Documenting: Virtual Design Master – Challenge 2

Presented to: Messrs. Virtual Design Master Judges

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[Synopsis]

We've examined how we can rebuild infrastructure from scratch, but now let's think outside the box, and inside the clouds. Before the zombie apocalypse began, many organizations were beginning to leverage public cloud infrastructures for a number of reasons. Some were using it for burst capacity, others for dev and test. Some startups even used public cloud for everything! Our billionaire philanthropist from Season 1 is a huge fan of public cloud, and was one of the early adopters. HIs task for you now is to design an environment to meet our needs using any existing public cloud infrastructure to run it on top of. Be sure to let him know why you picked this particular public cloud infrastructure, as if he's going to re-create it on Mars, he wants to make sure he's making the best choice.

Now for the fun part. We talked about a number of business critical applications in the first challenge. You must deploy one web application (think the time tracking application for the botanists in the greenhouses) and one business critical enterprise application (think life support systems) inside the public cloud infrastructure. As part of your design, you must state what the application requirements you are using are. Remember to think about things like performance, capacity, latency, and high availability. In this case, complexity can be your enemy, but the details can be your friend. Besides your overall design, you will also be judged on the application requirements you develop.

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1. Executive Summary

1.1. Project Overview

So for us to put out workload on a public cloud infrastructure we need to build one first, this project is all about delivering a solution that can accommodate the core IT services any business needs (even those based in Mars).

So on earth this was called a Public Cloud but on Mars I think we're ought to name it the Public Interstellar Cloud Services [**PICS**] (we have high hopes of delivering IT services to alien life form as well ;-)).

1.2. Intended audience

The document is to be used by the party responsible for implementing this solution following this design guide (you might need to get a spaceship because selling Interstellar Cloud Services will require moving between planets and galaxies).

1.3. Project Insights

Delivering a Public Interstellar Cloud Services using a Public Cloud Infrastructure technology from one of the elite vendors whom used to provide such services back on Earth.

1.3.1. Project Requirement

- R001: Accommodate burst capacity consumption model.
- R002: Accommodate dev/test consumption model.
- R003: Accommodate general usage consumption model.
- R004: Provision a public cloud instance for the current workload.
- R005: Web Application Design.
- R006: Business Critical Enterprise Application Design.

1.3.2. Project Constrains

- C001: Power and cooling.
- C002: Network latency.
- C003: High workloads might not be suitable for a Public Interstellar Cloud Infrastructure.
- C004: Disaster Recovery in case of a planetary failure.

1.3.3. Project Assumptions

- A001: There might be local infrastructures that want to integrate with the public cloud,
- A002: Network resources availability (Network addresses, DNS, LDAP, NTP, SSL and VPN).
- A003: All software packages and licenses were brought from earth.
- A004: The administration team is most knowledgeable with VMware technologies.

- A005: The SLAs that were made on earth are not binding on Mars, new SLAs will be written.
- A006: Money is not a caliber for comparison, the caliber is meeting the requirement.

2. Public Interstellar Cloud Services Platform Choice

Although we are fond of most of the cloud service providers back on earth, ultimately on Mars we're forced to choose a single platform to build ours PICS on, hereunder is the platform's main characteristics:

Reference Tag	Characteristic	Description	Key Metrics
CR001	Availability	Indicates the effect of a choice on the ability of a technology and the related infrastructure to achieve highly available operation and to sustain operation during system failures.	Percentage uptime
CR002	Performance	Reflects whether the option has a positive or negative impact on the overall infrastructure performance.	System response time System throughput
CR003	Scalability	Depicts the effect the option has on the ability of the solution to be augmented to achieve higher sustained performance within the infrastructure.	Utilization Cost/performance ratio
CR004	Security	Reflects whether the option has a positive or negative impact on overall infrastructure security. Can also indicate whether a quality has an impact on the ability of a business to demonstrate or achieve compliance with certain regulatory policies.	Unauthorized access prevention Data integrity and confidentiality Forensic capabilities in case of a compromise
CR005	Manageability	Relates the effect of a choice on overall infrastructure manageability.	Servers per administrator Clients per IT staff Time to deploy
CR006	Recoverability	Indicates the effect of a choice on the ability to recover from a catastrophic event.	Recovery time objective (RTO) Recovery point objective (RPO)

After evaluating other platforms it has become clear to us that **VMware's vCloud Air** platform has the requirements fulfilled, hereunder is a list of what VMware vCloud Air Service Offerings:

Service Offering
Compute
Availability Services
Storage
Network Services
Security and Compliance
Data Services
Developer Services
Mobile Services
Business Applications
Management

The up above service offerings are more than adequate to meet our requirement and criteria, as such the design decision is vCloud Air.

3. PICS Design Summary

3.1. PICS Physical Design

Since we have established 3 datacenters on Mars, we will be utilizing these datacenters to be our point of service, taking that into consideration we have performed an overhauling to these datacenter and the hardware design is now as follows:

3.1.1. Power

Solar Panels -> the Sun is a reliable, robust, and plentiful energy source. Using solar panels is the best choice for our PICS since it takes away the requirement to develop a complex power source, thereby saving time and money while avoiding the risks and concerns of the use of a nuclear power source.

3.1.2. Cooling

Ice Thermal Storage -> Mars is a planet that has a great portion of its geographical space filled with ice in addition to ice clouds formation. Cooling with ice thermal storage can be the most cost-effective, reliable system approach to cooling the datacenters and provides steady source of low temperature fluids for process cooling applications.

3.1.3. pCompute

We will be utilizing rack mounted servers in all datacenters, the vendor not yet known because we might be building our own servers to fit exactly our needs.

Eventually the nodes will be divided into two categories:

3.1.3.1. Management: these will be handling the vCloud Air VMs building blocks.
3.1.3.2. Servicing: these will be handling the vCloud Air user clouds.

