrapping the DSC Web Service** – The pull server runs the CreatePullServer.ps1 configuration script, which outputs a MOF file for the pull server. The settings are then applied locally to create the DSC web service listening on TCP port 8080, which is configured to use the self-signed certificate thumbprint created previously to secure the web service.
- **Generating Configurations** – The pull server executes the master configuration script, which produces a MOF file for each server in the environment. Each file must be renamed to the associated nodes ConfigurationID, which is represented as a globally unique identifier (GUID). Each instance is tagged in Amazon EC2 with a GUID using the AWS CloudFormation template. The pull server is able to obtain these ConfigurationIDs, match them with each node in the topology, and rename and checksum the file.

Pull Server Configuration Script

Figure 5 shows the code for CreatePullServer.ps1, which is the configuration script used to create the pull server.



```
 1  Configuration CreatePullServer {
 2      param(
 3          [string[]]$Computername
 4      )
 5
 6      Import-DscResource -ModuleName xPSDesiredStateConfiguration
 7
 8      Node $Computername {
 9          WindowsFeature DSCServiceFeature {
10              Ensure = "Present"
11              Name = "DSC-Service"
12          }
13
14          xDSCWebService PSDSCPullServer {
15              Ensure = "Present"
16              EndpointName = "PSDSCPullServer"
17              Port = 8080
18              PhysicalPath = "$env:SystemDrive\inetpub\wwwroot\PSDSCPullServer"
19              CertificateThumbPrint = (Get-ChildItem Cert:\LocalMachine\My)[0].Thumbprint
20              ModulePath = "$env:ProgramFiles\WindowsPowerShell\DscService\Modules"
21              ConfigurationPath = "$env:ProgramFiles\WindowsPowerShell\DscService\Configuration"
22              State = "Started"
23              DependsOn = "[WindowsFeature]DSCServiceFeature"
24          }
25      }
26  }
27
28  CreatePullServer -Computername $env:COMPUTERNAME -OutputPath c:\DSC
29  Start-DscConfiguration -Path c:\DSC -Wait
```

Figure 5: Pull Server Configuration Script

The CreatePullServer.ps1 configuration script depends on the xPSDesiredConfiguration resource module. This is a non-native module that can be obtained from Microsoft. The AWS CloudFormation template is configured to download this module from Amazon S3 as a .zip file, which it then unpacks into *$env:ProgramFiles\WindowsPowerShell\DscService\Modules* on the pull server.

A few points of interest about this configuration script:

- **Line 9** – We declare the DSCServiceFeature, ensuring that the DSC-Service WindowsFeature is present and installed on the server.
- **Line 19** – Notice that the value of the certificate thumbprint is retrieved from the machine's local certificate store. This is because we previously generated and installed the self-signed certificate during the bootstrapping process.
- **Line 23** – The PSDSCPullServer resource uses the DependsOn attribute to ensure that the DSC-Service is first installed before attempting to configure the DSC Web Service.
- **Line 29** – The call to Start-DscConfiguration tells us that this is a DSC "push" operation. The pull server is pushing this configuration to itself. Other nodes in the environment will be configured in pull mode.

The CreatePullServer.ps1 script is called on the pull server using AWS CloudFormation.

```
"bootstrapPullSvc" : {
    "commands" : {
        "a-create-pullserver" : {
            "command" : "powershell.exe -Command c:\\cfn\\scripts\\CreatePullServer.ps1",
            "waitAfterCompletion" : "0"
        },
```

Figure 6: Running the CreatePullServer.ps1 Configuration Script on Pull1 using AWS CloudFormation

Remember, there are two pull servers in this environment to provide high availability. Each pull server instance is bootstrapped using the steps outlined here.

After you've deployed your environment, you'll need to make sure that downloadable content (MOF files, resource modules, and checksums) are kept up to date on both pull servers. This can be done as a procedure of your deployment process or by using a file synchronization service to keep the modules and configuration directories on pull servers in sync.

Bootstrapping Client Instances

The bootstrapping process for the each client instance includes the following:

- **IAM Role** – Each server launches with an IAM role, allowing the instance to call the DescribeLoadBalancers and DescribeInstances actions. This process allows the server to determine the DNS name for the Elastic Load Balancer and to query tags set on each Amazon EC2 instance in the stack.

