Technical White Paper

ECS with HAProxy Load Balancer

Abstract

This document provides a technical deployment reference of the Dell EMC™ ECS™ with HAProxy load balancer.

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Revisions

Date	Description
January 2017	Initial release
November 2017	Modified based on input from HAProxy
April 2021	Update for HAProxy 2.1 with http head in Chapter 5.3.1

Acknowledgments

Author: Zhu, Jarvis

Support: Kraft, Chris

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Executive summary

ECS is the third generation object platform from Dell EMC. It is designed for traditional and next-generation applications. It is known for its flexible deployment, resiliency and simplicity. ECS is a consortium of software, hardware nodes with disks and switches seamlessly working together to provide access to object storage data. In an optimal configuration, a load balancer is recommended to distribute the load across the nodes within ECS and ECS clusters in different locations. ECS has not specific requirement for a particular load balancer. HAProxy provides one choice and is an open source; reliable and free load balancing software solution. It provides a low-cost option for customers who desire to utilize a load balancer with ECS.

1 Introduction

This white paper is a reference guide into deploying HA Proxy load balancer with ECS. It provides example configurations and highlights best practices when utilizing HAProxy load balancer with ECS.

1.1 Audience

This document is targeted for customers and Dell EMC personnel interested in a reference deployment of ECS with HAProxy load balancer.

1.2 Scope

This whitepaper is meant to be a reference deployment guide for customers who would like to use HAProxy with their ECS deployment. Its intent is to provide a “reference” or an example for customers to deploy ECS with HAProxy. Load balancing is optional and not part of ECS except for CAS. A quick overview of ECS object access will be covered in this whitepaper. For a more in-depth overview of ECS Architecture and description of how ECS handles and processes object and file access, refer to ECS Architecture and Overview whitepaper.

2 ECS Overview

ECS provides object and file storage. Object access via S3, Atmos, and Swift on ECS storage platform is achieved via REST APIs. Objects are written, retrieved, updated and deleted via HTTP or HTTPS calls of GET, POST, PUT, DELETE, and HEAD. For file access, ECS provides NFS version 3 natively. Each of the protocols supported communicate to ECS via specified ports as highlighted in Table 1. ECS also supports CAS protocol; however, a load balancer is not required since the Centera SDK has a built-in load balancer.

Table 1 Ports assignments per ECS protocol.

ECS Protocol	Transport Protocol or Daemon Service	Port
S3	HTTP	9020
	HTTPS	9021
Atmos	HTTP	9022
	HTTPS	9023
Swift	HTTP	9024
	HTTPS	9025
NFS	mountd,nfsd	2049
	portmap	111
	lockd	10000

These ports are important when configuring ECS with HAProxy. In order to access objects using the above protocols, certain firewall ports need to be opened. For more information on ECS ports refer to the ECS Security Configuration Guide.

3 HAProxy Overview

HAProxy, an open source TCP/HTTP load balancer software, is available for free and source can be downloaded from the HA Proxy site (http://www.haproxy.org). It runs on most Unix platforms such as Linux, Solaris, FreeBSD, OpenBSD and AIX. What makes HAProxy desirable is that it is free, easy to install, setup and maintain.

HAProxy supports both Layer 4 (tcp) and Layer 7 (http) load balancing modes. Layer 4 allows all data traffic to be forwarded directly to backend servers streamlining user requests. In Layer 7 mode, HAProxy can evaluate the HTTP headers and forward to backend servers based on content of user request. Support of both modes makes HAProxy a good low cost option for customers.

In addition to Layer 4 and 7 load balancing modes, HAProxy has support for the following:

- Access Control List (ACL) – allows forwarding traffic based on a certain pattern in content of user request
- Load Balancing Algorithms – options available include:
  - Round-Robin – default algorithm which selects servers in a rotating basis.
  - Least Connect – selects servers based on the least number of connections
  - Source – selects servers based on a hash of the source IP such as the user IP address to ensure request goes to the same server until something changes in the hash (i.e. one backend server goes down) .
  - Sticky Sessions – enables persistence in order for applications to connect to same backend server to process requests.
- Health Check – used to check if a backend is available and if not, then it is automatically removed from the rotation to process requests until it is restored or becomes healthy.
- Monitoring –statistics relating to HAProxy can be monitored and viewed through a web interface.

For further information on HAProxy, refer to the HAProxy site. Also available from this site is a community forum to ask questions and documentation that can provide further details specific to HAProxy.

4 ECS with HAProxy Deployments

There are various ways to deploy ECS with HAProxy such as single, highly available or global. In all deployments, HAProxy defines in its configuration file a "**frontend**" indicating how requests should be forwarded to a pool of servers or ECS nodes defined as the "**backend**". If the frontend is defined to be in http mode, the HTTP headers are analyzed and forwarded based on the content of request. If in "tcp" mode, HTTP headers will not be evaluated and requests are forwarded directly to pool of backend nodes for handling. A load balancing algorithm would define how incoming requests is distributed among the ECS nodes. As previously mentioned, HAProxy provides round-robin, least connect and source load balancing algorithms. Either a domain name system (DNS) addresses or virtual IPs of HAProxy load balancer are presented to clients.

The example images of HAProxy with ECS in this section only highlight object access. For NFS, it is recommended that a load balancer be used for high availability purposes only and not for balancing load across the ECS nodes. More detailed information on how to employ HAProxy with ECS when using NFS is described in a later section of this whitepaper.

4.1 Single

In a single HAProxy deployment, the frontend points to the IP address of the HAProxy endpoints and the backend points to the IP addresses of the ECS nodes at specified ports depending on object protocol. Figure 1 illustrates an example of a single deployment. This is the simplest of configurations; however, the single load balancer is also a single point of failure and not recommended in production environments.

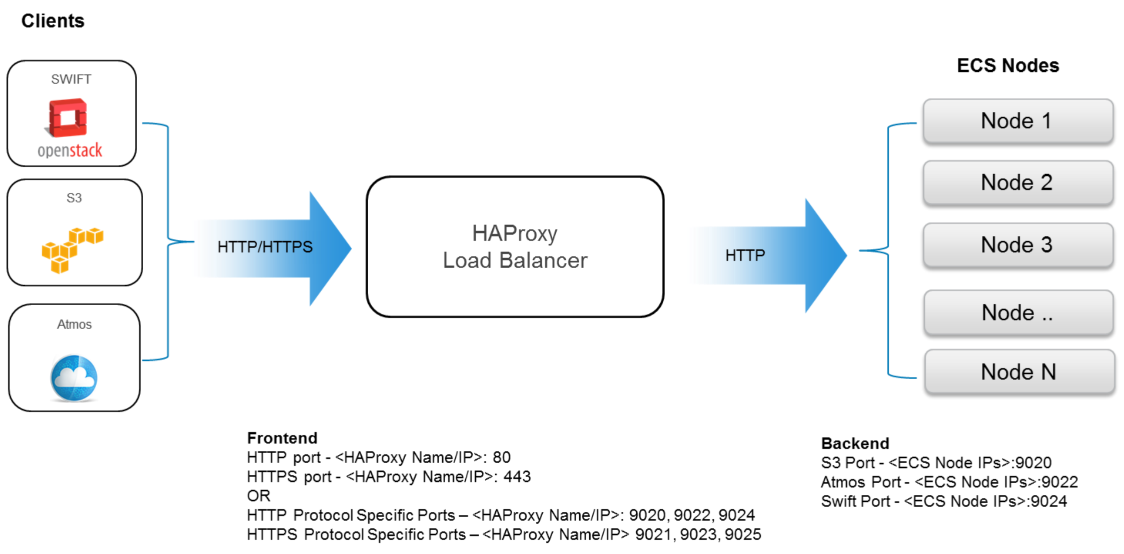

Clients
SWIFT
openstack
S3
Atmos
HTTP/HTTPS
HAProxy Load Balancer
HTTP
ECS Nodes
Node 1
Node 2
Node 3
Node ..
Node N
Frontend
HTTP port - <HAProxy Name/IP>: 80
HTTPS port - <HAProxy Name/IP>: 443
OR
HTTP Protocol Specific Ports – <HAProxy Name/IP>: 9020, 9022, 9024
HTTPS Protocol Specific Ports – <HAProxy Name/IP> 9021, 9023, 9025
Backend
S3 Port - <ECS Node IPs>:9020
Atmos Port - <ECS Node IPs>:9022
Swift Port - <ECS Node IPs>:9024

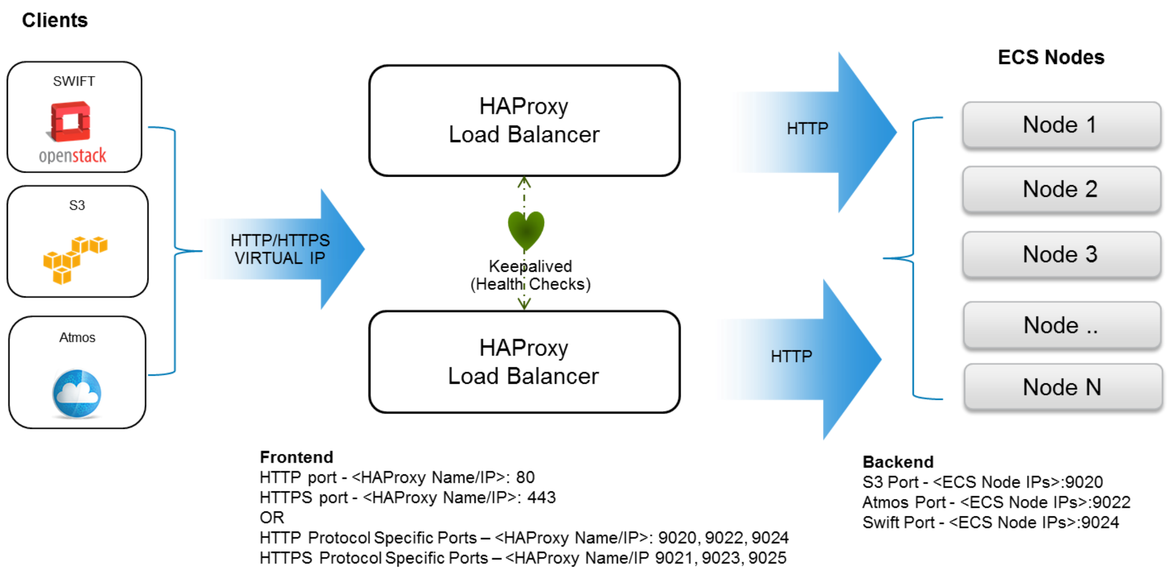
Figure 1 ECS with a single HAProxy

4.2 Highly Available (Redundancy)

In order to not have a single point of failure, it is best practice to setup HAProxy in a "highly available" configuration by setting up two HAProxy load balancers. This provides redundancy such that in case of failure another load balancer is available to handle requests. A mechanism such as Linux's "keepalived" utility can do health checks between the load balancers to inform HAProxy when one of the load balancers is not available. In a highly available setup, there are two ways to configure the redundant HAProxy load balancers:

- Active/Passive – one HAProxy load balancer act as a primary and the other will only be activated when the primary load balancer fails or is unresponsive.
- Active/Active – both HAProxy load balancers are active and either one can process client requests. As long as one of the load balancers is up and available, requests will be handled.

There are advantages and disadvantages of each method that should be considered. Since both load balancers are available for use in the active/active setup, the performance level will be higher than in an active/passive setup. However, in an active/passive, there is a consistent performance level when one fails whereas in active/active when one fails, performance level will drop by half as perceived by clients. If certain “levels of service” are expected, then consistency is an important criterion to consider. Upsizing the servers hosting the HAProxy in an active/passive setup can improve performance; however, it may not be as cost-effective. Understanding the tradeoffs and requirements is important in developing a deployment best suited for your needs. Figure 2 provides an example of redundant HAProxy load balancers in front of a pool of ECS Nodes with a virtual IP presented to clients.



Frontend
HTTP port - <HAProxy Name/IP>: 80
HTTPS port - <HAProxy Name/IP>: 443
OR
HTTP Protocol Specific Ports – <HAProxy Name/IP>: 9020, 9022, 9024
HTTPS Protocol Specific Ports – <HAProxy Name/IP 9021, 9023, 9025

Backend
S3 Port - <ECS Node IPs>:9020
Atmos Port - <ECS Node IPs>:9022
Swift Port - <ECS Node IPs>:9024

Figure 2 ECS with redundant HAProxy load balancers for high availability

4.3 Global Load Balancing

When there are two or more geographically dispersed ECS sites supporting the same namespace(s), a mechanism to load balance across the nodes between sites is recommended especially in three or more sites where it becomes key for taking advantage of ECS storage efficiency achieved via ECS XOR feature. Another advantage is when one site is unavailable; requests will automatically be forwarded to surviving site(s) providing disaster recovery and high availability. Global load balancing can be achieved by either using DNS, network routing (i.e. OSPF: Open Shortest Path First, BGP: Border Gateway Protocol, etc), a global server load balancer (GLSB) or combination of these techniques. Figure 3 provides an example of client requests being sent to a Domain Name System (DNS) which have an entry for a global load balancing mechanism or HAProxy load balancer which also can be setup to be redundant. The global load balancing techniques used would forward requests to a pool of HAProxy load balancers that will forward requests to a pool of ECS nodes within a replication group.