3.1.4. pNetworking

3.1.4.1. LAN: 40Gbs switches will serve the core and 10Gbs will serve the hosts.
3.1.4.2. WAN: Since Mars now has its own satellite network, we will be utilizing the Mars Satellite Internet for data transfer, a common misconception is that latency has an effect on transfer rate. This is not true. A one Megabyte file will transfer just as quick over a 1000 Kbps (Kilobits per second) satellite connection as it does over a 1000 Kbps terrestrial connection. The only difference is that the satellite connection takes a half second to begin the file transfer, which is insignificant. Thus reducing the complexity of establishing network service locations to accommodate service delivery and access.

3.1.5. pStorage

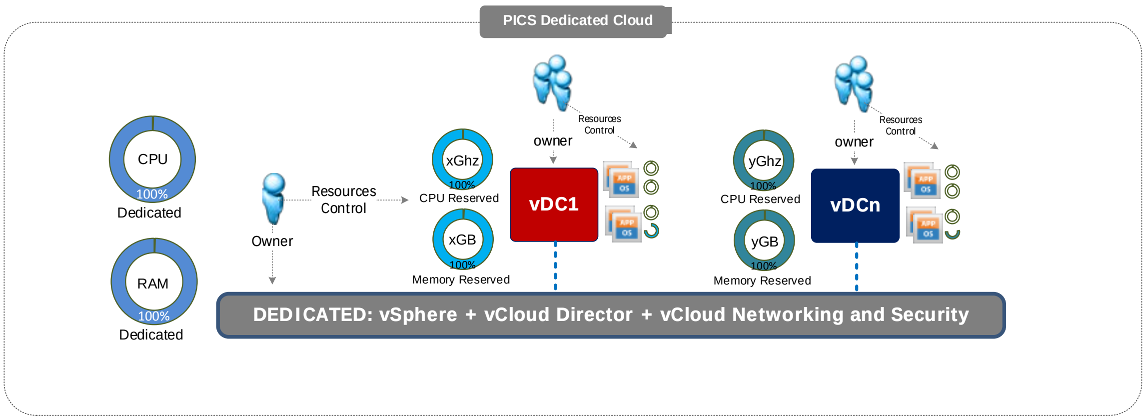
Because we're utilizing VMware technologies we get the added value of implementing our hosts with VSAN configured, thus removing the need of having a farm of dedicated SANs and fabrics and eventually reducing the complexity.

3.2. PICS Logical Design

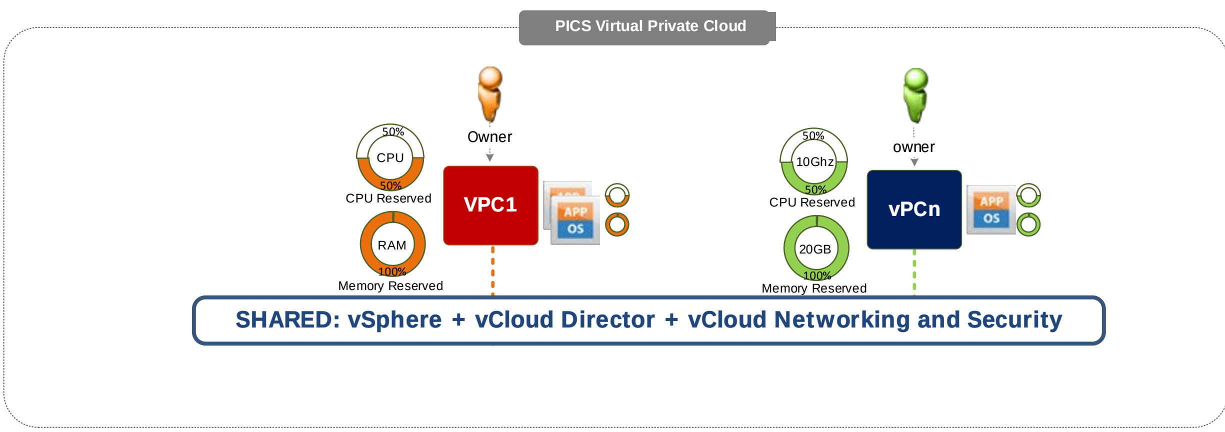
3.2.1. Cloud Offerings

vCloud Air is an Infrastructure as a Service (IaaS) offering with the following class of service alternatives:

- Dedicated Cloud – Class of service provides a single-tenant, private cloud with dedicated computing servers and Layer 2 network isolation for workload traffic. It also provides dedicated storage volumes and a dedicated cloud management instance. Infrastructure capacity can be allocated to a single virtual data center or multiple data centers.



- Virtual Private Cloud – Class of service provides a multi-tenant virtual private cloud with logically- isolated resources on a shared physical infrastructure, configured as a single virtual data center with networking resources.



- vCloud Air Disaster Recovery – Class of service provides a reserved multi-tenant virtual private cloud, configured as a disaster recovery virtual data center for replication, failover, and recovery of remote virtual machines. Similar to Virtual Private Cloud, this class of service leverages logically isolated resources on a shared physical infrastructure.

Component	Dedicated Cloud	Virtual Private Cloud
• Access Portal	• Shared	• Shared
• pNetwork infrastructure	• Shared	• Shared
• pStorage infrastructure	• Shared	• Shared
• pCompute infrastructure	• Dedicated	• Shared
• Workloads VLANs	• Dedicated	• Shared

• LUNs (datastores)	• Dedicated	• Shared
• vCenter / database	• Dedicated	• Shared
• vCloud Director cell / database	• Dedicated	• Shared
• VMware vShield™ Manager	• Dedicated	• Shared
• VXLAN vWires	• Dedicated	• Dedicated
• Edge gateways	• Dedicated	• Dedicated
• Private catalogue	• Dedicated	• Dedicated

Both of the up above offerings are suitable for:

- **Burst capacity environment.**
- **General usage environment.**
- **Development and testing environment.**

3.2.2. Service Objects

Each class of service includes the capability to access the following objects and manage them to align with different consumption and administration models.

1. Virtual data centers in all classes of service will be set up with an internal virtual data center network and edge gateway with an optional NAT-routed network.

2. Virtual machines are first-class objects in vCloud Air interactions. They can be created and managed individually. VMware vSphere vApps will be visible along with their virtual machine associations on the vCloud Air console, but can be created or managed only through VMware vCloud Director.