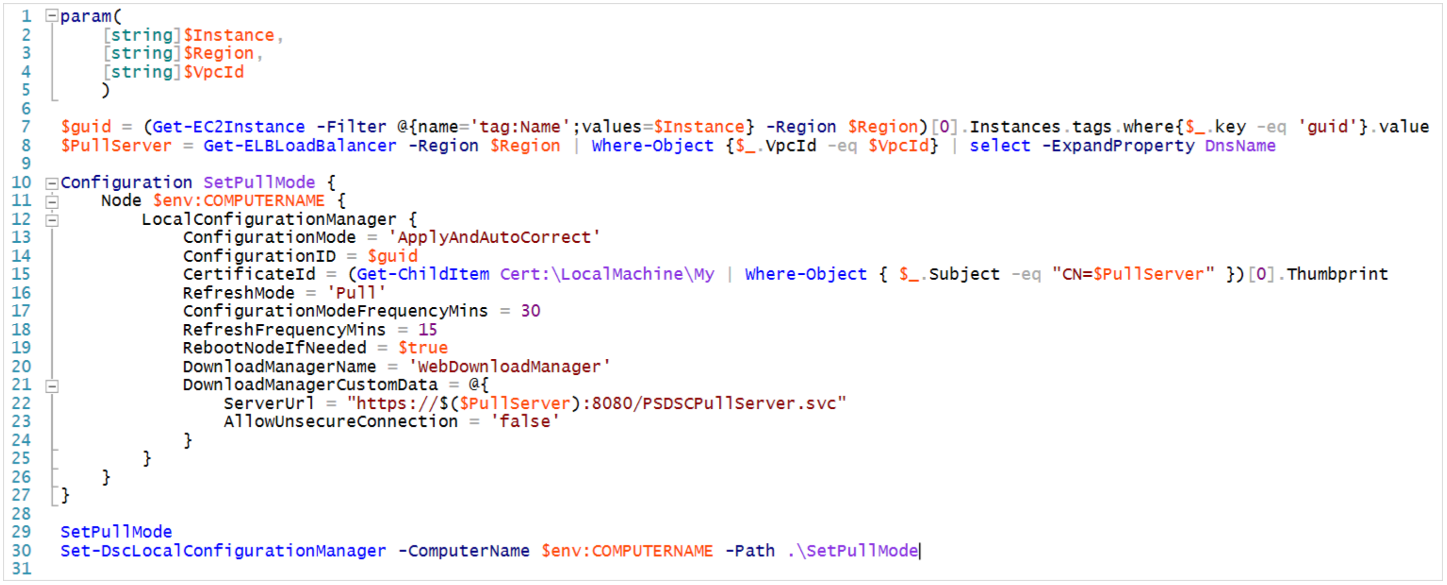
- **Setup** -- Downloads helper scripts from Amazon S3. These file downloads are completed by the AWS CloudFormation files resource.

- **Certificates** – In addition to connecting to the correct DNS name, clients must also trust the certificate installed on the pull server. The self-signed certificate is downloaded from the pull server and installed locally. Keep in mind this is for demonstration purposes, and an enterprise PKI solution is likely the best method for doing this in production.

- **Configuring the LCM** – The Local Configuration Manager is then configured with the HTTPS endpoint that should be used as the pull server. In this case, the endpoint will be the Elastic Load Balancer. Additionally, the ConfigurationID for the node is set. Again, each Amazon EC2 instance is tagged with a unique ConfigurationID, which can also be obtained from Amazon EC2.

Client Bootstrap Configuration Script

Figure 7 shows the code for SetPullMode.ps1, which is the configuration script used to configure the client.



```
1  param(
2      [string]$Instance,
3      [string]$Region,
4      [string]$VpcId
5      )
6
7  $guid = (Get-EC2Instance -Filter @{name='tag:Name';values=$Instance} -Region $Region)[0].Instances.tags.where{$_.key -eq 'guid'}.value
8  $PullServer = Get-ELBLoadBalancer -Region $Region | Where-Object {$_.VpcId -eq $VpcId} | select -ExpandProperty DnsName
9
10 Configuration SetPullMode {
11     Node $env:COMPUTERNAME {
12         LocalConfigurationManager {
13             ConfigurationMode = 'ApplyAndAutoCorrect'
14             ConfigurationID = $guid
15             CertificateId = (Get-ChildItem Cert:\LocalMachine\My | Where-Object { $_.Subject -eq "CN=$PullServer" })[0].Thumbprint
16             RefreshMode = 'Pull'
17             ConfigurationModeFrequencyMins = 30
18             RefreshFrequencyMins = 15
19             RebootNodeIfNeeded = $true
20             DownloadManagerName = 'WebDownloadManager'
21             DownloadManagerCustomData = @{
22                 ServerUrl = "https://$($PullServer):8080/PSDSCPullServer.svc"
23                 AllowUnsecureConnection = 'false'
24             }
25         }
26     }
27 }
28
29 SetPullMode
30 Set-DscLocalConfigurationManager -ComputerName $env:COMPUTERNAME -Path .\SetPullMode
31
```

Figure 7: DSC Client Configuration Script

A few points of interest about this configuration script:

- **Line 7** – The GUID assigned to the instance is retrieved from the Amazon EC2 "guid" tag and stored in a variable.
- **Line 8** – We store the DNS name of the Elastic Load Balancer in a variable called $PullServer.
- **Line 13** – The Local Configuration Manager ConfigurationMode is set to ApplyAndAutoCorrect. This setting helps ensure that modifications and configuration drift issues are corrected and that the system remains in the desired state.
- **Line 14** – The ConfigurationID for the client node is set using the value of the "guid" tag on the Amazon EC2 instance.
- **Line 15** – The CertificateID is set to the thumbprint of the self-signed certificate that was obtained from the pull server. In addition to using the self-signed certificate on the pull server to secure HTTPs connections, it's also used for encryption. Defining CertificateID allows the client node to decrypt credentials in the MOF documents.
- **Line 22** – the ServerUrl is configured to use the $PullServer variable, which is set to the DNS name of the Elastic Load Balancer.

The SetPullMode.ps1 script is called on each instance from AWS CloudFormation. The Instance and Region parameter values are passed in at runtime.

```
"c-set-dsc-pull-mode" : {
    "command" : {
        "Fn::Join" : [
            "",
            [
                "powershell.exe -Command c:\\cfn\\scripts\\SetPullMode.ps1 -Instance DC1",
                " -Region ",
                {
                    "Ref" : "AWS::Region"
                }
            ]
        ]
    },
    "waitAfterCompletion" : "0"
}
```

Figure 8: Running the SetPullMode.ps1 Configuration Script using AWSCloudFormation

After the pull mode has been set on the instance, a pull operation is invoked manually. This is done by calling the Update-DscConfiguration cmdlet that was released with the November 2014 update rollup for Windows Server 2012 R2 (KB3000850).