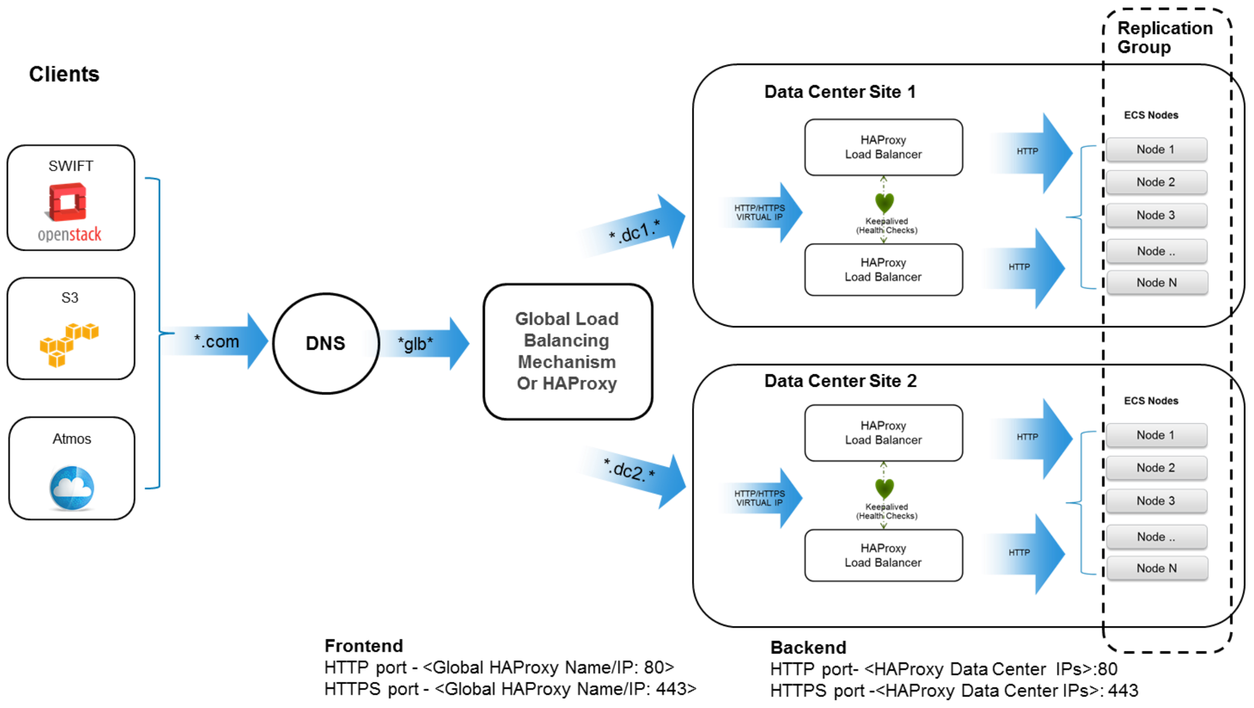


Figure 3 Global load balancing with HAProxy in a geo-replicated ECS deployment

When considering a global load balancing mechanism, it is important to understand that ECS reads check the owner of the object to validate if it has the latest copy locally. If data is not local in the site cache or the site is not the owner of object, then it would need to retrieve the data from site that owns the object. Thus when architecting a global load balancing solution, it is advised to send or direct the read requests to the owning site if possible. This may depend on the workflow and application.

5 Example Deployments of ECS with HAProxy setup

An example of how to setup ECS with HAProxy is detailed in the following sections. Although the different ways to deploy ECS with HAProxy described previously will not be fully covered in this whitepaper, it does provide a base in which the reader can enhance the deployment to implement further. In this example, information on how to configure HAProxy for load balancing object access and NFS access in a single deployment are described. For object access, “http mode” is used and for NFS “tcp mode” is used. Virtual machines running Mint version 17.1, an Ubuntu variant, was used as the server to host HAProxy. DNS installed on a Windows Server was used to map the HAProxy IP addresses to various names.

5.1 Installation

Components configured in this example to employ ECS with HAProxy include a server to host HAProxy running a Linux Operating system, HAProxy software package, Domain Name System (DNS) and an ECS U300 appliance with ECS 3.6.1 installed. Linux and Windows client servers were used to validate the HAProxy with ECS deployment for both object and file access. S3 Browser and Cyberduck was used to validate the setup of ECS with HAProxy and a regular Linux mount command was used to test NFS. Figure 4 illustrates the components in this example.

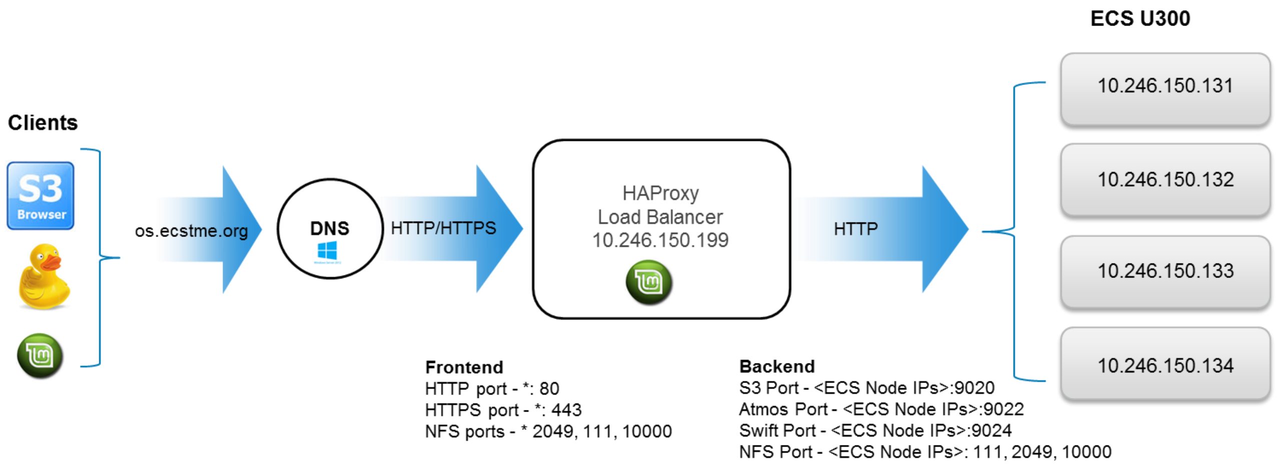


Figure 4 Single HAProxy

5.1.1 Server

A physical server (bare metal) or a virtual machine can be used to install HAProxy. The server should be sized (CPU, memory, network cards, etc.) based upon the following criteria:

- Workload or amount of traffic expected
- If using physical server or virtual machines
- Deploying multiple instances of HAProxy in active/passive or active/active mode.
- Expected service level agreements

A Unix operating system would also need to be installed on the server or virtual machine. Refer to the HAProxy site to get minimum server requirements and supported operating system.

5.1.2 HAProxy

The HAProxy load balancer software package (source) and documentation are available from HAProxy site: http://www.haproxy.org. HAProxy pre-built packages can also be found on the web in the form of Personal Package Archives (PPA) such as the one for Ubuntu or Debian at site http://haproxy.debian.net. An example of how to download and install HAProxy 1.7 on Ubuntu is described below and shown in Figure 5. In the example, the following are conducted:

1. Get and install "software-properties-common" which contains the binaries, manual pages, and libraries to add a repository and other commands.
2. Add to repository Personal Package Archive (PPA) "vbernat/haproxy1-7"
3. Get updates
4. Get and install HAProxy

```
# apt-get install software-properties-common
# add-apt-repository ppa:vbernat/haproxy-1.7

# apt-get update
# apt-get install haproxy
```

Figure 5 HAProxy 1.7 install on mint version 17.1 (Ubuntu)

Depending on the Unix operating system installed, the commands above will differ. If pre-built packages are not available for the operating system or server being used, the source can be downloaded from HAProxy site and compiled accordingly.

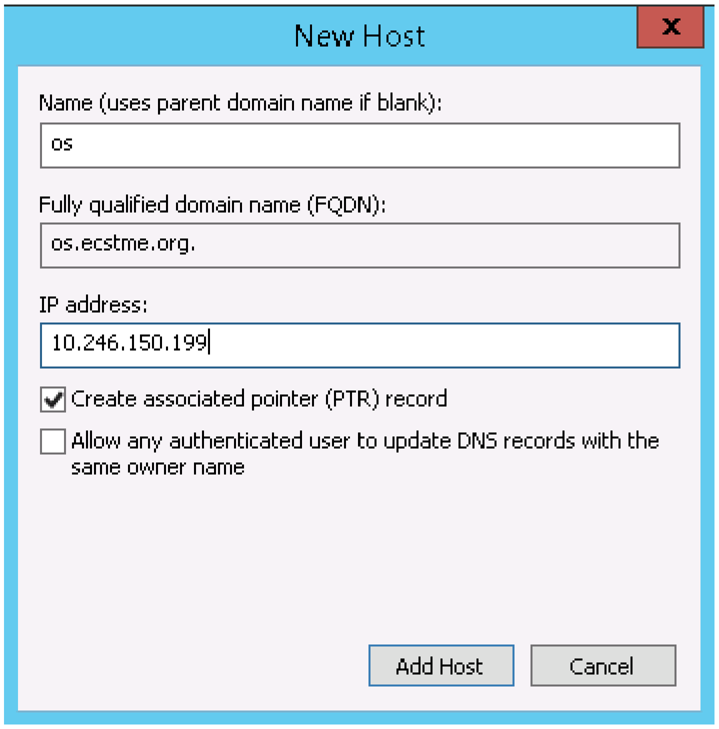
5.2 Domain Name System (DNS)

In this example a DNS is setup on a Windows server and accessible from the server hosting HAProxy. Table 2 shows the DNS entries created. Adding DNS entries allows mapping of "names" to IP addresses. In this example, DNS is used as a mechanism for translating the object protocol (S3, Atmos, or Swift) the client is using and allows HAProxy to direct request to the appropriate pool of ECS nodes based on protocol name. The advantage of this approach is that HAProxy runs all three protocols on the standard HTTP port 80. The names associated with each object protocol will be mapped to one IP address associated with the HAProxy and translate it to a pool of ECS nodes. An "A-record " is created in DNS which maps a name to the IP address of HAProxy and CNAME provides an alias for each protocol.

Table 2 DNS Entries Example

DNS Record	Record Type	Record Data	Comments
os.ecstme.org	A	10.246.150.199	HAProxy external IP Address and also used for S3 protocol access (os=object store)
*.os.ecstme.org	CNAME	os.ecstme.org	Used for S3 virtually hosted buckets, i.e. mybucket.os.ecstme.org
atmos.ecstme.org	CNAME	os.ecstme.org	Endpoint for clients using the Atmos
swift.ecstme.org	CNAME	os.ecstme.org	Endpoint for clients using the Swift protocol

From the Windows Server, start up the DNS Manager and add DNS entries of “New Host” for A-Record and “New Alias” in your domain zone as described in above table. Sample screenshots of this are shown in Figure 6 and Figure 7,


New Host

Name (uses parent domain name if blank):
os

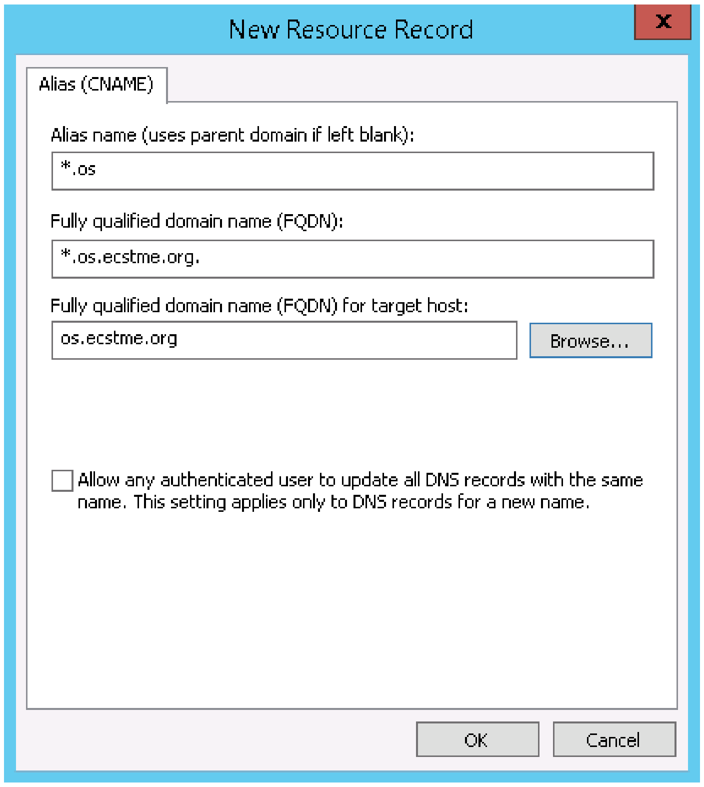
Fully qualified domain name (FQDN):
os.ecstme.org.

IP address:
10.246.150.199

[✓] Create associated pointer (PTR) record

[ ] Allow any authenticated user to update DNS records with the same owner name

Figure 6 A-Record screenshot



Alias name (uses parent domain if left blank):
*.os

Fully qualified domain name (FQDN):
*.os.ecstme.org.

Fully qualified domain name (FQDN) for target host:
os.ecstme.org

☐ Allow any authenticated user to update all DNS records with the same name. This setting applies only to DNS records for a new name.