3. Networks can be managed through the vCloud Air console for edge gateway configuration and common use cases such as NAT mappings, firewall rules, and virtual machine-to-network assignment. Advanced configuration and management such as VPN setup, load balancing, and network creation can be performed through the vCloud Director interface, which is accessible through the vCloud Air Console.

3.2.3. High Availability

vCloud Air is delivered using infrastructure that is architected for High Availability, leveraging vSphere vMotion, Distributed Resource Scheduler (DRS), and vSphere HA to migrate live workloads and/or automatically restart VMs in the event of unexpected issues. The Edge Gateways are also highly available in an active-standby pair to ensure that networks are protected and available after an event.

3.2.4. Resource Allocations

At a high level, a Virtual Private Cloud and a virtual data center on a Dedicated Cloud are essentially the same object type, but they differ considerably in how computational resources are allocated.

In a Dedicated Cloud model, every virtual data center is configured as a reservation pool and administrators can change resource reservations per virtual machine.

A limit equal to the reservation is set on a resource pool level, which gives the tenant a guaranteed pool of resources. There are no limits or reservations set on a per virtual machine level, which gives the virtual data center administrator flexibility. However, this flexibility could lead to severe over-commitment. As such, it is recommended to limit the amount of virtual machines to avoid a degraded user experience.

In a Virtual Private Cloud model, every Virtual Private Cloud is configured as an allocation pool with 50 percent memory reserved and 50 percent CPU reserved. No resource controls are permitted.

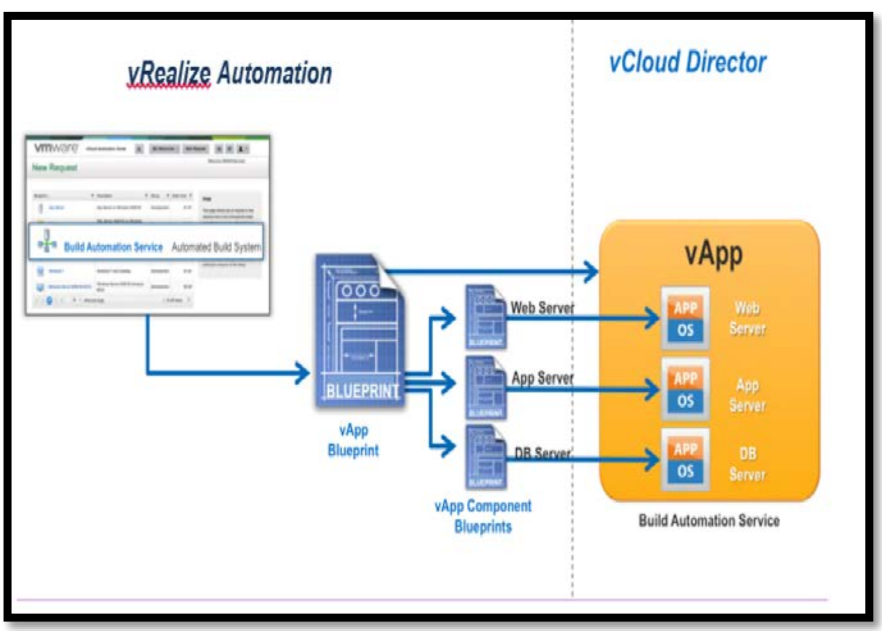
This means that the Virtual Private Cloud can never be over-committed, and the number of virtual machines strictly depends on the quantity of GB assigned until the purchased GB is reached.

Regardless of their nature, all virtual data centers appear as badges in the vCloud Air portal.

3.2.5. Provisioning (Blueprints and Catalogs)

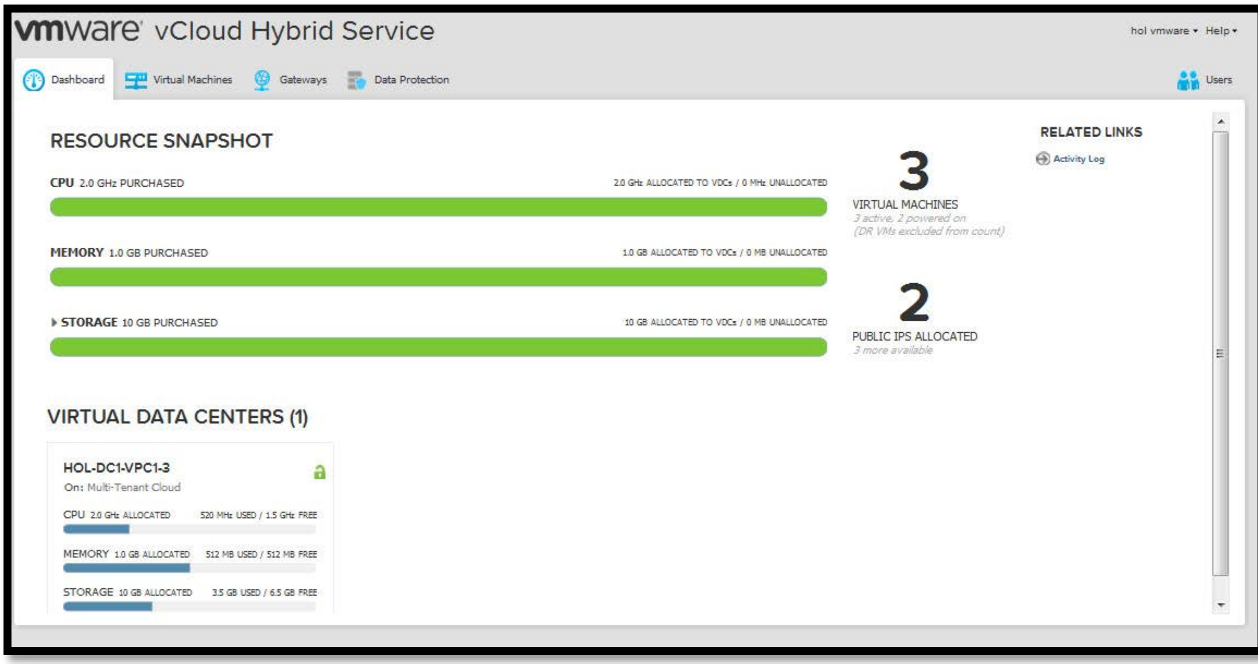
Blueprints: for vCloud Air are configured in VMware vRealize Automation as “vApp (vCloud Director)”. This means they can be configured as a single instance of multiple virtual machines.