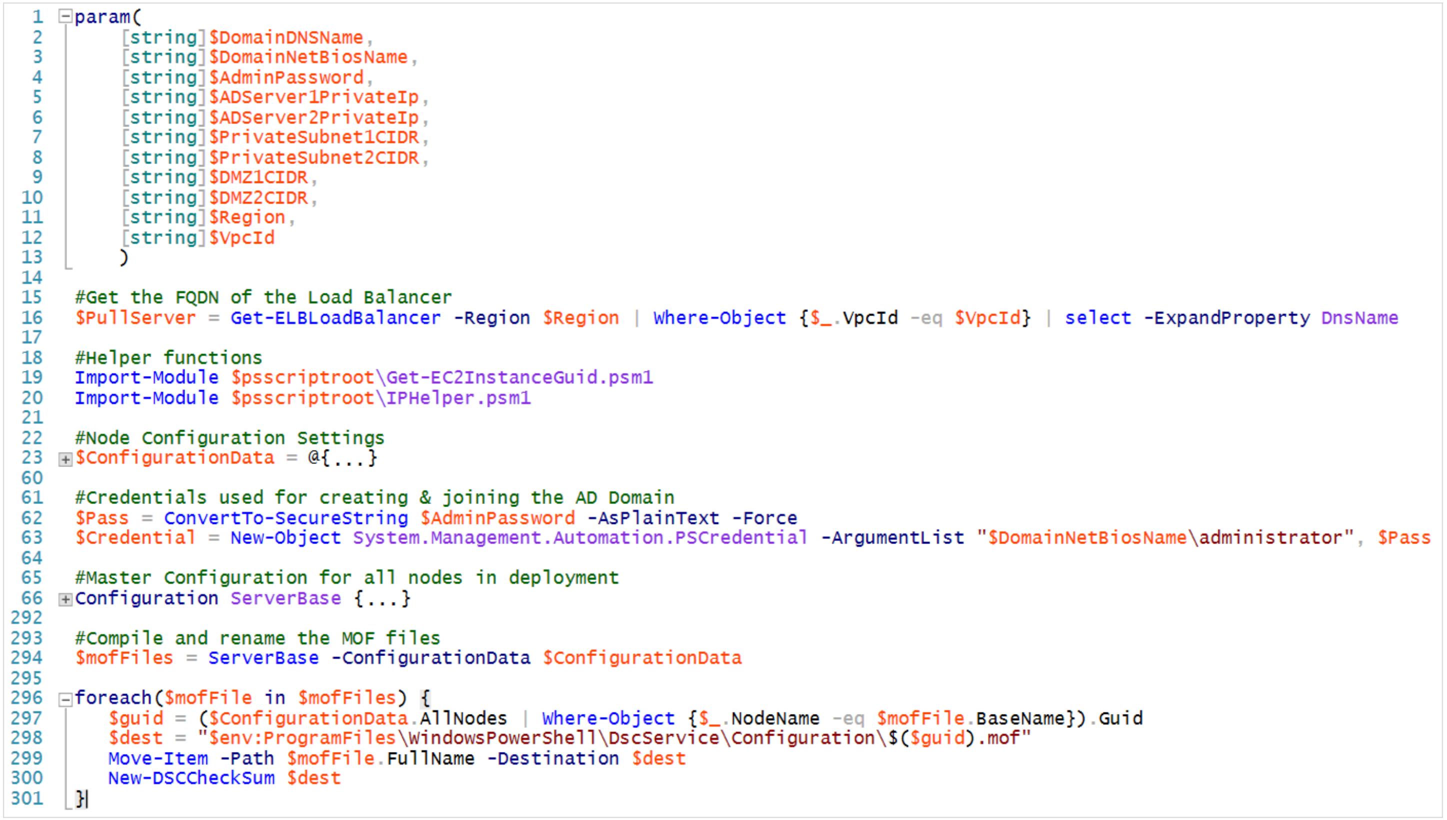
To view the Local Configuration Manager settings (meta-configuration) for a node, you can use the Get-DscLocalConfigurationManager cmdlet.

The Configuration Script

Now that we understand how the pull servers and client instances are bootstrapped, let's take a closer look at the configuration script that is responsible for defining the state of each server in the environment.

It's important to keep in mind that in this Quick Start Reference Deployment, the pull server is used as a "build server" meaning that it downloads and runs the configuration script, generating MOFs for all the servers in the environment. This means that any additional resources need to be downloaded and extracted into *$env:ProgramFiles\WindowsPowerShell\Modules* on the pull server during the bootstrapping process.