Figure 7 - DNS Alias (CNAME) screenshot

5.3 HAProxy Configuration for Single Setup

A configuration file is used to define how HAProxy should be configured to proxy requests to a pool of servers. The HAProxy configuration file haproxy.cfg located in /etc/haproxy directory is modified to define the following:

- Frontend – consists of a set of IP addresses and port used by clients to access HAProxy server, the mode (tcp or http), ACLs (optional), and backend rules based on ACL conditions.
- Backend – specifies options for load balancer algorithm to use, a list of ECS nodes and ports, the mode (tcp or http), and whether to perform health checks.

Frontend and backend definitions are explained in this section for http, https and NFS in addition to definitions to enable web monitoring. There are default global values defined in haproxy.cfg such as timeout for client and server, error files for different types of errors, stats timeout, mode, etc. These values are not modified in this example; however some of the parameters such as mode and log are overridden in the frontend and backend definitions for NFS.

5.3.1 HTTP

The sample or default /etc/haproxy.cfg file contains some parameters for global and defaults. The *"global"* section contains definitions that applies to the entire HAProxy process such as logging, default ciphers, etc. For this example, no additional changes will be needed in this section. In the *"defaults"* section as shown in Figure 8, the mode, timeouts, type of balance, options, etc can be added or modified. In this example the defaults labeled *HTTP*, the default timeouts are modified and additional parameters are added such as balance, to specify the load balancer algorithm type to "leastconn" and option for forwardfor to set the X-

Forwarded-For header with the source IP. By Using *"leastconn"* as the load balancer algorithm forwards requests to ECS nodes that has the least amount of active connections.

```
defaults HTTP
        log     global
        mode    http
        option  httplog
        option  dontlognull
        timeout connect 5s
        timeout client  50s
        timeout server  50s
        timeout http-request 10s
        timeout http-keepalive 10s
        option forwardfor
        balance leastconn
```

Figure 8 Defaults defintions

Next append the frontend block shown in Figure 9 to /etc/haproxy/haproxy.cfg file. In defaults section, the mode is http so a mode is not specifically added in the frontend block shown in Figure 9. The first line in the frontend block *"http-in"* tells HAProxy to listen for requests on port 80 on all interfaces. It also defines ACLS named "*host_s3"*, *"host_atmos"*, and *"host_swift"* such that it extracts the HTTP header "host" and if the path of the user header request matches *"os.ecstme.org, atmos.ecstme.org, or swift.ecstme.org"* it will re-direct the request to appropriate protocol backend defined by the *"use_backend"* line. The *"-i"* flag ignores case during matching, and *"-m dom"* indicates domain matching such that the input string delimited with dots matches the specified pattern in this case os.ecstme.org, atmos.ecstme.org, and swift.ecstme.org.

```
frontend http-in
        bind *:80

       # Define the hostnames
       acl host_s3 hdr(host) -i -m dom os.ecstme.org
       acl host_atmos hdr(host) -i -m dom atmos.ecstme.org
       acl host_swift hdr(host) -i -m dom swift.ecstme.org

       # Route to backend
       use_backend swift_backend if host_swift
       use_backend atmos_backend if host_atmos
       use_backend s3_backend if host_s3
```

Figure 9 Frontend definitions

Further append the haproxy.cfg file with the backend definitions of "*os.ecstme.org"*, *"swift.ecstme.org"*, and *"atmos.ecstme.org"* specified in the frontend as shown in Figure 10. Each object protocol goes thru a certain port thus all S3 requests for http go thru port 9020, Atmos, thru port 9022, and Swift thru 9024. So for each protocol backend, a list of ECS nodes IP addresses and ports are specified in *"server"* line. For the s3_backend and swift_backend, *"check"* is added at the end of the line to perform health checks on ECS services on each node using "S3 ping" or "Swift healthcheck" as specified in "option httpchk". The *"check"* specified for atmos_backend will only check if the ECS node is down since this protocol does not yet have support for the "ping operation" to check the ECS services.

```
backend os.ecstme.org
        # Use the s3 Ping extension to make sure ECS services on node
        # are alive.

        option httpchk GET /?ping "HTTP/1.1\r\nHost: haproxy"

        # List of data nodes.  S3 runs on port 9020.
        server hop-u300-12-01 10.246.150.131:9020 check
        server hop-u300-12-02 10.246.150.132:9020 check
        server hop-u300-12-03 10.246.150.133:9020 check
        server hop-u300-12-04 10.246.150.134:9020 check

backend atmos_backend

        # List of data nodes.  Atmos runs on port 9022
        server hop-u300-12-01 10.246.150.131:9022 check
        server hop-u300-12-02 10.246.150.132:9022 check
        server hop-u300-12-03 10.246.150.133:9022 check
        server hop-u300-12-04 10.246.150.134:9022 check

backend swift_backend

       # Use the Swift healthcheck to check the ECS services on node.
        option httpchk HEAD /healthcheck HTTP/1.0
        # List of data nodes.  Swift runs on port 9024
        server hop-u300-12-01 10.246.150.131:9024 check
        server hop-u300-12-02 10.246.150.132:9024 check
        server hop-u300-12-03 10.246.150.133:9024 check
        server hop-u300-12-04 10.246.150.134:9024 check
```

Figure 10 Backend definitions

For another example of how to implement the frontend and backend is of this example is described in Appendix A of this whitepaper.

After the haproxy.cfg has been modified, check the validity of the configuration file. If configuration file is valid, then restart haproxy to put in effect the load balancing directives in haproxy.cfg. Figure 11 exhibits how to check and restart HAProxy.

```
# haproxy -f haproxy.cfg -c
Configuration file is valid
```

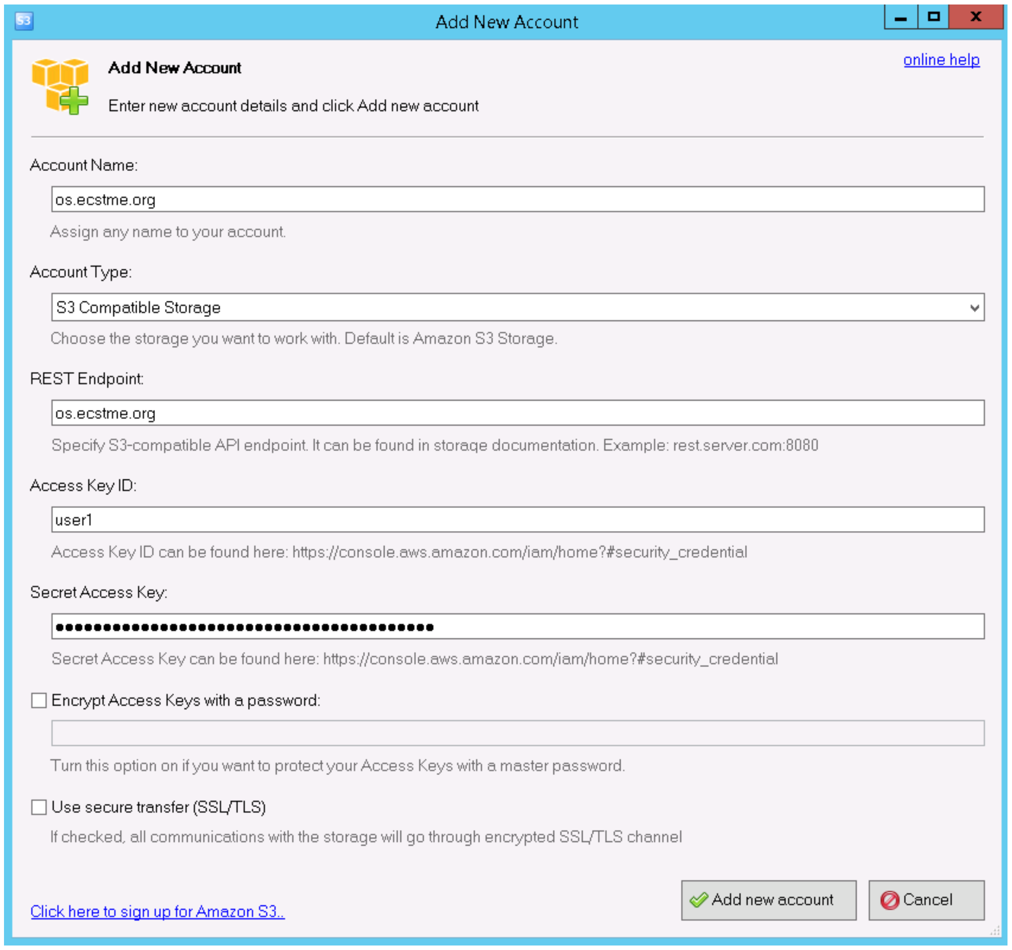
Figure 11   Command to restart HAProxy.

To have HAProxy automatically start after a reboot, edit /etc/default/haproxy file and add ENABLED=1 as shown in Figure 12.

```
# Defaults file for HAProxy
#
# This is sourced by both, the initscript and the systemd unit
file, so do not
# treat it as a shell script fragment.

ENABLED=1
```

Figure 12   Set ENABLED=1 in /etc/default/haproxy

To validate your HAProxy configuration, install S3 Browser or Cyberduck and set the IP or name of HAProxy. Figure 13 provides an example of the settings for S3 Browser. Since http is being tested, verify that the S3 Browser has the "Use secure transfer (SSL/TLS)" box unchecked.



Add New Account

Enter new account details and click Add new account

Account Name:
os.ecstme.org
Assign any name to your account.

Account Type:
S3 Compatible Storage
Choose the storage you want to work with. Default is Amazon S3 Storage.

REST Endpoint:
os.ecstme.org
Specify S3-compatible API endpoint. It can be found in storage documentation. Example: rest.server.com:8080

Access Key ID:
user1
Access Key ID can be found here: https://console.aws.amazon.com/iam/home?#security_credential

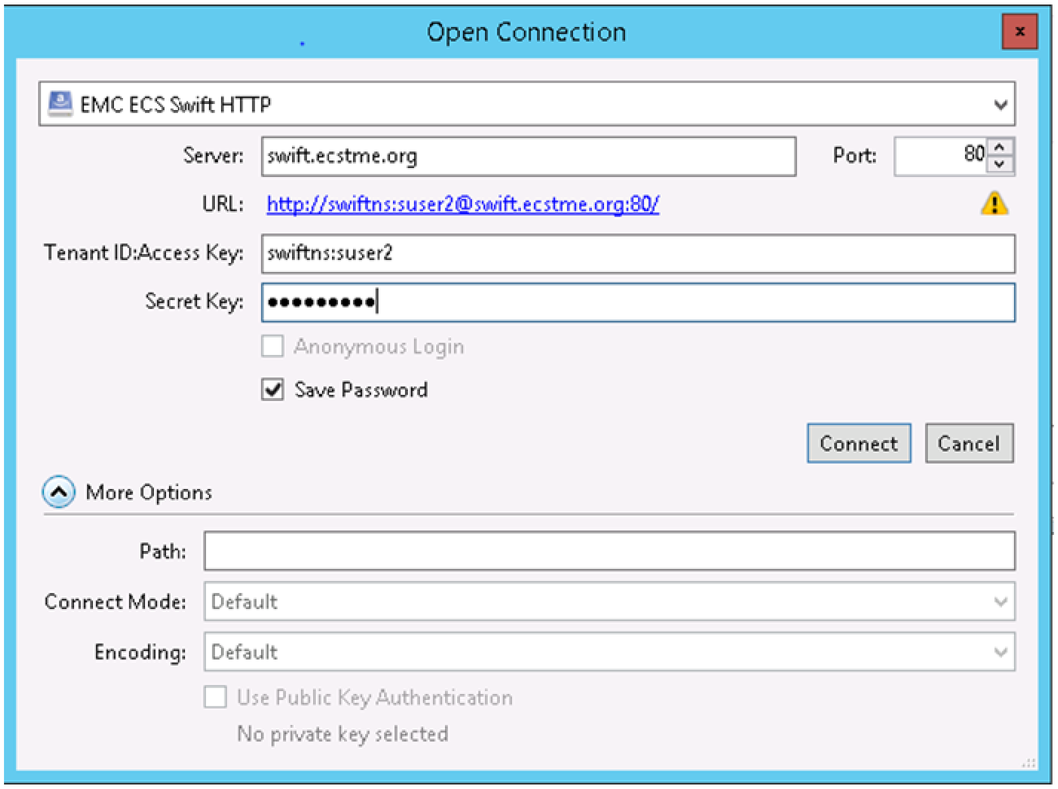
Secret Access Key:
●●
Secret Access Key can be found here: https://console.aws.amazon.com/iam/home?#security_credential

☐ Encrypt Access Keys with a password:
Turn this option on if you want to protect your Access Keys with a master password.

☐ Use secure transfer (SSL/TLS)
If checked, all communications with the storage will go through encrypted SSL/TLS channel

Figure 13 S3 Browser Settings Example Using HAProxy

Cyberduck can also be utilized to test both S3 and Swift. In this example, ECS Swift (HTTP) profile provided in the ECS community page https://community.emc.com/docs/DOC-27683 was used. From Cyberduck, open a new connection specifying "swift.ecstme.org" and port 80 for the server settings and providing the Swift credentials (e.g. namespace:user and password set for Swift user) as shown in Figure 14.