Catalogs: After the blueprint has been published, it can be made available to each business group. It is important to distinguish where this blueprint is going to be published so that the users will know what kind of service they are requesting.

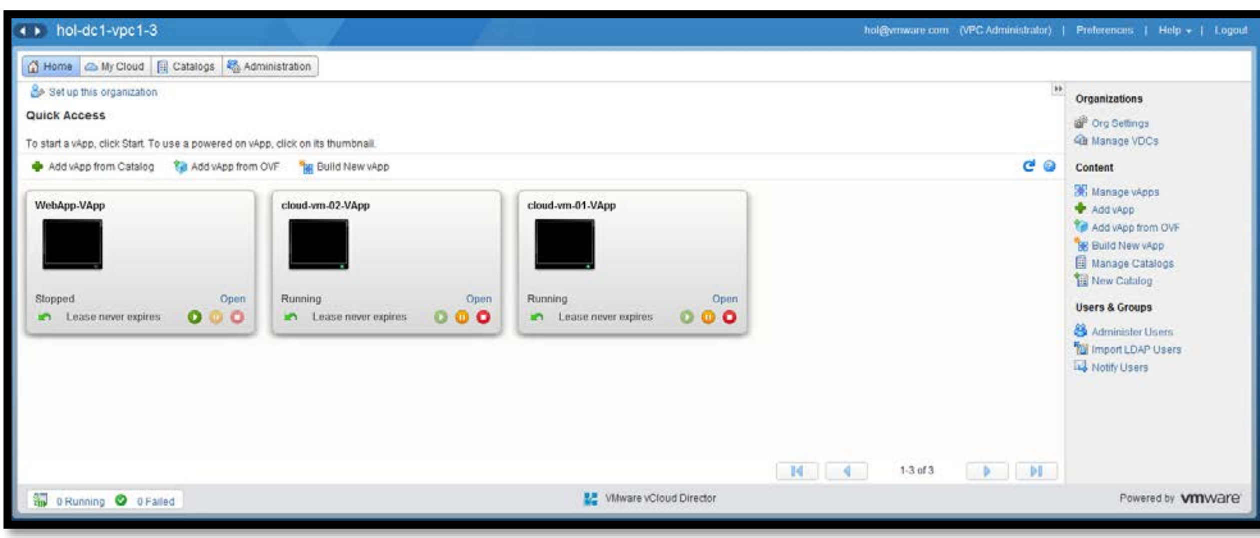


3.2.6. User Access (Management and Monitoring)

Users will be entitled to a self-service portal that the users can utilize to create their workloads and associate each workload with the plan required



vCloud Air utilizes and leverages vCloud Director, which eventually leverages a term VMware likes to call it the “a cloud of clouds”, users will be able to manage their virtual machines/vApps via vCloud Director.



Users will have access to basic metrics over the virtual machines running in PICS

If more metrics is required, it is recommended to configure a monitoring system on-premises as PICS VMs can be access via SSL-VPN and collect metrics from the public cloud for purpose of aggregation and reporting (i.e. VMware vRealize Hyperic Server would be on-premises and relative Hyperic Agents deployed inside the virtual machines on the public cloud in order to collect metrics, in addition we can utilize VMware vRealize Operations Manager to aggregate them, eventually creating super metrics and a comprehensive dashboard).

3.2.7. Security

The end-to-end security of the vCloud Air is a mutual effort between PICS and the PICS users.

3.2.7.1. PICS will be providing:

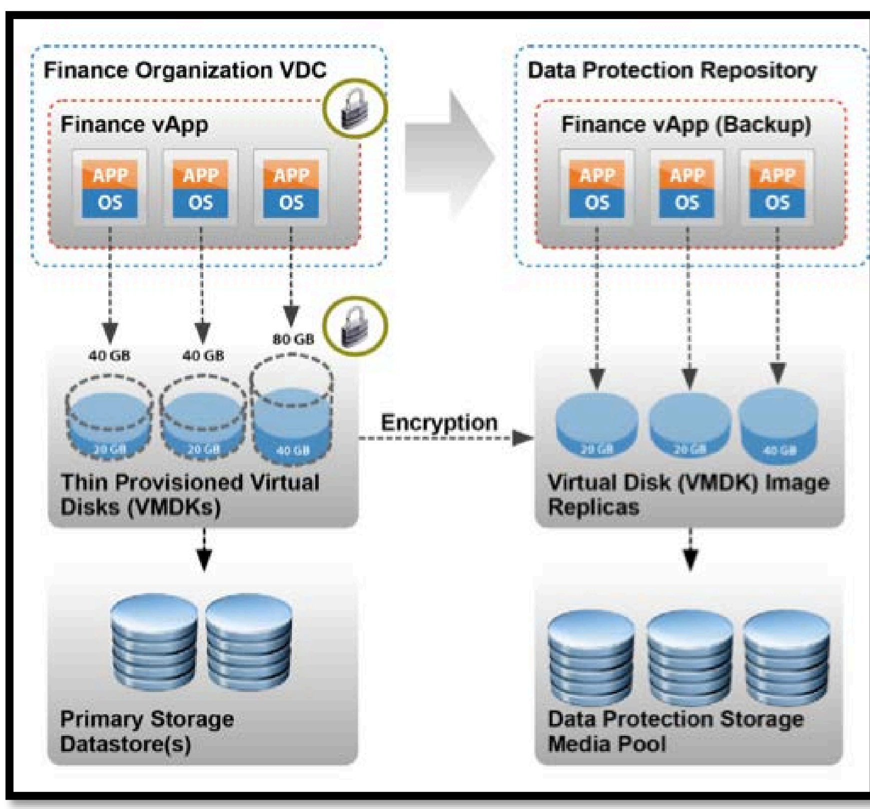
- Physical security –PICS will protect the data-centers housing the vCloud Air from physical security breaches.
- Information security – PICS will protect the information systems used to deliver the vCloud Air for which it has sole administrative level control.
- Network security – PICS will protect the networks containing its information systems up to the point where you have some control, permission, or access to modify your networks.
- Security Monitoring – PICS will monitor for security events involving the underlying infrastructure servers, storage, networks, and information systems used in the delivery of the vCloud Air over which it has sole administrative level control. This responsibility stops at any point where you have some control, permission, or access to modify an aspect of the service offering.
- Patching and vulnerability management – PICS will maintain the systems it uses to deliver the service offering, including the application of patches it deems critical for the target systems. VMware will perform routine vulnerability scans to surface critical risk areas for the systems it uses to deliver the service offering. Critical vulnerabilities will be addressed in a timely manner.