Let's take a look at the structure of the configuration script pictured in the following figure. Several code blocks are collapsed and will be covered in greater detail in the following sections of this guide.



```
  1  param(
  2       [string]$DomainDNSName,
  3       [string]$DomainNetBiosName,
  4       [string]$AdminPassword,
  5       [string]$ADServer1PrivateIp,
  6       [string]$ADServer2PrivateIp,
  7       [string]$PrivateSubnet1CIDR,
  8       [string]$PrivateSubnet2CIDR,
  9       [string]$DMZ1CIDR,
 10       [string]$DMZ2CIDR,
 11       [string]$Region,
 12       [string]$VpcId
 13      )
 14
 15  #Get the FQDN of the Load Balancer
 16  $PullServer = Get-ELBLoadBalancer -Region $Region | Where-Object {$_.VpcId -eq $VpcId} | select -ExpandProperty DnsName
 17
 18  #Helper functions
 19  Import-Module $psscriptroot\Get-EC2InstanceGuid.psm1
 20  Import-Module $psscriptroot\IPHelper.psm1
 21
 22  #Node Configuration Settings
 23  $ConfigurationData = @{...}
 60
 61  #Credentials used for creating & joining the AD Domain
 62  $Pass = ConvertTo-SecureString $AdminPassword -AsPlainText -Force
 63  $Credential = New-Object System.Management.Automation.PSCredential -ArgumentList "$DomainNetBiosName\administrator", $Pass
 64
 65  #Master Configuration for all nodes in deployment
 66  Configuration ServerBase {...}
292
293  #Compile and rename the MOF files
294  $mofFiles = ServerBase -ConfigurationData $ConfigurationData
295
296  foreach($mofFile in $mofFiles) {
297      $guid = ($ConfigurationData.AllNodes | Where-Object {$_.NodeName -eq $mofFile.BaseName}).Guid
298      $dest = "$env:ProgramFiles\WindowsPowerShell\DscService\Configuration\$($guid).mof"
299      Move-Item -Path $mofFile.FullName -Destination $dest
300      New-DSCCheckSum $dest
301  }
```

Figure 9: The Structure of the Master Configuration Script

Lines 1 through 13 – The param block includes a number of parameters that are used to define the settings in our environment. All of these parameters map to the parameters of the AWS CloudFormation template. When you launch the stack, you're given the opportunity to customize the environment at launch time. You can change subnet CIDR ranges, IP addresses, the DNS name of the Active Directory Domain, and more. These parameter values are passed in from AWS CloudFormation to the pull server that builds the configurations using the settings you've provided.

Line 16 – A single call to Get-ELBLoadBalancer to get the DNS name of the Elastic Load Balancer. This will be the end-point that client nodes use to pull configurations from the pull server.

Lines 19 and 20 – Imports helper functions used to retrieve node GUIDs and aid in formatting IP information used by the xNetworking DSC resource.

Line 23 – The Configuration Data for the environment, covered in more detail in the following sections of this guide.

Lines 62 and 63 – The credentials used by member servers to join the Active Directory Domain.

Line 66 – The DSC configuration called "ServerBase." Within the configuration, we import the xNetworking, xActiveDirectory, and xComputerManagement DSC resources since they are not native to Windows Server 2012 R2.

Line 294 and beyond – The code used to create the MOF files, rename them, and then move them to the appropriate directory on the pull server.

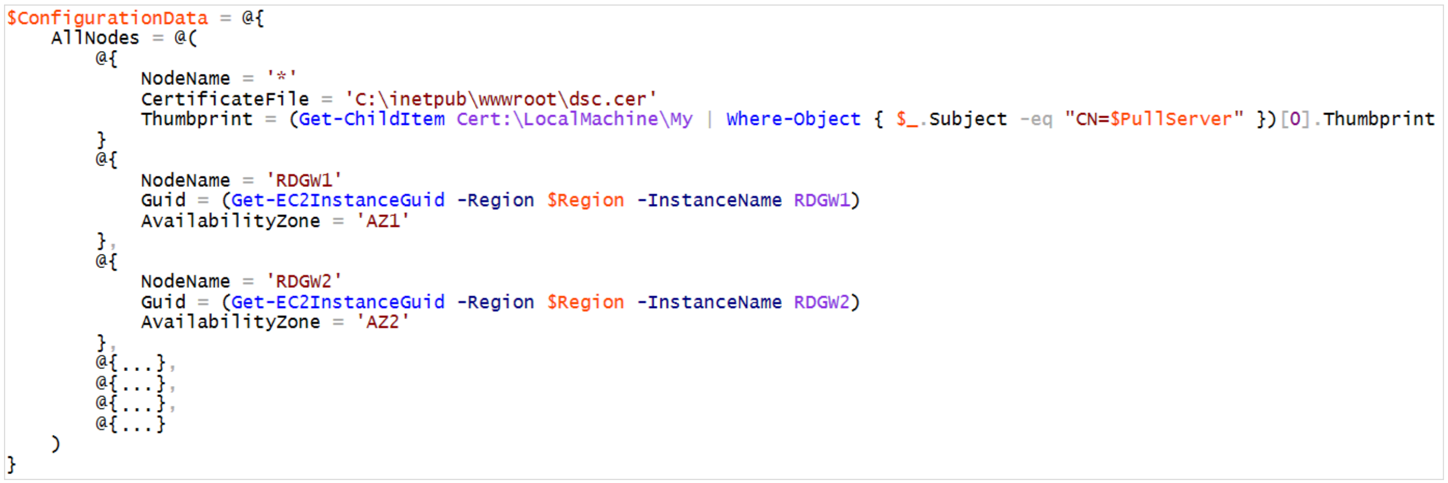
Now let's take a closer look at each aspect of the Configuration script.

DSC Resources

The only DSC resource used in our configuration script that is native to Windows Management Framework 4.0 is the WindowsFeature resource. The other resources, which include resources from the xNetworking, xActiveDirectory, and xComputerManagment resource modules, were made available by Microsoft in an out-of-band release. These resource modules have been stored in Amazon S3 and are downloaded by the pull servers in .zip format. The pull servers are then configured to host the zipped resource modules so they can be downloaded from DSC client nodes.