EMC ECS Swift HTTP

Server: swift.ecstme.org Port: 80

URL: http://swiftns:suser2@swift.ecstme.org:80/

Tenant ID:Access Key: swiftns:suser2

Secret Key: ●●●●●●●●●●

☐ Anonymous Login

☑ Save Password

Path:

Connect Mode: Default

Encoding: Default

☐ Use Public Key Authentication

No private key selected

Figure 14 Cyberduck with swift settings

To validate S3 virtually hosted style addressing scheme, a base URL (i.e. os.ecstme.org) would need to be specified in ECS via the ECS portal and S3curl utility can be used as a check. Figure 15 shows an example of how to install S3curl onto a Linux machine which requires retrieving the utility from github and unzipping the bundle. The unzip will create an s3curl directory which contains the files needed to use the utility.

```
# wget https://github.com/rtdp/s3curl/archive/master.zip
# unzip master.zip
```

Figure 15 Install of S3Curl utility on Linux

Create an “*.s3curl”* configuration file in the home directory which contains the ECS user id, secret keys, and ECS endpoints. After editing the file as shown in Figure 16, modify the permissions of the *“.s3curl”* configuration file to 600.

```
%awsSecretAccessKeys = (
    # ECS account
    ecsid => {
        id => 'user1',
        key => 'xaHTZWMPlvNFeMeKdQhH+FZJ8eLB8+qFC/W0dhzk',
},
@endpoints = ('10.246.150.179',
'10.246.150.180',
'10.246.150.181',
'10.246.150.182',
'os.ecstme.org',)
);
```

Figure 16 S3curl configuration file

Execute the s3curl command located in s3curl directory with the virtual host style addressing as illustrated in Figure 17. In this example, the bucket name is prepended to the base URL of os.ecstme.org.

```
# cd s3curl-master
# ./s3curl.pl --id ecsid -- http://testb.os.ecstme.org | xmllint --format -
```

Figure 17 S3curl command

A snippet output after running this command is pictured in Figure 18 and shows a bucket listing of a bucket named “testb”

```
<?xml version="1.0" encoding="UTF-8" standalone="yes"?>
<ListBucketResult xmlns="http://s3.amazonaws.com/doc/2006-03-01/">
  <Name>testb</Name>
  <Prefix/>
  <Marker/>
  <MaxKeys>1000</MaxKeys>
  <IsTruncated>false</IsTruncated>
  <ServerSideEncryptionEnabled>false</ServerSideEncryptionEnabled>
  <Contents>
    <Key>foo1M_0</Key>
    <LastModified>2017-05-31T16:59:33.898Z</LastModified>
    <ETag>"1d0bc7dd91164422eb8961e58f4c458b"</ETag>
    <Size>1048576</Size>
   ...
```

Figure 18 Snippet output of running s3curl.pl

HAProxy starting from 2.1 will forward http headers in small capital letter (etag) to be more compliant with http/2 protocol, this was not the same in 1.x versions (ETag) which will cause issue with using with Isilion cloud pool. It is needed to change the configure file like “h1-case-adjust & option h1-case-adjust-bogus-client” in the new version.

```
global
…
        h1-case-adjust etag ETag

defaults HTTP
…
        option h1-case-adjust-bogus-client
```

5.3.2 HTTPS

Developing trust between two entities is established via Secure Socket Layer (SSL) and SSL certificates. The purpose of SSL and certificates is encryption and identification to ensure that communication exchange between two parties is secure and trustworthy. For identification of who to trust, a certificate would need to be generated and installed on HAProxy or ECS nodes. Certificates usually will contain information about the owner of the certificate (i.e. company, organization, city, state, email address of owner), duration of validity, resource location (i.e. Fully Qualified Domain Name or common name), public key, and hash. The certificate generated can be signed by either:

- Certificate Authority (CA) – trusted organizations that can verify the identity and validity of the entity requesting the certificate.
- Self-signed - authenticated by the system where the certificate resides.

As a best practice, using a Certificate Authority to sign certificate is preferred over issuing self-signed certificates. Almost all client systems come with a list of trusted root CA certificates that will automatically validate your CA-signed certificate. If you opt to use a self-signed certificate, that certificate will need to be installed on all client systems as a “trusted” certificate. If your organization has an internal Certificate Authority, you can use that CA to sign your certificates; just make sure that any client systems have your CA’s root certificate installed. Also, utilizing HAPrxoy to offload and terminate SSL is a best practice in order to not add extra load on ECS nodes to establish SSL sessions. Thus, the certificate generated in this example is to be installed on HAProxy load balancer. Some organizations have security policies that specify that the connection to ECS must be encrypted all the way to ECS. In those cases you will need to terminate SSL on the ECS appliance itself. If SSL termination is required on ECS nodes, then use Layer 4 (tcp) load balancing mode to pass through the SSL traffic to ECS nodes for handling. In this scenario, the certificates would need to be installed on ECS. For information on how to generate certificates for ECS Nodes, refer to ECS System and Administration Guide.

5.3.2.1 Certificate Generation for HAProxy Load Balancer Example

OpenSSL is used in this example to generate the certificates. Note that you do not need to generate the certificates on ECS; any system with suitable tools like OpenSSL can generate certificates. By default, OpenSSL is installed on most Linux releases. General steps to create a certificate for HAProxy using OpenSSL include:

1. Generate a private key.
2. Modify configuration file to add Subject Alternative Names (SANs).
3. Create a certificate request to submit to CA or generate a self-signed certificate.
4. Combine the private key and certificate and place in HAProxy directory.

When generating certificates, the hostname of where the certificate will be used needs to be specified. For compatibility with the S3 protocol, the Common Name (CN) on the certificate should point to the wildcard DNS entry used by S3 since S3 is the only protocol that utilizes virtually hosted-style URL buckets where the bucket name is in the hostname. There can only be one wildcard entry on an SSL certificate and it must be under the CN. If specifying IP Addresses or other DNS entries for Atmos and Swift protocols, Subject Alternative Names (SANs) should be registered on the certificate. Some organizations do not allow the use of wildcard certificates. In this case, you will need to make sure that all of your S3 applications use “path-style” access so they can use the base hostname of S3 (e.g. os.ecstme.org) instead of the default method of adding the bucket to the hostname (e.g. bucket.os.ecstme.org).

Step 1: Generate a Private Key

A private key is required for self-signed and CA requests certificates. This key will be combined with the certificate generated. An example of how to generate the private key is shown in Figure 19. Permissions are also changed on the key generated to safeguard from accidentally modification or deletion.

```
# openssl genrsa -des3 -out server.key 2048
Generating RSA private key, 2048 bit long modulus
............................................................+++
.......+++
e is 65537 (0x10001)
Enter pass phrase for server.key: <enter a password>
Verifying - Enter pass phrase for server.key: <enter a password>

# chmod 0400 server.key
```

Figure 19 Create private key using OpenSSL

Step 2: Modify the Configuration File with SANs

OpenSSL does not allow passing of SANs through the command line so a configuration file is created to define them. A sample configuration file for openssl can be used as a reference and is located in /usr/lib/ssl/openssl.cnf. Copy the openssl.cnf file to a temporary directory where certificates will be generated and placed as pictured in Figure 20.

```
# cp /usr/lib/ssl/openssl.cnf request.conf
```

Figure 20 Copying of openssl configuration file

Edit the request.conf file to include the SAN by adding the IP addresses or DNS entries mapping of the HAProxy server. Figure 21 is an example of the SAN setting for both DNS entries and IP addresses.

```
[ alternate_names ]
DNS.1 = os.ecstme.org
DNS.2 = atmos.ecstme.org
DNS.3 = swift.ecstme.org
IP.1 = 10.246.150.199
```

Figure 21 SANs setting in configuration file

In the [req] section, add the following lines if not present in the configuration file as shown in Figure 22.

```
x509_extensions = v3_ca # The extentions to add to the self-signed
cert
req_extensions = v3_ca  # For cert signing req
```

Figure 22 Indicate parameter(s) for extensions

In the [v3_ca] section, add the following lines as shown in Figure 23. This indicates that there are alternate names provided.

```
[ v3_ca ]
subjectAltName    = @alternate_names
basicConstraints = CA:FALSE
keyUsage = nonRepudiation, digitalSignature, keyEncipherment
extendedKeyUsage = serverAuth
```

Figure 23 Specify [v3_ca] parameters for SAN

Also in [v3_ca] section, if creating a certificate signing request, comment out “authorityKeyIdentifier” as illustrated in Figure 24. No need to comment out for self-signed certificates.

```
#authorityKeyIdentifier=keyid:always,issuer
```

Figure 24 comment out authorityKeyIdentifier paramteter in [v3_ca]

Finally in section [CA_default], uncomment or add the copy_extension line as pictured in Figure 25.

```
copy_extension=copy
```

Figure 25 Parameter to add at [CA_default] section

Step 3a: Creation of a Certificate Signing Request for CA Submission

Figure 26 provides an example ***openssl*** command of how to create a certificate signing request. The command requires the private key, *"server.key"* created in Step 1, and the modified configuration file, request.conf containing the subject alternate names as described in Step 2. Several user inputs are expected such as location and organization information, email address and Common Name. As previously mentioned, the Common Name should be set to the wildcard DNS entry used by S3 which is "*.os.ecstme.org" in this example.

```
# openssl req -new -key server.key -config request.conf -out server.csr

Enter pass phrase for server.key: <your passprhase from above>

You are about to be asked to enter information that will be
incorporated into your certificate request. What you are about to enter
is what is called a Distinguished Name or a DN. There are quite a few
fields but you can leave some blank
For some fields there will be a default value,
If you enter '.', the field will be left blank.
-----
Country Name (2 letter code) [AU]: <Enter value>
State or Province Name (full name) [Some-State]: <Enter value>
Locality Name (eg, city) []: <Enter value>
Organization Name (eg, company) [Internet Widgits Pty Ltd]: <Enter
value>
Organizational Unit Name (eg, section) []: <Enter value>
Common Name (e.g. server FQDN or YOUR name) []: *.os.ecstme.org
Email Address []: <admin email>

Please enter the following 'extra' attributes
to be sent with your certificate request
A challenge password []: <optional>
An optional company name []: <optional>
```

Figure 26 Command to generate a certificate signing request

Step 3b: Creation of a Self-Signed Certificate

The command to create self-signed certificates is similar to certificate request except for *"-x509"* option added. Figure 27 provides an example command to generate the self-signed certificate. Also, the Common Name is set to *"*.os.ecstme.org"* for the S3 wildcard DNS entry. The validity of this certificate by default is one month, if more days are desired, specify command with "-days <# of days> (i.e." –days 366").

```
# openssl req -x509 -new -key server.key -config request.conf -out
server.crt

Enter pass phrase for server.key: <your passprhase from above>

You are about to be asked to enter information that will be
incorporated into your certificate request. What you are about to
enter is what is called a Distinguished Name or a DN. There are quite
a few fields but you can leave some blank
For some fields there will be a default value,
If you enter '.', the field will be left blank.
-----
Country Name (2 letter code) [AU]: <Enter value>
State or Province Name (full name) [Some-State]: <Enter value>
Locality Name (eg, city) []: <Enter value>
Organization Name (eg, company) [Internet Widgits Pty Ltd]: <Enter
value>
Organizational Unit Name (eg, section) []: <Enter value>
Common Name (e.g. server FQDN or YOUR name) []: *.os.ecstme.org
Email Address []: <admin email>

Please enter the following 'extra' attributes
to be sent with your certificate request
A challenge password []: <optional>
An optional company name []: <optional>
```

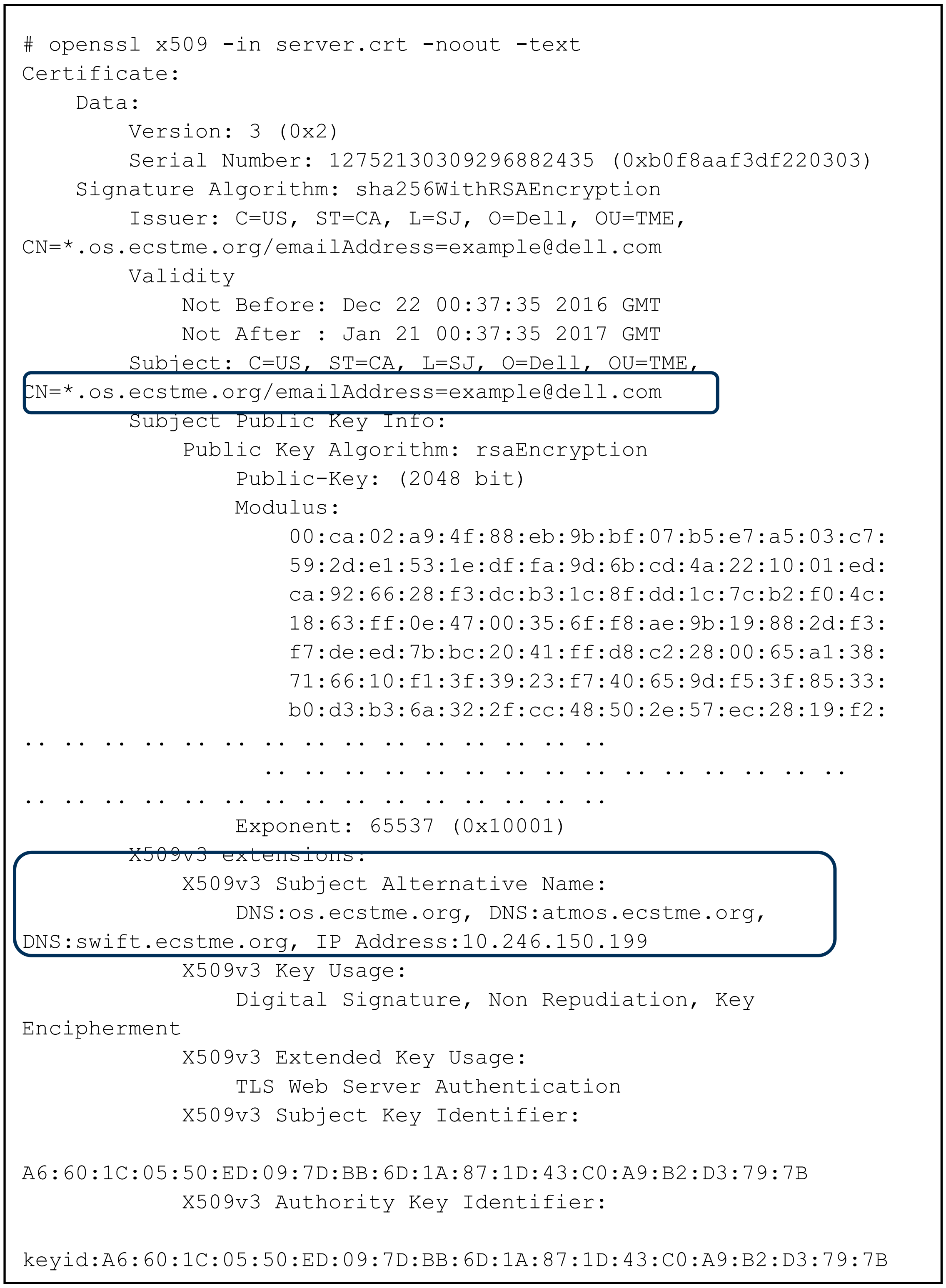
Figure 27 Command for creation of self-signed certificate