3.2.7.2. PICS users will be responsible for:

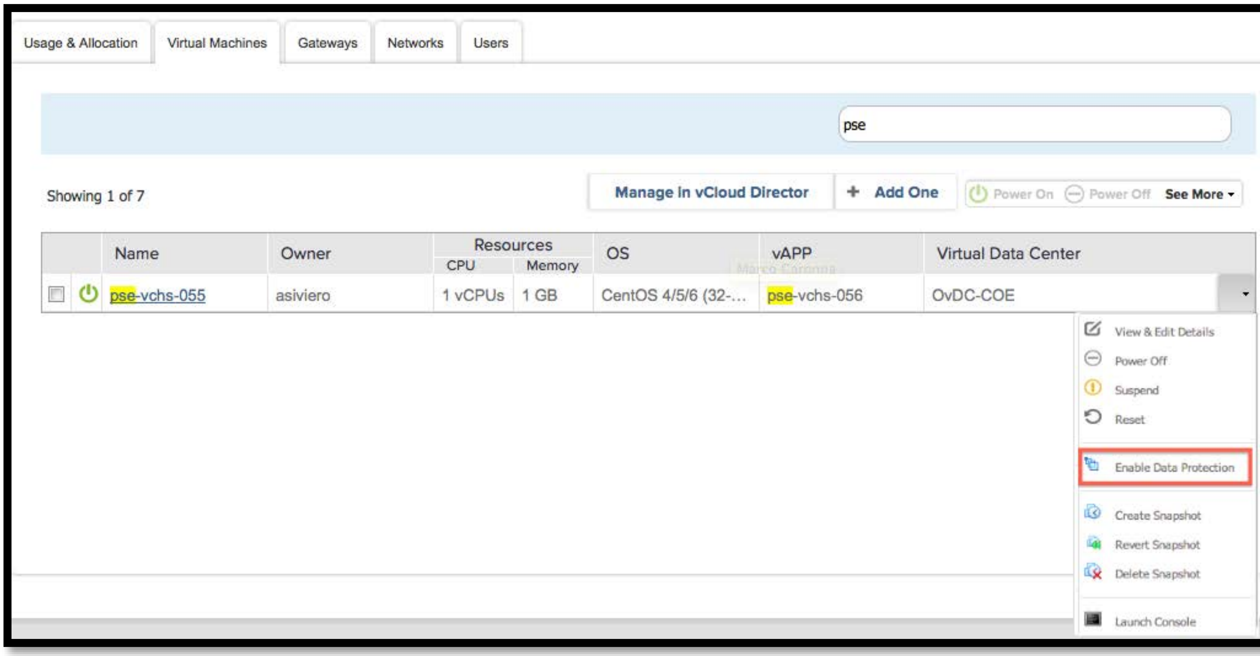
- Information security – PICS users will be responsible for ensuring adequate protection of the information systems, data, content, or applications that you deploy and/or access on the vCloud Air. This includes, but is not limited to, any level of patching, security fixes, data encryption, access controls, roles and permissions granted to your internal, external, or third-party users, and so on.
- Network security – PICS users will be responsible for the security of the networks over which you have administrative level control. This includes, but is not limited to, maintaining effective firewall rules, exposing only communication ports that are necessary to conduct business, locking down promiscuous access, and so on.
- Security monitoring – PICS users will be responsible for the detection, classification, and remediation of all security events that are isolated with your vCloud Air account, associated with virtual machines, operating systems, applications, data, or content, surfaced through vulnerability scanning tools, or required for a compliance or certification program in which you are required to participate and which are not serviced under another PICS security program.

3.2.8. Backup and Restore

- VMware vCloud Air offers a per virtual machine backup service with the following features:
- Fixed 24-hour RPO
- Full vApp metadata coherency
- Virtual machine Image-level Restore Granularity Objective (RGO)
- Custom retention periods from 1 to 365 days
- Industry-standard AES-256 image-level encryption



PICS users can enable backup service using the vCloud Air dashboard and selecting the specific virtual machine properties.



Capability	Dedicated Cloud	Virtual Private Cloud
Data protection capacity units	6 TB front-end protected storage	2 TB front-end protected storage
Unlimited backups	Yes	Yes
Unlimited restores	Yes	Yes
Backup operations (concurrent)	16	16
Restore operations (concurrent)	16	16
Production support	24 hours/day 7 days/week 365 days/year	24 hours/day 7 days/week 365 days/year
Subscription Term	1 month 12 month 24 month 36 month	1 month 3 month 12 month 24 month 36 month

To restore a virtual machine from backup, PICS users Operations Team will contact the PICS Technical Support, and they will perform the restore within 4 hours.

4. Web Application Workload

For this kind of workload we have decided to go with a **Virtual Private Cloud**, because our WebApp is exposed to the public thus we might need to increase the resources allocated for our infrastructure in times of peaks and spikes then decrease those resources.