Configuration Data

Configuration Data provides a way to define additional environmental settings for the nodes in a configuration. The configuration data is a hash table of settings that can be passed into a configuration when generating MOF documents. Figure 10 shows an example of the configuration data used for the master DSC configuration for our environment.



```
$ConfigurationData = @{
    AllNodes = @(
        @{
            NodeName = '*'
            CertificateFile = 'C:\inetpub\wwwroot\dsc.cer'
            Thumbprint = (Get-ChildItem Cert:\LocalMachine\My | Where-Object { $_.Subject -eq "CN=$PullServer" })[0].Thumbprint
        }
        @{
            NodeName = 'RDGW1'
            Guid = (Get-EC2InstanceGuid -Region $Region -InstanceName RDGW1)
            AvailabilityZone = 'AZ1'
        },
        @{
            NodeName = 'RDGW2'
            Guid = (Get-EC2InstanceGuid -Region $Region -InstanceName RDGW2)
            AvailabilityZone = 'AZ2'
        },
        @{...},
        @{...},
        @{...},
        @{...}
    )
}
```

Figure 10: DSC Configuration Data

In the example in Figure 10 (which is condensed for the sake of brevity) the configuration data contains a hash table for each node in our deployment. Each property is described below:

- **NodeName** – The hostname of the instance, which corresponds to the node name in the configuration script.
- **Guid** – The ConfigurationID (in the form of a GUID) that the pull server and DSC client both use to determine which configuration should be pulled from the server.
- **AvailabilityZone** – This is a custom property to indicate which AWS Availability Zone the instance is located in. As we'll see, this custom property is used within the configuration script to apply settings specific to the location of the instance.
- **CertificateFile** – The physical path on the "build server" (in this case, the pull server) of the certificate that will be used to encrypt embedded credentials in the resulting MOF file. Remember, client nodes must have the private key to decrypt the credentials.
- **Thumbprint** – The certificate thumbprint on the client node to indicate which installed certificate should be used to decrypt data.

DNS Client Configuration

Since our architecture will be distributed across two Availability Zones, it makes sense for domain-joined servers to use the Active Directory DNS server in the local Availability Zone. We account for this in our configuration using some additional logic and the xDnsServerAddress resource, which is made available as part of the xNetworking resource module.

```
Node $AllNodes.Where{$_.AvailabilityZone -eq 'AZ1'}.NodeName {
    xDnsServerAddress DnsServerAddress {
        Address        = $ADServer1PrivateIp, $ADServer2PrivateIp
        InterfaceAlias = 'Ethernet'
        AddressFamily  = 'IPv4'
    }
}

Node $AllNodes.Where{$_.AvailabilityZone -eq 'AZ2'}.NodeName {
    xDnsServerAddress DnsServerAddress {
        Address        = $ADServer2PrivateIp, $ADServer1PrivateIp
        InterfaceAlias = 'Ethernet'
        AddressFamily  = 'IPv4'
    }
}
```

Figure 11: DNS Settings

As you can see in Figure 11, we filter $AllNodes (which will be defined by our configuration data) so that instances in AZ1 will point to the Domain Controller in the first Availability Zone for its primary DNS server, and vice versa.

Domain Controller Configuration

The Domain Controller configuration is mostly completed by resources from the xActiveDirectory resource module. In order to fully implement a distributed Active Directory topology, we add a number of additional resources to the module.

```
Node DC1 {
    cIPAddress DCIPAddress {
        InterfaceAlias = 'Ethernet'
        IPAddress = $ADServer1PrivateIp
        DefaultGateway = (Get-AWSDefaultGateway -IPAddress $ADServer1PrivateIp)
        SubnetMask = (Get-AWSSubnetMask -SubnetCIDR $PrivateSubnet1CIDR)
    }

    xDnsServerAddress DnsServerAddress {
        Address        = $ADServer1PrivateIp
        InterfaceAlias = 'Ethernet'
        AddressFamily  = 'IPv4'
        DependsOn = '[cIPAddress]DCIPAddress'
    }

    WindowsFeature ADDSInstall {
        Ensure = 'Present'
        Name = 'AD-Domain-Services'
        DependsOn = '[cIPAddress]DCIPAddress'
    }

    WindowsFeature ADDSToolsInstall {
        Ensure = 'Present'
        Name = 'RSAT-ADDS-Tools'
    }
    xADDomain ActiveDirectory {
        DomainName = $DomainDNSName
        DomainAdministratorCredential = $Credential
        SafemodeAdministratorPassword = $Credential
        DependsOn = '[WindowsFeature]ADDSInstall'
    }

    cADSubnet AZ1Subnet1 {
        Name = $PrivateSubnet1CIDR
        Site = 'Default-First-Site-Name'
        Credential = $Credential
        DependsOn = '[xADDomain]ActiveDirectory'
    }

    cADSubnet AZ1Subnet2 {
        Name = $DMZ1CIDR
        Site = 'Default-First-Site-Name'
        Credential = $Credential
        DependsOn = '[xADDomain]ActiveDirectory'
    }

    cADSite AZ2Site {
        Name = 'AZ2'
        DependsOn = '[WindowsFeature]ADDSInstall'
        Credential = $Credential
    }

    cADSubnet AZ2Subnet1 {
        Name = $PrivateSubnet2CIDR
        Site = 'AZ2'
        Credential = $Credential
        DependsOn = '[cADSite]AZ2Site'
    }

    cADSubnet AZ2Subnet2 {
        Name = $DMZ2CIDR
        Site = 'AZ2'
        Credential = $Credential
        DependsOn = '[cADSite]AZ2Site'
    }

    cADSiteLinkUpdate SiteLinkUpdate {
        Name = 'DEFAULTIPSITELINK'
        SitesIncluded = 'AZ2'
        Credential = $Credential
        DependsOn = '[cADSubnet]AZ2Subnet1'
    }
}
```

Figure 12: DC1 Configuration

A few points to note about the configuration for DC1 as shown in Figure 12:

- The cIPAddress resource sets the IP Address for the DC through the AWS CloudFormation template parameter. The default gateway and subnet mask are set based off the IP Address and subnet CIDR using a couple of helper functions.
- The cADSubnet resource is used to create subnet definitions for each subnet in the Amazon VPC. The cADSubnet is a custom resource that was not originally included in the xActiveDirectory resource module. We added it to aid in configuring the Active Directory (AD) Site Topology for this Quick Start Reference Deployment.