Step 3c: Validation of SANs in Certificate Request and Self Signed Certificate

In either certificate generation, user inputs and the Subject Alternate Names provided are included in the certificate. An openssl command to output certificate in text format is highlighted in Figure 28 and Figure 29 for each type of certificates.

```
# openssl req -in server.csr -text -noout
Certificate Request:
    Data:
        Version: 0 (0x0)
        Subject: C=US, ST=CA, L=SJ, O=Dell, OU=TME,
CN=*.os.ecstme.org/emailAddress=example@dell.com
        Subject Public Key Info:
            Public Key Algorithm: rsaEncryption
                Public-Key: (2048 bit)
                Modulus:
                    00:ca:02:a9:4f:88:eb:9b:bf:07:b5:e7:a5:03:c7:
                    59:2d:e1:53:1e:df:fa:9d:6b:cd:4a:22:10:01:ed:
                    ca:92:66:28:f3:dc:b3:1c:8f:dd:1c:7c:b2:f0:4c:
                    18:63:ff:0e:47:00:35:6f:f8:ae:9b:19:88:2d:f3:
                    f7:de:ed:7b:bc:20:41:ff:d8:c2:28:00:65:a1:38:
                    71:66:10:f1:3f:39:23:f7:40:65:9d:f5:3f:85:33:
                    b0:d3:b3:6a:32:2f:cc:48:50:2e:57:ec:28:19:f2:
                    85:01:d1:32:9c:51:df:2d:5f:0c:93:97:ad:cd:48:
                    1d:fe:50:5d:cc:44:03:15:48:20:cb:cf:b6:77:a4:
                    8c:11:71:57:68:34:9c:b8:3b:30:2e:0e:17:3e:78:
                    34:f4:66:bc:1c:99:9c:bb:ae:50:7f:89:53:f4:1f:
                    b2:7b:21:9c:34:42:01:66:eb:42:47:9d:af:ab:91:
                    6e:16:49:3c:cc:d4:51:14:96:1e:98:cc:c0:08:d1:
                    a8:71:a4:ab:aa:c6:a5:c4:b7:91:74:20:de:bf:e2:
                    71:b8:65:23:3e:3f:f5:21:c7:10:c3:d5:21:0a:52:
                    c6:a6:89:c7:ec:6e:ee:0f:78:58:3f:28:1a:92:b0:
                    40:a9:a8:a2:84:74:e0:72:b4:3e:c4:19:0c:d4:31:
                    6d:37
                Exponent: 65537 (0x10001)
        Attributes:
        Requested Extensions:
            X509v3 Subject Alternative Name:
                DNS:os.ecstme.org, DNS:atmos.ecstme.org,
DNS:swift.ecstme.org, IP Address:10.246.150.199
            X509v3 Key Usage:
                Digital Signature, Non Repudiation, Key Encipherment
            X509v3 Extended Key Usage:
                TLS Web Server Authentication
            X509v3 Subject Key Identifier:
```

Figure 28 Text Output of certificate request



```
# openssl x509 -in server.crt -noout -text
Certificate:
    Data:
        Version: 3 (0x2)
        Serial Number: 12752130309296882435 (0xb0f8aaf3df220303)
    Signature Algorithm: sha256WithRSAEncryption
        Issuer: C=US, ST=CA, L=SJ, O=Dell, OU=TME,
CN=*.os.ecstme.org/emailAddress=example@dell.com
        Validity
            Not Before: Dec 22 00:37:35 2016 GMT
            Not After : Jan 21 00:37:35 2017 GMT
        Subject: C=US, ST=CA, L=SJ, O=Dell, OU=TME,
CN=*.os.ecstme.org/emailAddress=example@dell.com
        Subject Public Key Info:
            Public Key Algorithm: rsaEncryption
                Public-Key: (2048 bit)
                Modulus:
                    00:ca:02:a9:4f:88:eb:9b:bf:07:b5:e7:a5:03:c7:
                    59:2d:e1:53:1e:df:fa:9d:6b:cd:4a:22:10:01:ed:
                    ca:92:66:28:f3:dc:b3:1c:8f:dd:1c:7c:b2:f0:4c:
                    18:63:ff:0e:47:00:35:6f:f8:ae:9b:19:88:2d:f3:
                    f7:de:ed:7b:bc:20:41:ff:d8:c2:28:00:65:a1:38:
                    71:66:10:f1:3f:39:23:f7:40:65:9d:f5:3f:85:33:
                    b0:d3:b3:6a:32:2f:cc:48:50:2e:57:ec:28:19:f2:
.. .. .. .. .. .. .. .. .. .. .. .. .. .. ..
                  .. .. .. .. .. .. .. .. .. .. .. .. .. .. ..
.. .. .. .. .. .. .. .. .. .. .. .. .. .. ..
                Exponent: 65537 (0x10001)
        X509v3 extensions:
            X509v3 Subject Alternative Name:
                DNS:os.ecstme.org, DNS:atmos.ecstme.org,
DNS:swift.ecstme.org, IP Address:10.246.150.199
            X509v3 Key Usage:
                Digital Signature, Non Repudiation, Key
Encipherment
            X509v3 Extended Key Usage:
                TLS Web Server Authentication
            X509v3 Subject Key Identifier:

A6:60:1C:05:50:ED:09:7D:BB:6D:1A:87:1D:43:C0:A9:B2:D3:79:7B
            X509v3 Authority Key Identifier:

keyid:A6:60:1C:05:50:ED:09:7D:BB:6D:1A:87:1D:43:C0:A9:B2:D3:79:7B
```

Figure 29 Self-signed certificate output after generation

Step 4: Combining the Private Key with Certificate File

After the certificate files have been created, HAProxy requires the private key to be combined with the certificate file. If your certificate was signed by a CA, the intermediate CA files and certificate chain file would need to also be appended to the certificate signing request prior to combining with the private key. Figure 30 illustrates how to extract the private key by removing the password, concatenate it with a self-signed certificate file to generate a combined file and then placing the combined file in HAProxy directory.

```
# openssl rsa -in server.key -out server_unsec.key
Enter pass phrase for server.key: <your passprhase from above>

# cat server.crt server_unsec.key > combined.pem
# rm server_unsec.key

# chown root:root combined.pem
# cp combined.pem /etc/haproxy/
```

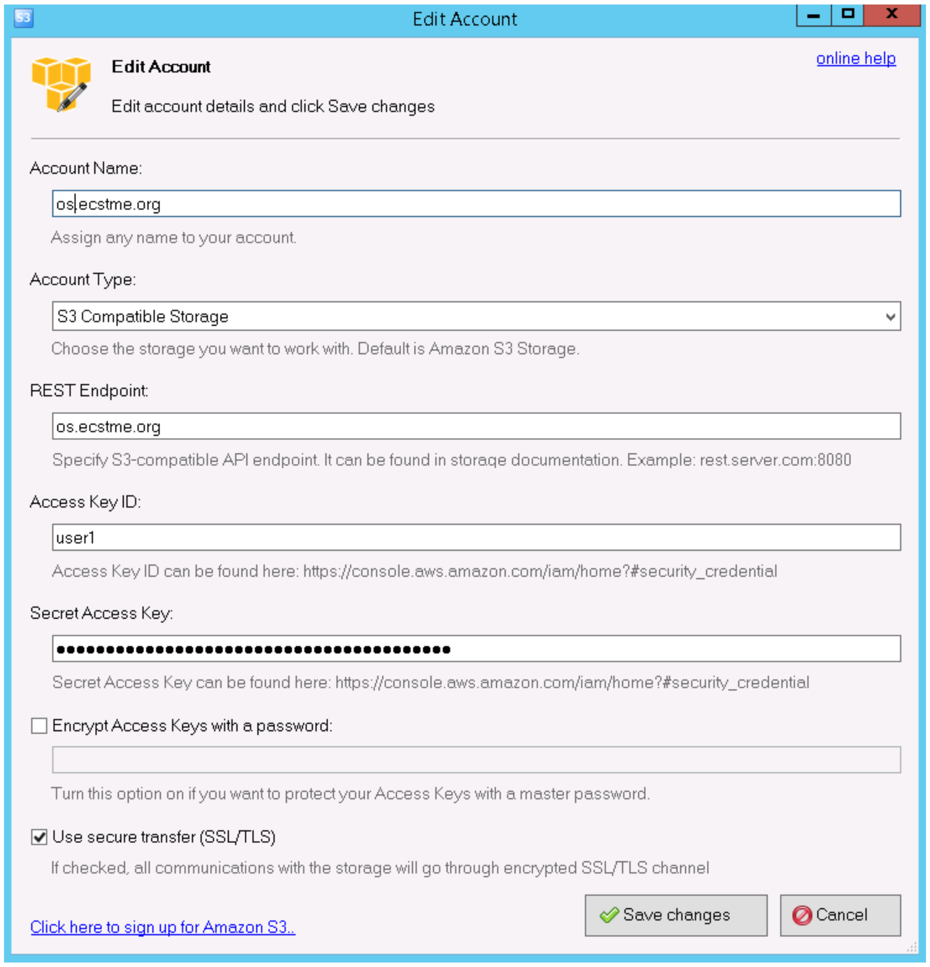
Figure 30 commands for combining the private key with certificate

Once the certificate generation has been completed, the frontend definition in HAProxy configuration file, “haproxy.cfg”, for https can be defined. Figure 31 provides an example of a frontend for handling https request. In this example the, SSL is terminated at the HAProxy load balancer and thus certificates will not need to be created for the ECS nodes and the same backend using the non-SSL ports of the ECS nodes will be used as previously defined in the http section. Check the validity of the configuration file and restart haproxy service to put in effect the load balancing directives defined for “https-in”.

```
frontend https-in
        bind *:443 ssl crt /etc/haproxy/combined.pem
        reqadd X-Forwarded-Proto:\ https

        # Define the hostnames
        acl host_s3 hdr(host) -i -m dom os.ecstme.org
        acl host_atmos hdr(host) -i -m dom atmos.ecstme.org
        acl host_swift hdr(host) -i -m dom swift.ecstme.org
        acl host_s3_ip hdr(host) -i -m dom 10.246.150.199

        # Route to backend
        use_backend swift_backend if host_swift
        use_backend atmos_backend if host_atmos
        use_backend s3_backend if host_s3
        use_backend s3_backend if host_s3_ip
```

Figure 31 Frontend definitions for HTTPS

S3Browser can be used to validate that “https” traffic and SSL certificates are going thru HAProxy. For S3 Browser, edit the account and place a checkmark in “Use secure transfer (SSL/TLS) box as pictured in Figure 32.



Edit Account

Edit account details and click Save changes

Account Name: os.ecstme.org

Assign any name to your account.

Account Type: S3 Compatible Storage

Choose the storage you want to work with. Default is Amazon S3 Storage.

REST Endpoint: os.ecstme.org

Specify S3-compatible API endpoint. It can be found in storage documentation. Example: rest.server.com:8080

Access Key ID: user1

Access Key ID can be found here: https://console.aws.amazon.com/iam/home?#security_credential

Secret Access Key: ●●

Secret Access Key can be found here: https://console.aws.amazon.com/iam/home?#security_credential

☐ Encrypt Access Keys with a password:

Turn this option on if you want to protect your Access Keys with a master password.

☑ Use secure transfer (SSL/TLS)

If checked, all communications with the storage will go through encrypted SSL/TLS channel

Click here to sign up for Amazon S3..

Figure 32 S3 Browser Options to Enable HTTPS

5.3.3 NFS

ECS NFS implementation utilizes server-side metadata caching and the cache exists locally on each node. Thus, it is important that NFS requests are handled by the same backend ECS node and a load balancer is used predominately for high availability purposes for NFS. If one of the ECS nodes currently serving NFS request fails, then HAProxy will redirect requests to another ECS node.