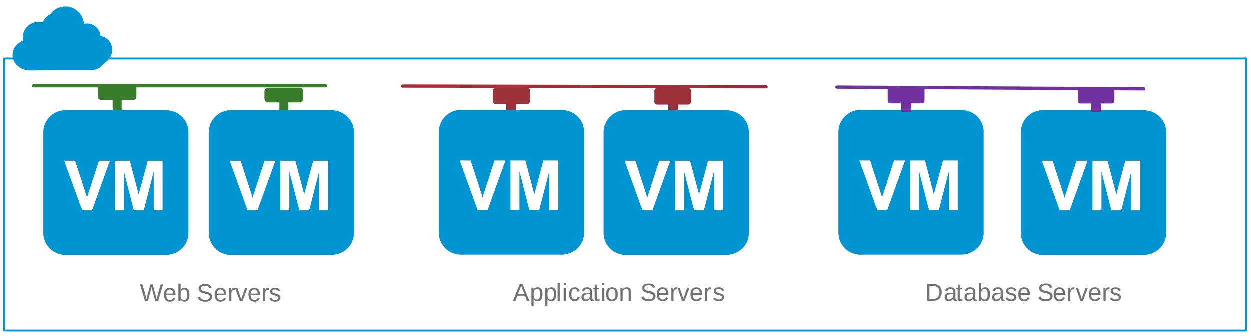
4.1. Capacity Design Decision

Based on previous benchmarks and monitoring of the workloads we have deduced the hereunder requirement for the VPC:

Type	Virtual Private Cloud
CPU GHz (% reserved)	10 GHz burst to 20 GHz (50% reserved)
Memory GB (% reserved)	30 GB (50% reserved)
SSD Storage	0.5 TB
Standard Storage	2.5 TB
Network Bandwidth	10 Mbps 50 Mbps (burst)
Public IP addresses	2

Within the VPC here is the allocation for the Virtual Machines:

Our web application is a 3 tiered model and it can be visualized in the hereunder diagram:



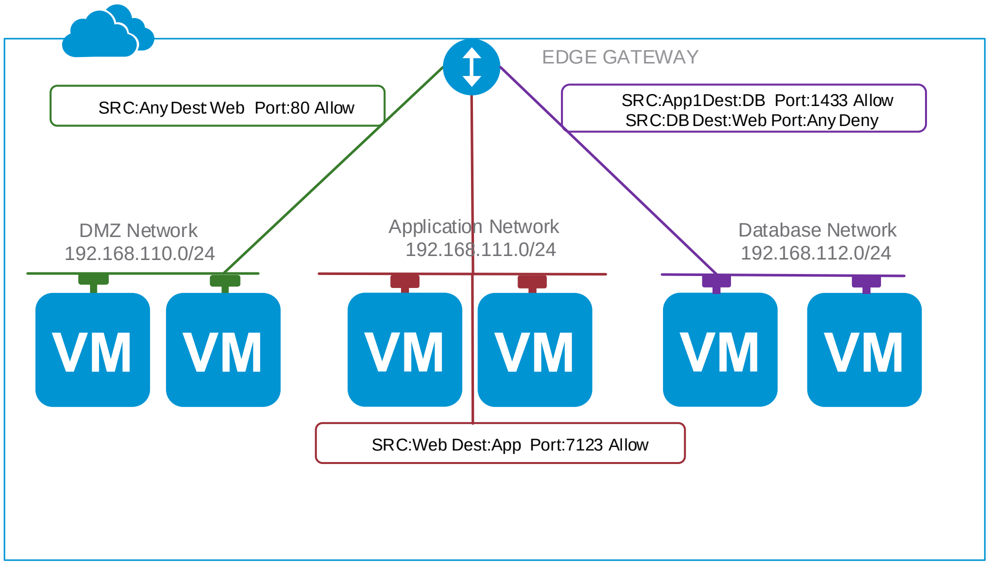
Web Application VPC

Within the VPC the virtual machines have the following allocations:

Virtual Machine Name	CPU (GHz)	Memory (GB)	Standard Storage (TB)	SSD Storage	Public IP Addresses
Time Tracking Web Server 1 VM	1 GHz	1 GB	0.25 TB	None	1 (load balanced)
Time Tracking Web Server 2 VM	1 GHz	1 GB	0.25 TB	None	
Time Tracking Web Application 1	2 GHz	2 GB	0.25 TB	None	None
Time Tracking Web Application 2	2 GHz	2 GB	0.25 TB	None	None
Time Tracking Database VM 1	2 GHz	4 GB	0.5 TB	0.15 TB	None
Time Tracking Database VM2	2 GHz	4 GB	0.5 TB	0.15 TB	None

4.2. Network Allocation Design Decision

Network Name	Network Address	Edge Gateways	Networks
Time Tracking Web Servers	192.168.110.0/24	WebApp-EdgeGW	Web-default-Routed
Time Tracking Application Servers	192.168.111.0/24	WebApp-EdgeGW	App-services-Routed
Time Tacking Database Servers	192.168.112.0/24	WebApp-EdgeGW	DB-Services-Routed



Web Application VPC

4.3. Backup Design Decision

Design Option	Justification	Implication
Data Protection Enabled	Virtual machines will be protected	Upon VM failure, it will be restored from backup.

5. Business Critical Enterprise Application Workload

For this kind of workload we have decided to go with a **Dedicated Cloud** because this is a business critical application we do not want anyone to share the resources with it.

5.1. Capacity Design Decision

Based on previous benchmarks and monitoring of the workloads we have deduced the hereunder requirement for the Dedicated Cloud:

Type	Dedicated Cloud
CPU GHz (% reserved)	50 GHz (100% reserved)
Memory GB (% reserved)	120 GB (100% reserved)
SSD Storage	6 TB
Standard Storage	12 TB
Network Bandwidth	50 Mbps (1Gbps Mbps (burst))

Public IP addresses	1

We are also going to utilize the capability of having multiple Virtual Data Centers across and since this is a life support system it is very much important to segregate and split the authorization of the tenants, we are well aware that this is a collaborative human work but it is better to be safe than sorry.