- The cADSite resource is used to create AD Site objects for each Availability Zone that will host a Domain Controller. The cADSite is a custom resource that was not originally included in the xActiveDirectory resource module. We added it to aid in configuring the Active Directory Site Topology for this Quick Start Reference Deployment.

- The cADSiteLinkUpdate resource is used to link the two AD sites so the Domain Controllers will replicate data to each other. The cADSiteLinkUpdate is a custom resource that was not originally included in the xActiveDirectory resource module. We added it to aid in configuring the Active Directory Site Topology for this Quick Start Reference Deployment.

After the first Domain Controller is built, DC2 is installed in the second Availability Zone using the following node configuration:

```
Node DC2 {
    cIPAddress DC2IPAddress {
        InterfaceAlias = 'Ethernet'
        IPAddress = $ADServer2PrivateIp
        DefaultGateway = (Get-AWSDefaultGateway -IPAddress $ADServer2PrivateIp)
        SubnetMask = (Get-AWSSubnetMask -SubnetCIDR $PrivateSubnet2CIDR)
    }

    xDnsServerAddress DnsServerAddress {
        Address        = $ADServer1PrivateIp
        InterfaceAlias = 'Ethernet'
        AddressFamily  = 'IPv4'
        DependsOn = '[cIPAddress]DC2IPAddress'
    }

    xComputer JoinDomain {
        Name = 'DC2'
        DomainName = $DomainDNSName
        Credential = $Credential
        DependsOn = '[cIPAddress]DC2IPAddress'
    }

    WindowsFeature ADDSInstall {
        Ensure = 'Present'
        Name = 'AD-Domain-Services'
        DependsOn = '[xComputer]JoinDomain'
    }

    WindowsFeature ADDSToolsInstall {
        Ensure = 'Present'
        Name = 'RSAT-ADDS-Tools'
    }

    xADDomainController ActiveDirectory {
        DomainName = $DomainDNSName
        DomainAdministratorCredential = $Credential
        SafemodeAdministratorPassword = $Credential
        DependsOn = '[WindowsFeature]ADDSInstall'
    }
}
```

Figure 13: DC2 Configuration

Since the forest and domain were created by DC1, you can see in Figure 13 that DC2 simply needs to be added to the domain and promoted to a Domain Controller.

Remote Desktop Gateway Configuration

The node configuration for the Remote Desktop Gateway servers is fairly straightforward. The RDGateway service and associated Remote Server Administration Tools (RSAT) are installed on the server, and the server is then joined to the Active Directory domain.

```
Node RDGW1 {
    WindowsFeature RDGateway {
        Name = 'RDS-Gateway'
        Ensure = 'Present'
    }

    WindowsFeature RDGatewayTools {
        Name = 'RSAT-RDS-Gateway'
        Ensure = 'Present'
    }

    xComputer JoinDomain {
        Name = 'RDGW1'
        DomainName = $DomainDNSName
        Credential = $Credential
        DependsOn = "[xDnsServerAddress]DnsServerAddress"
    }
}
```

Figure 14: RDGW1 Configuration

The configuration for RDGW2 is identical to the one shown in Figure 14 for RDGW1, with the exception of the node name. After the environment has been deployed, you can initiate a Remote Desktop Connection to either gateway using a standard TCP Port 3389 connection. To fully configure the RDGateway role with certificates (so that connections can be made securely over HTTPS) you should follow the additional steps in our Quick Start Reference Deployment for the Remote Desktop Gateway.

Web Server Configuration

The web server configuration is the same for both the WEB1 and WEB2 servers. After each server is joined to the domain, then IIS, ASP.NET, and sample "hello world" web pages are installed on the systems.

```
Node WEB1 {
    xComputer JoinDomain {
        Name = 'WEB1'
        DomainName = $DomainDNSName
        Credential = $Credential
        DependsOn = "[xDnsServerAddress]DnsServerAddress"
    }

    WindowsFeature IIS {
        Ensure = 'Present'
        Name = 'Web-Server'
    }

    WindowsFeature AspNet45 {
        Ensure = 'Present'
        Name = 'Web-Asp-Net45'
    }

    WindowsFeature IISConsole {
        Ensure = 'Present'
        Name = 'Web-Mgmt-Console'
    }

    File default {
        DestinationPath = "c:\inetpub\wwwroot\index.html"
        Contents = "<h1>Hello World</h1>"
        DependsOn = "[WindowsFeature]IIS"
    }
}
```

Figure 15: WEB1 Configuration

The configuration in Figure 15 creates a single IIS website listening on TCP port 80 hosting a single web page. You can navigate to either web server after the deployment to confirm that IIS is working properly.

Generating the MOF Documents

As we've discussed, the pull server runs the configuration script which produces a MOF file for each server in the environment. Each MOF file initially has a basename matching the hostname of the associated server. For example, the first Domain Controllers file will be named DC1.MOF.