The Linux server that is hosting HAProxy should not be running “rpcbind” otherwise there will be a conflict when setting up HAProxy to forward NFS requests to ECS. If “rpcbind” is installed by default in the operating system, disable or remove.

Similar to the HTTP default definitions, there will be a set of defaults specifically for NFS requests as shown in Figure 33. The defaults will apply to all sections defined below the defaults NFS section. Thus in the defaults section, the mode, timeouts and balance algorithm for NFS are defined. For NFS, tcp mode or Layer 4 is used such that traffic is directly passed thru to the ECS Nodes for handling. Also, the load balance algorithm “source” is used. With load balance of source, backend server is selected based on a hash of the source IP such as the user IP address to ensure request goes to the same server until something changes in the hash (ie. one backend server goes down).

```
defaults NFS
        mode tcp
        log global
        option tcplog
        timeout client 1m
        timeout server 1m
        timeout connect 4s
        balance source
```

Figure 33 Defaults for NFS requests

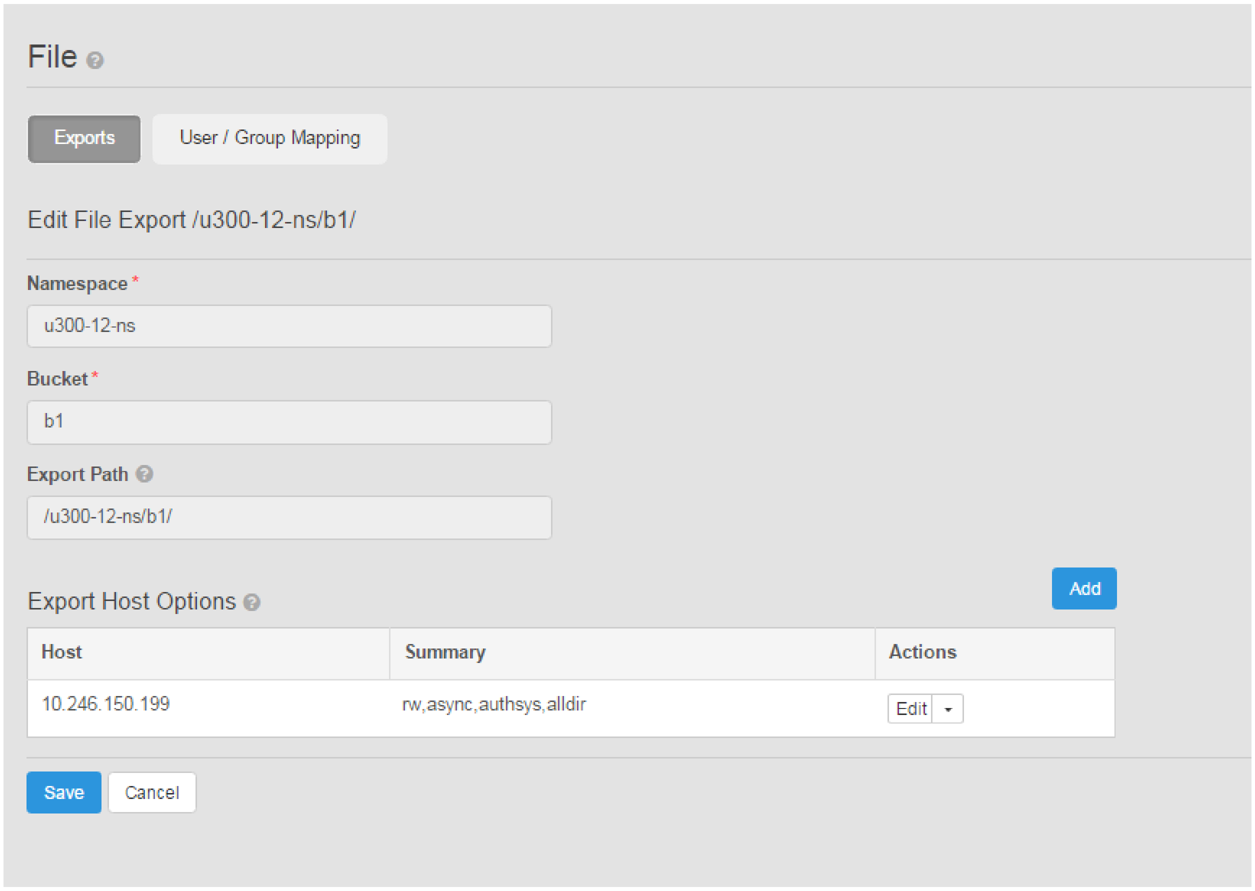
HAProxy will listen for requests on ports 2049, 111, and 10000 where NFS service and daemons such as nfsd, mountd, nlockmgr and portmapper are listening to on the ECS nodes. As shown in the example directives in Figure 34, there is a frontend and backend handler defined for each port. The backend defines the list of ECS nodes with the appropriate port. It is assumed that ECS has been configured to support file and the exports and user and group mappings have been configured appropriately for NFS. The HAProxy IP or hostname should be added to the exports hosts in ECS. Each backend server definitions has a check to conduct availability checks on each backend server. If the server check fails, then requests will be forwarded to another backend server on the list.

```
frontend nfs-in1
        bind *:2049
        use_backend nfs_backend1

frontend nfs-in2
        bind *:111
        use_backend nfs_backend2

frontend nfs-in3
        bind *:10000
        use_backend nfs_backend3

backend nfs_backend1
        server hop-u300-12-01 10.246.150.131:2049 check
        server hop-u300-12-02 10.246.150.132:2049 check
        server hop-u300-12-03 10.246.150.133:2049 check
        server hop-u300-12-04 10.246.150.134:2049 check

backend nfs_backend2
        server hop-u300-12-01 10.246.150.131:111 check
        server hop-u300-12-02 10.246.150.132:111 check
        server hop-u300-12-03 10.246.150.133:111 check
        server hop-u300-12-04 10.246.150.134:111 check
```

Figure 34 Frontend and backend definitions for NFS

The configuration file should be checked using the “haproxy –f haproxcy.cfg –c” command and the HAProxy service would need to be restarted using command “service haproxy restart” to pick up the changes to the haproxy.cfg. If using HAProxy version 1.7.10 or later, refer to Appendix A for another example that simplifies the frontend and backend definitions to handle NFS requests and provides an approach that improves this example by implementing stick tables.

As mentioned previously, ECS should have the File exports and user mappings configured prior to mount as pictured in Figure 35 and Figure 36 respectively. Then from an NFS client, another server different from HAProxy server, issue a mount command specifying the IP or name of HAProxy, port 2049 and NFS version 3. Figure 37 shows the example “mount” command and output of “df” command to illustrate the success of the mount. There should be an equivalent user in the Linux client with the same *userid* (506, in this example) specified as in ECS to access data as shown in Figure 38.



Edit File Export /u300-12-ns/b1/

Namespace*
u300-12-ns

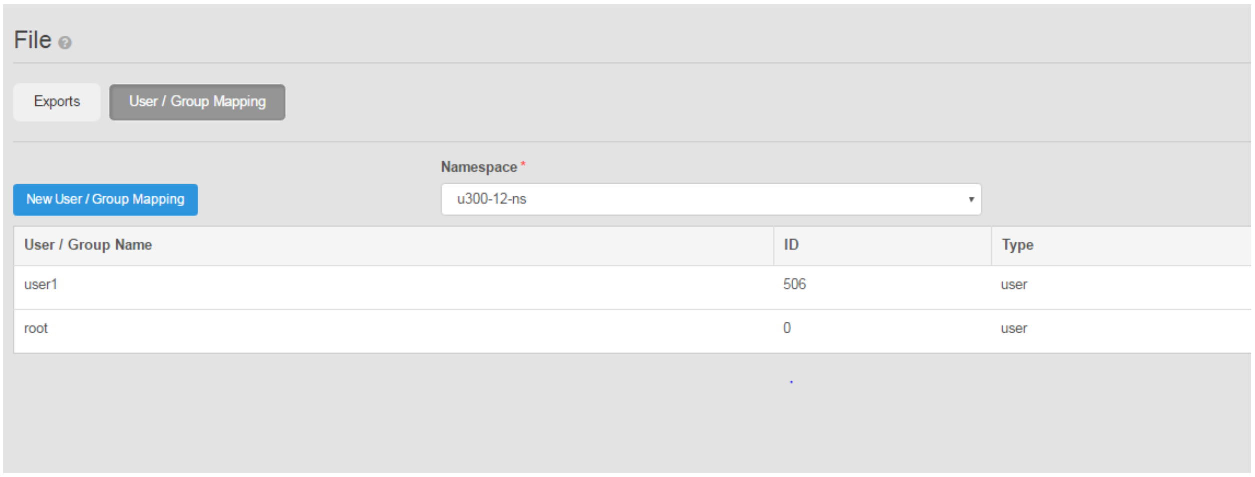
Bucket*
b1

Export Path
/u300-12-ns/b1/

Export Host Options

Host	Summary	Actions
10.246.150.199	rw,async,authsys,alldir	Edit

Figure 35 Example of File Export Settings in ECS



Namespace * u300-12-ns

User / Group Name	ID	Type
user1	506	user
root	0	user

Figure 36   Example of User Mapping Settings in ECS

```
c1-vm ~ # mount -o user,vers=3,proto=tcp,port=2049 os.ecstme.org:/u300-12-
ns/b1 /mnt
c1-vm ~ # df
Filesystem                      1K-blocks      Used    Available Use%
Mounted on
udev                              2008548         4      2008544   1% /dev
tmpfs                              404824      1212       403612   1% /run
/dev/sda1                        98952796   5615160     88288088   6% /
```

Figure 37   "Mount" and "df" command

```
user1@c1-vm:~$ id
uid=506(user1) gid=1002(user1) groups=1002(user1)

user1@c1-vm:~$ ls /mnt
ECS_-_Beauty_FL.jpg  foo1     foo10000  foo1_11  foo1_442  foo1_8    foo2
perfMon1BytesSentRec.gif       report-267335281_overview.pdf
foo                  foo1_0   foo1_10   foo1_4   foo1_7    foo1_933
haproxy.cfg  report-266278156_10K_1000.pdf  treport1.csv
```

Figure 38   Output of user ID on linux

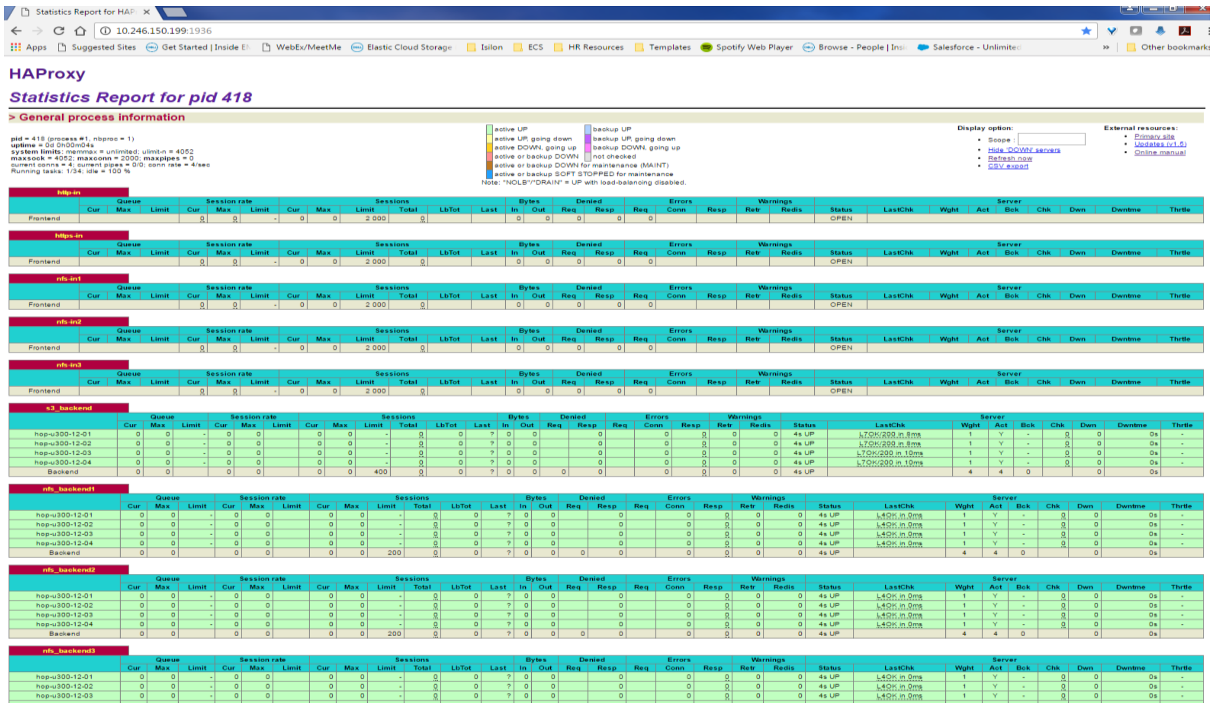
5.3.4 Monitoring

HAProxy provides a web monitoring capability that shows how much bandwidth is used, which backend ECS nodes are up or down, how many clients are connected, the number of bytes in and out, errors, warnings and much more. Monitoring information is also available to be exported in comma separated value (CSV) format. Tools can take advantage of this feature to provide a more enhanced experience such as adding graphs, charts and trending views. To set this up, the following lines shown in Figure 39 would need to be added to end of the haproxy.cfg file.

```
# Web monitoring
listen HAProxy_Stats
    bind 10.246.150.199:1936
    mode http
    stats enable
    stats uri /
    stats hide-version
    stats auth stats:password
```

Figure 39 HAProxy definitions for eeb monitoring.