Each virtual datacentre will host a workload, as explained in the hereunder table:

Virtual Datacenter 1 (vDC1) – Management Web Servers					
Virtual Machine Name	**CPU (GHz)**	**Memory (GB)**	**Standard Storage (TB)**	**SSD Storage**	**Public IP Addresses**
Life Support System Management Web Server 1	3 GHz	8 GB	0.5 TB	0.25 TB	None
Life Support System Management Web Server 2	3 GHz	8 GB	0.5 TB	0.25 TB	None

Virtual Datacenter 2 (vDC2) – Electricity Application Servers					
Virtual Machine Name	**CPU (GHz)**	**Memory (GB)**	**Standard Storage (TB)**	**SSD Storage**	**Public IP Addresses**
Life Support System Electricity Application Server 1	5 GHz	10 GB	0.75 TB	0.25 TB	None
Life Support System Electricity Application Server 2	5 GHz	10 GB	0.75 TB	0.25 TB	None

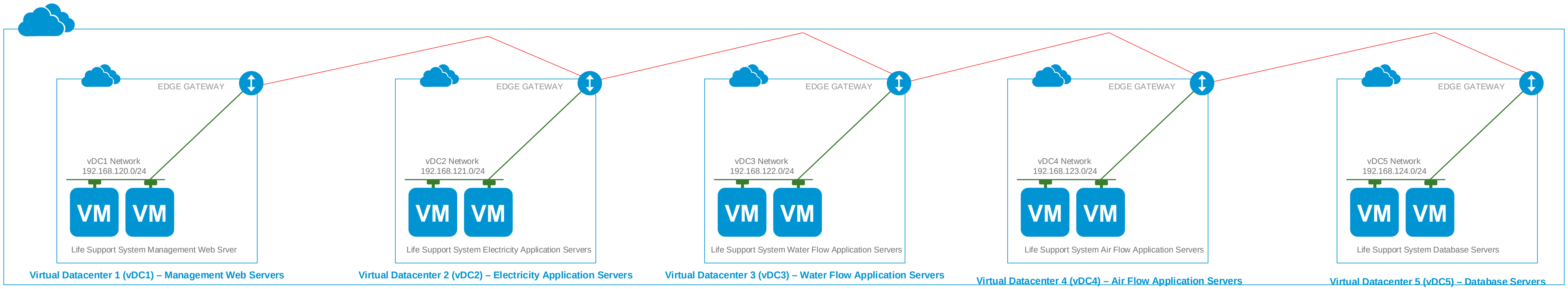
Virtual Datacenter 3 (vDC3) – Water Flow Application Servers					
Virtual Machine Name	**CPU (GHz)**	**Memory (GB)**	**Standard Storage (TB)**	**SSD Storage**	**Public IP Addresses**
Life Support System Water Flow Application Server 1	5 GHz	10 GB	0.75 TB	0.25 TB	None
Life Support System Water Flow Application Server 2	5 GHz	10 GB	0.75 TB	0.25 TB	None

Virtual Datacenter 4 (vDC4) – Air Flow Application Servers					
Virtual Machine Name	**CPU (GHz)**	**Memory (GB)**	**Standard Storage (TB)**	**SSD Storage**	**Public IP Addresses**
Life Support System Air Flow Application Server 1	5 GHz	10 GB	0.75 TB	0.25 TB	None
Life Support System Air Flow Application Server 2	5 GHz	10 GB	0.75 TB	0.25 TB	None

<table>
<tr><th colspan="7">Virtual Datacenter 5 (vDC5) – Database Servers</th></tr>
<tr><th>Virtual Machine Name</th><th>CPU (GHz)</th><th>Memory (GB)</th><th colspan="2">Standard Storage (TB)</th><th>SSD Storage</th><th>Public IP Addresses</th></tr>
<tr><td>Life Support System Database Server 1</td><td>4 GHz</td><td>16 GB</td><td>Clustered
1.5TB</td><td>0.5 TB</td><td>1 TB</td><td>None</td></tr>
<tr><td>Life Support System Database Server 2</td><td>4 GHz</td><td>16 GB</td><td></td><td>0.5 TB</td><td>1 TB</td><td>None</td></tr>
</table>

5.2. Network Allocation Design Decision

vDC	Network Address	Edge Gateways	Networks
Virtual Datacenter 1 (vDC1) – Management Web Servers	192.168.120.0/24	vDC1-MWS-EG	vDC1-MWS-Routed
Virtual Datacenter 2 (vDC2) – Electricity Application Servers	192.168.121.0/24	vDC2-EAS-EG	vDC2-EAS-Routed
Virtual Datacenter 3 (vDC3) – Water Flow Application Servers	192.168.122.0/24	vDC3-WFA-EG	vDC3-WFA-Routed
Virtual Datacenter 4 (vDC4) – Air Flow Application Servers	192.168.123.0/24	vDC4-AFA-EG	vDC4-AFA-Routed
Virtual Datacenter 5 (vDC5) – Database Servers	192.168.124.0/24	vDC5-DB-EG	vDC5-DB-Routed



Life Support System Business Critical Application Dedicated Cloud

5.3. Security Design Decision

These critical systems will require several teams for management and thus each team will have access to their own vDC separately. This is we improve the security and the risk of unpredicted changes, in addition to data leakage.

5.4. Backup Design Decision

Design Option	Justification	Implication
Data Protection Enabled	Production virtual machines will be protected	Upon VM failure, it will be restored from backup.

5.5. Replication Design Decision

Of course having such a critical system implies that the system's uptime must be a 99.99999->aleph, we will be doing a best effort here to achieve those nines by adding a hot disaster site to our environment.

Since vCloud Air has the service of disaster recovery, we will be utilizing another dedicated cloud to host a replica of our infrastructure.

We could have just gotten a VPC (Virtual Private Cloud) which is the shared platform, but this is a life support system people and we don't want a fight over processing power which might for some reason decrease the percentage of air flow for example, thus a dedicate cloud for replication it is.