In order for client nodes to pull these configurations, the files must be renamed using the nodes ConfigurationID, which is the GUID stored in the CloudFormation template, and tagged on the Amazon EC2 instance.

```
foreach($mofFile in $mofFiles) {
   $guid = ($ConfigurationData.AllNodes | Where-Object {$_.NodeName -eq $mofFile.BaseName}).Guid
   $dest = "$env:ProgramFiles\WindowsPowerShell\DscService\Configuration\$($guid).mof"
   Move-Item -Path $mofFile.FullName -Destination $dest
   New-DSCCheckSum $dest
}
```

Figure 16: Code Snippet

The snippet shown in Figure 16 is the code at the end of the configuration script that runs on the pull server and generates the MOFs, renames the files, and moves them to the appropriate folder. The configuration name is ServerBase, and we store the result of running the configuration in the $mofFiles variable, which will store the collection of file system objects representing each MOF file. We then simply loop through the list of files, matching the GUID (ConfigurationID) with each node name, and renaming the file. Finally, we move the files to the Configuration folder where they are checksummed and ready for download.

Deploy the Pull Mode Stack

To launch the PowerShell DSC Pull Server infrastructure AWS CloudFormation template into the US West (Oregon) region, **launch the Quick Start**.

Note
You are responsible for the cost of the AWS Services used while running this Quick Start Reference Deployment. The Cost for creating and running the template with default settings is approximately $3.50 an hour. See the pricing pages of the AWS services you will be using for full details.

The DSC Pull Server infrastructure template allows for rich customization of 15 defined parameters at template launch. The template parameters include the following default values:

Parameter	Default	Description
KeyPairName	*<User Provided>*	Public/private key pairs allow you to connect securely to your instance after it launches.
AdminPassword	Password123	Password for the administrator user account
ADServer1PrivateIp	10.0.0.10	Fixed private IP for the first Active Directory server located in AZ1
ADServer2PrivateIp	10.0.64.10	Fixed private IP for the second Active Directory server located in AZ2
DMZ1CIDR	10.0.32.0/20	CIDR block for the Public subnet located in AZ1
DMZ2CIDR	10.0.96.0/20	CIDR block for the Public subnet located in AZ2
PrivateSubnet1CIDR	10.0.0.0/19	CIDR block for the Private Subnet 1 located in AZ1
PrivateSubnet2CIDR	10.0.64.0/19	CIDR block for the Private Subnet 2 located in AZ2
DomainDNSName	Example.com	DNS Domain for the AD Domain (example.com)
DomainNetBiosName	EXAMPLE	Netbios name for the domain (EXAMPLE)
NATInstanceType	t2.small	Amazon EC2 Instance type for the NAT Instances
PullServerInstanceType	t2.medium	Amazon EC2 Instance type for the Pull Server Instances
Pullserver1PrivateIP	10.0.0.15	Fixed private IP for the first DSC Pull server located in AZ1
Pullserver2PrivateIP	10.0.64.15	Fixed private IP for the second DSC Pull server located in AZ2
VPCCIDR	10.0.0.0/16	CIDR block for the VPC.
WindowsInstanceType	m3.xlarge	Amazon EC2 Instance type for the Windows Instances

You can modify these parameters, change the default values, or, if you choose to edit the code of the template itself, create an entirely new set of parameters based on your specific deployment scenario.

Testing Configuration Drift Resistance

After the deployment is complete, you can confirm that the state of each system will retain its desired configuration. One way to test this is to perform the following steps:

1. Open a web browser and navigate to either http://web1 or http://web2. You'll see a placeholder web page that was installed by the DSC configuration for the web servers.

2. Delete the index.html file from c:\inetpub\wwwroot on the web server.

3. Refresh the browser to confirm that you can no longer view the page.

4. After 15 minutes, refresh the browser again to confirm that the state of the system has been re-applied and the system is resistant to configuration drift issues.

If you do not want to wait, you can force DSC to connect to the pull server and apply the current configuration using the Update-DscConfiguration cmdlet.

Deployment with a Push Server Infrastructure

In addition to deploying a pull server infrastructure, we've also developed an AWS CloudFormation template that deploys the reference architecture in "push" mode. This means that we do not deploy pull servers or an Elastic Load Balancer, and that each instance will utilize an individual configuration script which is specific to that server.

As each instance is bootstrapped, a configuration script is downloaded, run (producing a MOF file), and pushed locally to configure the server. The node configurations for each instance are almost identical to those we've looked at in the pull model, with the exception that each node configuration now resides in an individual configuration script.

Figure 17 shows the architecture diagram for the push mode infrastructure.