An example of HAProxy web monitoring page is pictured in Figure 40 below. When accessing the Web Monitoring page, the username and password is indicated by the "stats auth" line which in this example is "stats:password".



HAProxy

Statistics Report for pid 418

> General process information

```
pid = 418 (process #1, nbproc = 1)
uptime = 0d 0h00m04s
system limits: memmax = unlimited; ulimit-n = 4052
maxsock = 4052; maxconn = 2000; maxpipes = 0
current conns = 4; current pipes = 0/0; conn rate = 4/sec
Running tasks: 1/34; idle = 100 %
```

🟩	active UP	▨	backup UP
🟨	active UP, going down	▨	backup UP, going down
🟧	active DOWN, going up	▨	backup DOWN, going up
🟥	active or backup DOWN	⬜	not checked
🟫	active or backup DOWN for maintenance (MAINT)		
🟦	active or backup SOFT STOPPED for maintenance		

Note: "NOLB"/"DRAIN" = UP with load-balancing disabled.

Display option:
- Scope :
- Hide 'DOWN' servers
- Refresh now
- CSV export

External resources:
- Primary site
- Updates (v1.5)
- Online manual

http-in

	Queue			Session rate			Sessions						Bytes		Denied		Errors			Warnings		Server								
	Cur	Max	Limit	Cur	Max	Limit	Cur	Max	Limit	Total	LbTot	Last	In	Out	Req	Resp	Req	Conn	Resp	Retr	Redis	Status	LastChk	Wght	Act	Bck	Chk	Dwn	Dwntme	Thrtle
Frontend				0	0	-	0	0	2 000	0			0	0	0	0	0					OPEN								

https-in

	Queue			Session rate			Sessions						Bytes		Denied		Errors			Warnings		Server								
	Cur	Max	Limit	Cur	Max	Limit	Cur	Max	Limit	Total	LbTot	Last	In	Out	Req	Resp	Req	Conn	Resp	Retr	Redis	Status	LastChk	Wght	Act	Bck	Chk	Dwn	Dwntme	Thrtle
Frontend				0	0	-	0	0	2 000	0			0	0	0	0	0					OPEN								

nfs-in1

	Queue			Session rate			Sessions						Bytes		Denied		Errors			Warnings		Server								
	Cur	Max	Limit	Cur	Max	Limit	Cur	Max	Limit	Total	LbTot	Last	In	Out	Req	Resp	Req	Conn	Resp	Retr	Redis	Status	LastChk	Wght	Act	Bck	Chk	Dwn	Dwntme	Thrtle
Frontend				0	0	-	0	0	2 000	0			0	0	0	0	0					OPEN								

nfs-in2

	Queue			Session rate			Sessions						Bytes		Denied		Errors			Warnings		Server								
	Cur	Max	Limit	Cur	Max	Limit	Cur	Max	Limit	Total	LbTot	Last	In	Out	Req	Resp	Req	Conn	Resp	Retr	Redis	Status	LastChk	Wght	Act	Bck	Chk	Dwn	Dwntme	Thrtle
Frontend				0	0	-	0	0	2 000	0			0	0	0	0	0					OPEN								

nfs-in3

	Queue			Session rate			Sessions						Bytes		Denied		Errors			Warnings		Server								
	Cur	Max	Limit	Cur	Max	Limit	Cur	Max	Limit	Total	LbTot	Last	In	Out	Req	Resp	Req	Conn	Resp	Retr	Redis	Status	LastChk	Wght	Act	Bck	Chk	Dwn	Dwntme	Thrtle
Frontend				0	0	-	0	0	2 000	0			0	0	0	0	0					OPEN								

s3_backend

	Queue			Session rate			Sessions						Bytes		Denied		Errors			Warnings		Server								
	Cur	Max	Limit	Cur	Max	Limit	Cur	Max	Limit	Total	LbTot	Last	In	Out	Req	Resp	Req	Conn	Resp	Retr	Redis	Status	LastChk	Wght	Act	Bck	Chk	Dwn	Dwntme	Thrtle
hop-u300-12-01	0	0	-	0	0		0	0	-	0	0	?	0	0		0		0	0	0	0	4s UP	L7OK/200 in 8ms	1	Y	-	0	0	0s	-
hop-u300-12-02	0	0	-	0	0		0	0	-	0	0	?	0	0		0		0	0	0	0	4s UP	L7OK/200 in 8ms	1	Y	-	0	0	0s	-
hop-u300-12-03	0	0	-	0	0		0	0	-	0	0	?	0	0		0		0	0	0	0	4s UP	L7OK/200 in 10ms	1	Y	-	0	0	0s	-
hop-u300-12-04	0	0	-	0	0		0	0	-	0	0	?	0	0		0		0	0	0	0	4s UP	L7OK/200 in 10ms	1	Y	-	0	0	0s	-
Backend	0	0		0	0		0	0	400	0	0	?	0	0	0	0		0	0	0	0	4s UP		4	4	0		0	0s	

nfs_backend1

	Queue			Session rate			Sessions						Bytes		Denied		Errors			Warnings		Server								
	Cur	Max	Limit	Cur	Max	Limit	Cur	Max	Limit	Total	LbTot	Last	In	Out	Req	Resp	Req	Conn	Resp	Retr	Redis	Status	LastChk	Wght	Act	Bck	Chk	Dwn	Dwntme	Thrtle
hop-u300-12-01	0	0	-	0	0		0	0	-	0	0	?	0	0		0		0	0	0	0	4s UP	L4OK in 0ms	1	Y	-	0	0	0s	-
hop-u300-12-02	0	0	-	0	0		0	0	-	0	0	?	0	0		0		0	0	0	0	4s UP	L4OK in 0ms	1	Y	-	0	0	0s	-
hop-u300-12-03	0	0	-	0	0		0	0	-	0	0	?	0	0		0		0	0	0	0	4s UP	L4OK in 0ms	1	Y	-	0	0	0s	-
hop-u300-12-04	0	0	-	0	0		0	0	-	0	0	?	0	0		0		0	0	0	0	4s UP	L4OK in 0ms	1	Y	-	0	0	0s	-
Backend	0	0		0	0		0	0	200	0	0	?	0	0	0	0		0	0	0	0	4s UP		4	4	0		0	0s	

nfs_backend2

	Queue			Session rate			Sessions						Bytes		Denied		Errors			Warnings		Server								
	Cur	Max	Limit	Cur	Max	Limit	Cur	Max	Limit	Total	LbTot	Last	In	Out	Req	Resp	Req	Conn	Resp	Retr	Redis	Status	LastChk	Wght	Act	Bck	Chk	Dwn	Dwntme	Thrtle
hop-u300-12-01	0	0	-	0	0		0	0	-	0	0	?	0	0		0		0	0	0	0	4s UP	L4OK in 0ms	1	Y	-	0	0	0s	-
hop-u300-12-02	0	0	-	0	0		0	0	-	0	0	?	0	0		0		0	0	0	0	4s UP	L4OK in 0ms	1	Y	-	0	0	0s	-
hop-u300-12-03	0	0	-	0	0		0	0	-	0	0	?	0	0		0		0	0	0	0	4s UP	L4OK in 0ms	1	Y	-	0	0	0s	-
hop-u300-12-04	0	0	-	0	0		0	0	-	0	0	?	0	0		0		0	0	0	0	4s UP	L4OK in 0ms	1	Y	-	0	0	0s	-
Backend	0	0		0	0		0	0	200	0	0	?	0	0	0	0		0	0	0	0	4s UP		4	4	0		0	0s	

nfs_backend3

	Queue			Session rate			Sessions						Bytes		Denied		Errors			Warnings		Server								
	Cur	Max	Limit	Cur	Max	Limit	Cur	Max	Limit	Total	LbTot	Last	In	Out	Req	Resp	Req	Conn	Resp	Retr	Redis	Status	LastChk	Wght	Act	Bck	Chk	Dwn	Dwntme	Thrtle
hop-u300-12-01	0	0	-	0	0		0	0	-	0	0	?	0	0		0		0	0	0	0	4s UP	L4OK in 0ms	1	Y	-	0	0	0s	-
hop-u300-12-02	0	0	-	0	0		0	0	-	0	0	?	0	0		0		0	0	0	0	4s UP	L4OK in 0ms	1	Y	-	0	0	0s	-
hop-u300-12-03	0	0	-	0	0		0	0	-	0	0	?	0	0		0		0	0	0	0	4s UP	L4OK in 0ms	1	Y	-	0	0	0s	-

Figure 40 HAProxy web monitoring page

5.4 Example of ECS with Redundant HAProxy Setup

The ECS with single HAProxy example in previous section can be extended to add another HAProxy to create a redundant HAProxy setup. In this example, another virtual machine with Mint operating system and HAProxy load balancer was configured. The “keepalived” utility was installed on both HAProxy servers to do health checks between the two HAProxy load balancers. The redundant HAProxy load balancers were configured in an active/passive mode. A virtual IP initially maps to a primary HAProxy and if the primary load balancer fails, then the virtual IP will point to the IP of secondary load balancer until the primary load balancer comes up again. Figure 41 illustrates the setup for the redundant HAProxy load balancers environment described in this example.

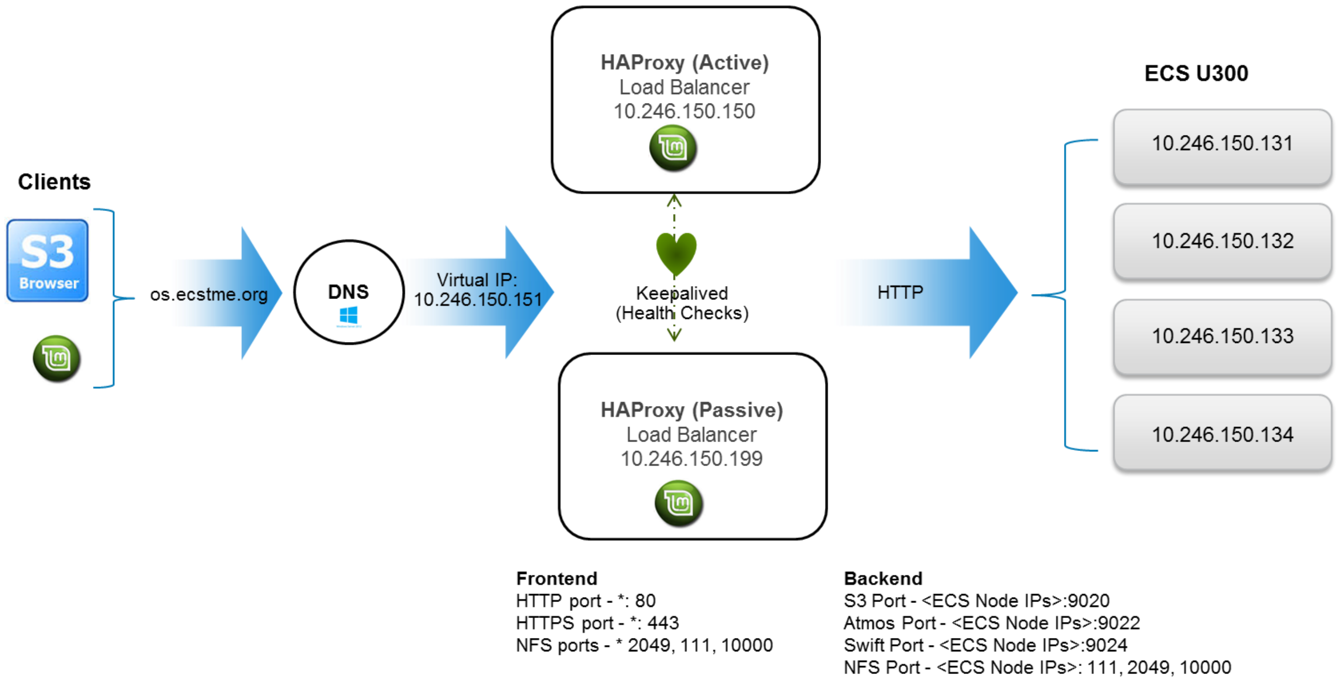


Figure 41 ECS with Redundant HAProxy Setup Example

5.4.1 Virtual IP

On each of the load balancer servers which is hosted on a virtual machine with Mint installed, modify the *“net.ipv4.ip_nonlocal_bind”* to 1 in the kernel file /etc/sysctl.conf to allow HAProxy to bind to a shared IP address which is 10.246.150.151 in this example. With an editor, such as “vi”, add the line shown in Figure 42.

```
net.ipv4.ip_nonlocal_bind=1
```

Figure 42 Add to "/etc/sysctl.conf"

Run “sysctl –p” command to have this setting take into effect without the need to reboot as shown in Figure 43.

```
# sysctl -p
```

Figure 43   Command to enable the setting modified

5.4.2 Keepalived

The keepalived utility is a routing software package available on Linux. It is written in C and its main purpose is to provide health checks between systems. Install the keepalived utility on both load balancers. Figure 44 provides the commands to install keepalived.

```
# apt-get update
```

Figure 44   Command to install keepalived

In both load balancers, edit or create a keepalived.conf file in “/etc/keepalived” directory with entries as shown in Figure 45 and Figure 46. The difference between the two files is the priority value, where 101 represent the primary and 100 is secondary. Also note that eth0 is set to the virtual IP. For more information on keepalived, refer to the Keepalived website: http://www.keepalived.org/

```
vrrp_script ckhaproxy {                  # Use version keepalived-1.1.13 or
higher
        script "killall -0 haproxy"      # Check if process exists
        interval 2                       # Does checks every two seconds
        weight 2                         # Add two points of prio if OK
}

vrrp_instance vi1 {
        virtual_router_id 51
        state MASTER
        priority 101                     # 101 is primary and 100 is
secondary
        interface eth0
        virtual_ipaddress {
            10.246.150.151               # Virtual IP
        }
        track_script {
            ckhaproxy
```

Figure 45 Keepalived.conf for primary load balancer

```
vrrp_script ckhaproxy {                    # Use version keepalived-
1.1.13 or higher
        script "killall -0 haproxy"     # Check if process exists
        interval 2                      # Does checks every two
seconds
        weight 2                        # Add two points of prio if
OK
}

vrrp_instance vi1 {
        virtual_router_id 51
        state MASTER
        priority 100                    # 101 is primary and 100 is
secondary
        interface eth0
        virtual_ipaddress {
            10.246.150.151              # Virtual IP
        }
        track_script {
            ckhaproxy
        }
}
```

Figure 46 Keepalived.conf for secondary load balancer

Prior to starting the service, it is recommended as a best practice to validate that the *virtual_router_id* is not already being used on the same network. Running tcpdump command (i.e. tcpdump -i eth0 host 224.0.0.18) on primary and secondary HAProxy hosts can provide information on whether the identifier is being used. To further secure your virtual IP from being taken over by a primary router or prevent devices to use the same identifier, setting a virtual router redundancy protocol (vrrp) password is another option.