5.5.1. Test Failover

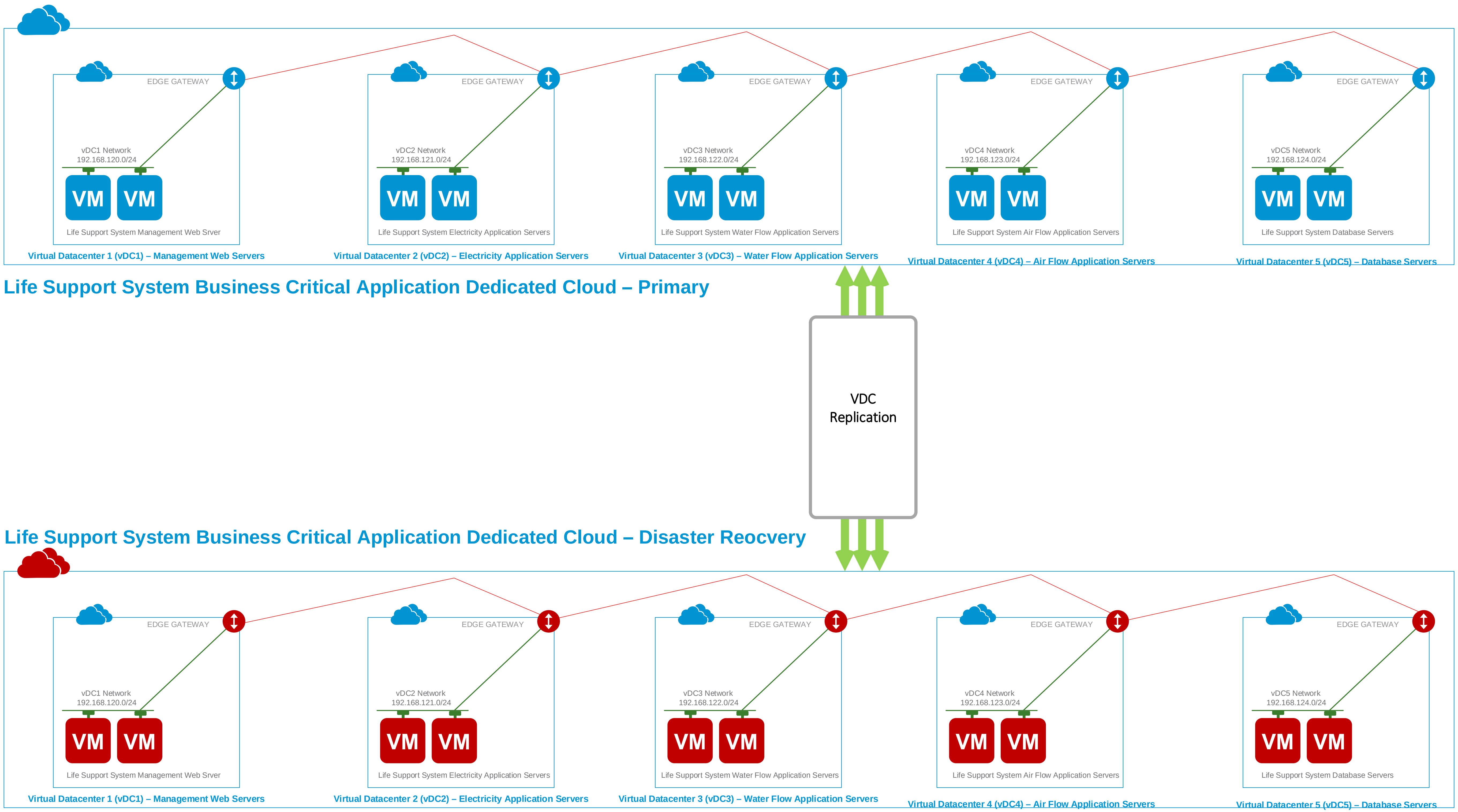
Because we want to make sure our DR is always there when we need it, tests must be performed to insure that when its needed it will be as we expect it to be.

Invoking a test includes contacting the PICS Global Support Service and the test failover will be enabled for 7 days which is plenty of time to test things and get them sorted.

5.5.2. Upon Disaster

In case of disaster, before you panic please make sure to invoke the failover process and we at PICS will make sure that your resources are brought online, note this does not include control over the applications which means that you have to take control of that once the virtual machines are accessible.

After the disaster has passed and things are back to normal, a failback is invoked so that to return the original datacentre.



EDGE GATEWAY
vDC1 Network
192.168.120.0/24
VM
VM
Life Support System Management Web Srver
Virtual Datacenter 1 (vDC1) – Management Web Servers
EDGE GATEWAY
vDC2 Network
192.168.121.0/24
VM
VM
Life Support System Electricity Application Servers
Virtual Datacenter 2 (vDC2) – Electricity Application Servers
EDGE GATEWAY
vDC3 Network
192.168.122.0/24
VM
VM
Life Support System Water Flow Application Servers
Virtual Datacenter 3 (vDC3) – Water Flow Application Servers
EDGE GATEWAY
vDC4 Network
192.168.123.0/24
VM
VM
Life Support System Air Flow Application Servers
Virtual Datacenter 4 (vDC4) – Air Flow Application Servers
EDGE GATEWAY
vDC5 Network
192.168.124.0/24
VM
VM
Life Support System Database Servers
Virtual Datacenter 5 (vDC5) – Database Servers
Life Support System Business Critical Application Dedicated Cloud – Primary
VDC Replication
Life Support System Business Critical Application Dedicated Cloud – Disaster Reocvery
EDGE GATEWAY
vDC1 Network
192.168.120.0/24
VM
VM
Life Support System Management Web Srver
Virtual Datacenter 1 (vDC1) – Management Web Servers
EDGE GATEWAY
vDC2 Network
192.168.121.0/24
VM
VM
Life Support System Electricity Application Servers
Virtual Datacenter 2 (vDC2) – Electricity Application Servers
EDGE GATEWAY
vDC3 Network
192.168.122.0/24
VM
VM
Life Support System Water Flow Application Servers
Virtual Datacenter 3 (vDC3) – Water Flow Application Servers
EDGE GATEWAY
vDC4 Network
192.168.123.0/24
VM
VM
Life Support System Air Flow Application Servers
Virtual Datacenter 4 (vDC4) – Air Flow Application Servers
EDGE GATEWAY
vDC5 Network
192.168.124.0/24
VM
VM
Life Support System Database Servers
Virtual Datacenter 5 (vDC5) – Database Servers

6. Final Words

It is not hidden that even upon leaving our mother planet earth the cloud seems to have moved along with us and it is the best IT solution if we are ought to focus on other important things than maintaining an on premises IT infrastructure.

Thank you for taking the time to go through this design and we hope that PICS will be your choice when it comes to building a public cloud on Mars.

7. Appendices

Appendix A – References

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