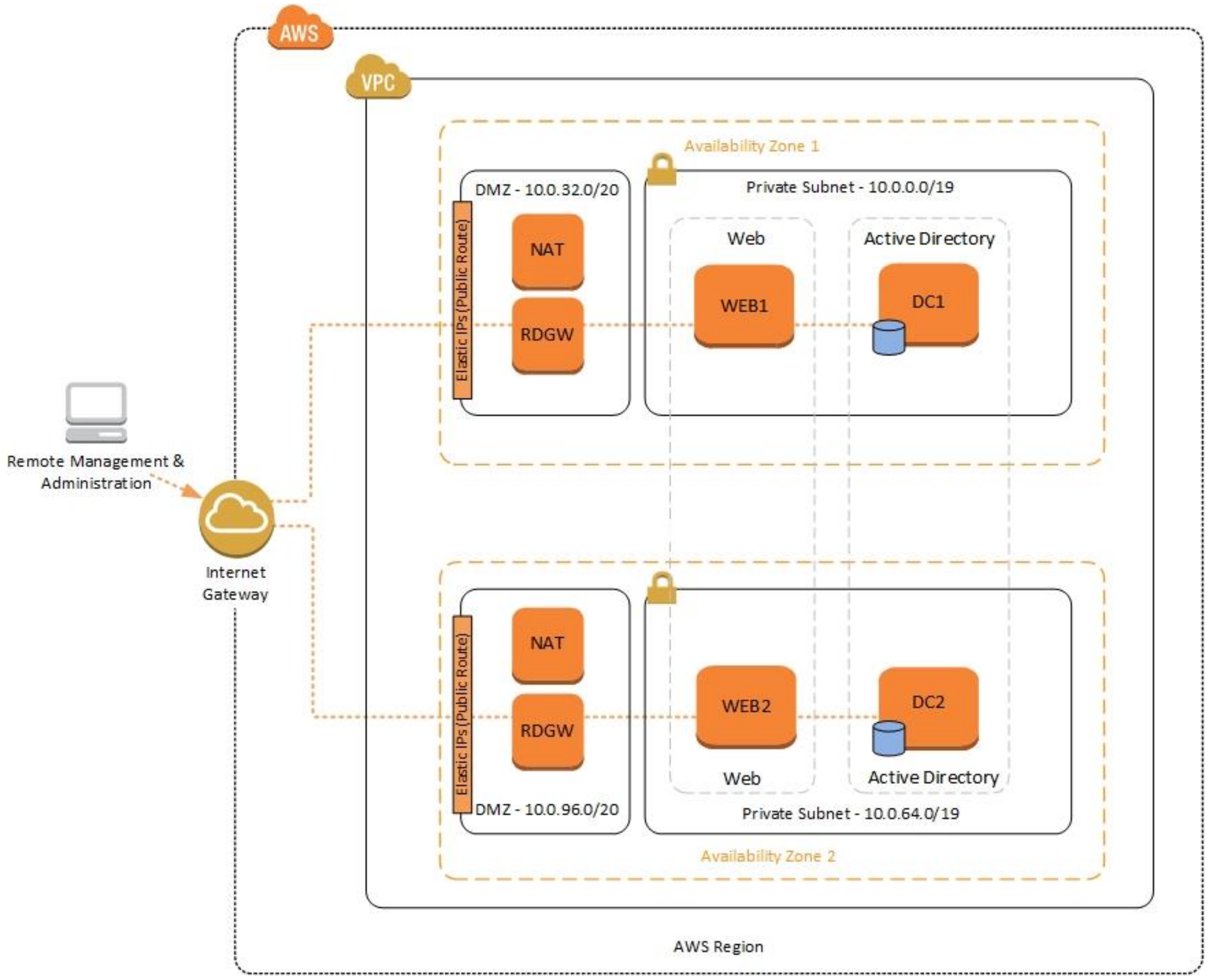


Figure 17: Reference Architecture Deployed by the DSC "Push" Mode Stack

Deploy the Push Mode Stack

To launch the PowerShell DSC Push mode infrastructure AWS CloudFormation template into the US West (Oregon) region, **launch the Quick Start**.

Note
You are responsible for the cost of the AWS Services used while running this Quick Start Reference Deployment. The cost for creating and running the template with default settings is approximately $3.50 an hour. See the pricing pages of the AWS services you will be using for full details.

The template parameters for the push mode template are identical to those in the pull mode template.

Additional Resources

- Microsoft on AWS:
  - http://aws.amazon.com/microsoft/
- Bootstrapping Applications via AWS CloudFormation:
  - https://s3.amazonaws.com/cloudformation-examples/BoostrappingApplicationsWithAWSCloudFormation.pdf
- Bootstrapping AWS CloudFormation Windows Stacks:
  - http://docs.aws.amazon.com/AWSCloudFormation/latest/UserGuide/cfn-windows-stacks-bootstrapping.html
- Amazon EC2 Windows Guide:
  - http://docs.aws.amazon.com/AWSEC2/latest/WindowsGuide/
- AWS Windows and .NET Developer Center:
  - http://aws.amazon.com/net
- Microsoft License Mobility:
  - http://aws.amazon.com/windows/mslicensemobility
- DSC topics on the PowerShell Team Blog:
  - http://blogs.msdn.com/b/powershell/archive/tags/dsc
- Whitepapers, Books, and Videos:
  - Active Directory Reference Architecture
    http://aws.amazon.com/microsoft/whitepapers/ad-reference-architecture/
  - Remote Desktop Gateway Reference Architecture
    http://aws.amazon.com/microsoft/whitepapers/rdgateway-reference-architecture/
  - Securing the Microsoft Platform on AWS
    http://media.amazonwebservices.com/AWS_Microsoft_Platform_Security.pdf
  - The DSC Book
    http://powershell.org/wp/ebooks
  - A Practical Overview of Desired State Configuration
    http://channel9.msdn.com/events/teched/northamerica/2014/DCIM-B417

Send Us Your Feedback

Please post your feedback or questions on the AWS Quick Start Discussion Forum.

Document Revisions

Date	Change	In section
March 2015	Optimized the underlying Amazon VPC design to support expansion and to reduce complexity.	Architecture diagram and template updates
November 2014	In the sample template, changed the default type for **NATInstanceType** to **t2.small** to support the EU (Frankfurt) region.	Deploy the Pull Mode Stack (template parameters table)