Afterwards, start the keepalived service on each load balancer server as illustrated in Figure 47.

```
# service keepalived start
```

Figure 47 Command to start keepalived

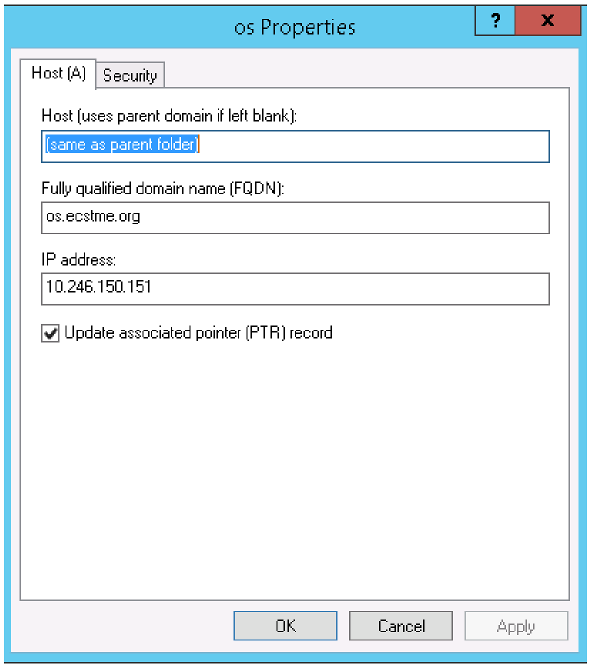
Then, check that the virtual IP is on the primary load balancer server as highlighted in Figure 48.

```
# ip addr show eth0
2: eth0: <BROADCAST,MULTICAST,UP,LOWER_UP> mtu 1500 qdisc mq state UP group
default qlen 1000
    link/ether 00:0c:29:37:17:49 brd ff:ff:ff:ff:ff:ff
    inet 10.246.150.150/24 brd 10.246.150.255 scope global eth0
       valid_lft forever preferred_lft forever
    inet 10.246.150.151/32 scope global eth0
       valid_lft forever preferred_lft forever
    inet6 fe80::20c:29ff:fe37:1749/64 scope link
       valid_lft forever preferred_lft forever
```

Figure 48 Virtual IP on primary load balancer Server

5.4.3 Redundant HAProxy and DNS

On the redundant HAProxy load balancer server, copy the haproxy.cfg file and the SSL certificate created on the other HAProxy load balancer described in the previous example and place in the /etc/haproxy directory and start the haproxy service. For the SSL certificates, DNS names in the SANs should be used as opposed to IP addresses so the same certificate file can be used on both systems. Then modify the DNS as pictured in Figure 49 to point the os.ecstme.org A-record to the virtual IP defined in the keepalived.conf file, 10.246.150.151 in this example.



Host (uses parent domain if left blank):
(same as parent folder)

Fully qualified domain name (FQDN):
os.ecstme.org

IP address:
10.246.150.151

[✓] Update associated pointer (PTR) record

Figure 49 Virtual IP Set in DNS

5.4.4 Validation

Start the S3 Browser to validate the setup. Since the S3 browser is utilizing the DNS entry name, “os.ecstme.org”, no additional modifications are needed. Afterwards, shutdown the primary HAProxy load balancer to validate the redundant setup. Once the secondary HAProxy load balancer recognizes that the primary is down, the secondary will pick up the Virtual IP as exemplified in Figure 50. Access to the objects on ECS should still be available via S3 Browser since the secondary HAProxy load balancer is handling the requests.

```
2: eth0: <BROADCAST,MULTICAST,UP,LOWER_UP> mtu 1500 qdisc mq state UP group
default qlen 1000
    link/ether 00:0c:29:b1:d6:a3 brd ff:ff:ff:ff:ff:ff
    inet 10.246.150.199/24 brd 10.246.150.255 scope global eth0
       valid_lft forever preferred_lft forever
    inet 10.246.150.151/32 scope global eth0
       valid_lft forever preferred_lft forever
    inet6 fe80::20c:29ff:feb1:d6a3/64 scope link
       valid_lft forever preferred_lft forever
```

Figure 50   Virtual IP on secondary load balancer server

6 Best Practices

Utilizing a load balancer with ECS is highly recommended. Highlights of some the best practices when deploying with ECS include:

- Do not use a load balancer for CAS traffic since the Centera SDK has a built-in load balancer in software and cannot function without direct access to all nodes.
- Load balancer is best for data traffic.
- Use the load balancer to terminate SSL connections to reduce the load on the ECS Nodes
- If SSL termination is required on ECS nodes itself, then use Layer 4 (tcp) to pass through the SSL traffic to ECS nodes for handling. The certificates would need to be installed on the ECS nodes and not on the load balancer.
- Use redundant load balancers to prevent single point of failure.
- For NFS, use only the high available functionality of the load balancer.
- Enable web monitoring for HAProxy to monitor traffic.
- When deploying 3 or more ECS sites, employ a global load balancing mechanism to distribute load across sites to take advantage of ECS XOR storage efficiency. Also important to optimize the local object read hit rate in a global deployment.

7 Conclusion

HAProxy load balancer provides a low-cost option for customers desiring to utilize a load balancer with ECS. It offers both Layer 4 and Layer 7 load balancing that is sufficient to support client requests for both object and file access on ECS. An example and best practices were described in this whitepaper to provide guidance and a reference to architects interested in deploying HAProxy with ECS.

A Other Configuration Examples

This section discusses recommendations provided by HAProxy engineer, Baptiste Assmann (bassmann@haproxy.com). The sample configuration files in this section simplifies and improves upon the configuration files defined in the previous examples for HTTP and NFS.

A.1 HTTP/HTTPS Configuration Definitions

In the previous example for handling HTTP requests described in Section 5.3.1, the frontend defined three different rules to handle the different ECS protocols (object, atmos and swift). Also there was a separate frontend to handle HTTPS type of requests described in Section 5.3.2. In the example shown in Figure 51, there is a single frontend to handle both http and https type of traffic and a single rule. In order to handle virtual host style addressing (i.e. prepending bucket name to ECS base URL), a separate map file called host2backen.map is defined. This file contains two entries, the host header it needs to match and the destination backend name that will handle the request with the matching host header as illustrated in Figure 50.

```
#regex_matching_host_header   destination_backend_name
os.ecstme.org                 os
atmos.ecstme.org              atmos
swift.ecstme.org              swift
```

Figure 51 Map file for HAProxy

After the globals and defaults section of the configuration file in /etc/haproxy/haproxy.cfg, append the frontend block shown in Figure 50. The first line in the frontend block *"http-in"* tells HAProxy to listen for requests on port 80 for http requests and port 443 for https requests on all interfaces. It also specifies a single use_backend rule to route the traffic to the backend having the same name as the host header defined in the host2backend.map file. For instance, if the path of the user header request contains *"os.ecstme.org, atmos.ecstme.org,* or *swift.ecstme.org"* it will re-direct the request to appropriate named protocol backend such as *os, atmos, and swift*.

```
frontend http-in
        bind *:80 name http
        bind *:443 name https ssl crt /etc/haproxy/lbhai.pem

        # Define the hostnames
        http-request add-header X-Forwarded-Proto https if { ssl_fc }
        use_backend
%[req.hdr(Host),lower,word(1,:),map_reg(/etc/haproxy/host2backend.map)]
```

Figure 52 Frontend definitions for object access

Further append the haproxy.cfg file with the backend definitions of "*os"*, *"swift"*, and *"atmos"* specified as the named backend in host2backend.map file as shown in Figure 52. Each object protocol goes through a certain port thus all S3 requests for http go thru port 9020, Atmos, thru port 9022, and Swift thru 9024. So for each protocol backend, a list of ECS nodes IP addresses and ports are specified in *"server"* line. Similar the previous example described in Section 5, the s3_backend and swift_backend, *"check"* is added at the end of the line to perform health checks on ECS services on each node using "S3 ping" or "Swift healthcheck" as specified in "option httpchk". The *"check"* specified for atmos_backend will only check if the ECS node is reachable since this protocol does not yet have support for the "ping operation" to check the ECS services.

```
backend os
        # Use the s3 Ping ViPR extension to make sure node
        # is alive

        option httpchk GET /?ping "HTTP/1.1\r\nHost: haproxy"

        # List of data nodes.  S3 runs on port 9020.
        server hop-u300-12-01 10.246.150.179:9020 check
        server hop-u300-12-02 10.246.150.180:9020 check
        server hop-u300-12-03 10.246.150.181:9020 check
        server hop-u300-12-04 10.246.150.182:9020 check

backend atmos
        # List of data nodes.  Atmos runs on port 9022
        server hop-u300-12-01 10.246.150.179:9022 check
        server hop-u300-12-02 10.246.150.180:9022 check
        server hop-u300-12-03 10.246.150.181:9022 check
        server hop-u300-12-04 10.246.150.182:9022 check

backend swift
        option httpchk HEAD /healthcheck HTTP/1.0
        # List of data nodes.  Swift runs on port 9024
        server hop-u300-12-01 10.246.150.179:9024 check
        server hop-u300-12-02 10.246.150.180:9024 check
        server hop-u300-12-03 10.246.150.181:9024 check
        server hop-u300-12-04 10.246.150.182:9024 check
```

Figure 53 Backend definitions using map

This example provides a more manageable solution especially if the HAProxy server is forwarding different types of requests to numerous backend servers. Thus, a single frontend rule is able to handle other types of requests by adding another entry in the host2backend.map file which defines the host header to match and the name of backend handler in the configuration file.

A.2 NFS Configuration Definitions

Note: The definitions in this section to handle NFS requests will only work with HAProxy version 1.7.10 or later.

The HAProxy definitions for NFS discussed in Section 5.3.3 has been further simplified by combining all frontend and backend definitions for each port into a single handler section as shown in Figure 54. In this example, it is not required for the port to be specified in the server line. If there is no port defined on the server line, HAProxy will automatically forward the traffic to the same port that the request came in. Also, stick tables are implemented in this example. By using stick tables, a client is “sticked” to a server such that requests are redirected to the same backend server , unless the server is down or the entry expires in the stick table. For NFS requests, this stickiness is important since ECS utilizes server-side metadata caching and the cache exists locally on each node. Stick tables stores the source IP address in memory. In this example, the size of this table is 10k.

```
peers haproxy
        peer glb 10.246.150.150:1023
defaults NFS
        mode tcp
        log global
        option tcplog
        timeout client 1m
        timeout server 1m
        timeout connect 4s
        balance source
# Only works on HAProxy version 1.8 or later
frontend nfs-in
        bind *:2049
        bind *:111
        bind *:10000
        mode tcp
        use_backend nfs_backend

backend nfs_backend
        mode tcp
        option tcp-check
        tcp-check connect port 111
        tcp-check connect port 2049
        tcp-check connect port 10000
        stick-table type ip size 10k expire 24h peers haproxy
        stick on src

        server hop-u300-12-01 10.246.150.179 check
        server hop-u300-12-02 10.246.150.180 check
        server hop-u300-12-03 10.246.150.181 check
        server hop-u300-12-04 10.246.150.182 check
```

Figure 54 simplified frontend and backend for ECS NFS

For redundancy and reload safe purposes, a “peers” section is defined to synchronize the content of the stick table between multiple HAProxy instances. In this example only one HAProxy instance is being used where the IP address is the IP of the HAProxy host and the peer name is actual hostname of server running HAProxy instance which is “glb”. The port of the peer can be any number as long as firewalls are open for this port.

For more information on stick tables, refer to this blog by Baptiste, https://www.haproxy.com/blog/client-ip-persistence-or-source-ip-hash-load-balancing/