

Oracle Cloud Infrastructure (OCI) Security Handbook

A practical guide for OCI Security



Naresh Kumar Miryala
Dinesh Kumar Budagam

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Dedicated to

My loving wife Aruna

- Naresh Kumar Miryala

*My parents, wife Anitha and kids Viyona varma and
Vihaana*

- Dinesh Kumar Budagam

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About the Authors

- **Naresh Kumar Miryala** is a distinguished engineering leader with an extensive background in database, cloud platform reliability, and security engineering, having spent nearly two decades in the field. His deep understanding of both technical and business intricacies empowers him to pioneer innovative solutions spanning diverse domains such as database systems, large-scale infrastructure, multi-cloud environments, automation, cloud infrastructure, DevOps, and cyber security. He is an adept engineering executive and technologist with extensive experience in working with cloud migrations, infrastructure implementation, database management, ERP solutions, and DevOps deployments with security first approach.

Naresh currently leads the engineering team at Meta, having previously contributed to esteemed organizations like Oracle Corp and Computer Sciences Corporations, Naresh played a pivotal role in migrating or implementing Oracle technologies for over 60 organizations globally, many of which are Fortune 500 entities. His impact spans across various industries, including pharmaceuticals, retail, banking, and gold mining companies worldwide.

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data ecosystem, privacy and security, and cybersecurity. He worked at IBM and has also served as a consultant for Microsoft and Meta, beginning his career as a developer and progressing to roles as a technical lead and senior technical manager. Currently, Dinesh Budagam serves as a senior manager and senior cybersecurity consultant at VISA, specializing in cybersecurity. In his role as a security architect, Dinesh is at the forefront of driving key initiatives aimed at safeguarding the organization's most critical assets. He leads efforts to design and implement robust security frameworks and strategies specifically tailored for big data and cloud environments. His work focuses on ensuring that these platforms maintain high levels of security, compliance, and resilience against evolving cyber threats. By collaborating with cross-functional teams, he helps align security policies with business objectives, ensuring the protection of sensitive data and the integrity of VISA's digital infrastructure.

Dinesh Kumar Budagam holds a bachelor of technology in electrical and electronics engineering and a master's degree in software engineering, providing a solid foundation for his technical expertise. In addition to his academic credentials, he is an IBM Certified Solution Architect for Big Data Analytics, Cloud Certified Architect, Certified System Architect, **Project Management Professional (PMP)** and Senior Member of IEEE. Furthermore, he has completed an advanced cybersecurity program, generative AI-Technology, Business, and Society Program at Stanford University.

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reviewer, he excels at breaking down complex concepts for clarity while also ensuring the content is accurate and practically relevant.

- ❖ **Naga Venkata P Janapareddy** is a distinguished leader in the IT industry with over 18 years of unparalleled experience. He is recognized as one of the foremost experts in Oracle DBA and Oracle EBS technologies, as well as a cloud solution architect. Renowned for his strategic vision and technical acumen, he excels in deploying and managing cutting-edge Oracle solutions that drive enterprise success. Over the years, he has partnered with customers, the engineering team, and product/program managers to build roadmaps, launch plans for database migrations, build scalable support structures, and recommend end-to-end security mechanisms while advocating for the customers and influencing product and service specifications within the roadmaps.

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- *Naresh Kumar Miryala*

- I would like to express my deepest gratitude to my parents, Budagam Srinivasa Rao and Uma, who has been my guiding light throughout my life. Their constant support, love, and belief in me have given me the strength to pursue my dreams. They have always been there to encourage me, and I could not have come this far without the values and lessons you instilled in me.

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I would like to sincerely thank technical reviewer Pradeep Vengala for his thorough and insightful review of this book. His expertise and attention to detail have greatly improved the technical accuracy and quality of the content.

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and my sincere thanks to associate professor Ramakrishna Kothuri, (PhD in electrical and electronics engineering) from BV Raju Institute of Technology for inspiring my passion for research. I would like to extend my heartfelt thanks to Malla Mekala (President and co-founder of Infodat Technologies), who inspired me to explore new technologies and guided me into the cybersecurity/GenAI field during my tenure in his esteemed organization. I want to sincerely thank my former IBM US manager, Joseph Amici, for acknowledging my skills and efforts and for providing me with many opportunities to work on critical projects Involving technology stacks such as IBM bluemix, IBM Watson during my time at IBM.

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- *Dinesh Kumar Budagam*

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Preface

Oracle Cloud Infrastructure (OCI) Security Handbook is the ultimate guide for safeguarding your mission critical resources and data on Oracle Cloud Infrastructure. In the world of cloud first approach, it's essential to understand the security risks and how to protect the sensitive data and resources in the cloud using different tools and technologies. The book covers all the aspects of security, considering all the layers of the Oracle Cloud. This book contains 11 chapters which outline introducing the basics of the Oracle Cloud services to advance concepts in the security and security principles.

The foundational principle of the book is to introduce complex security concepts with a practical approach with clear examples of how to secure highly sensitive resources in Oracle Cloud. The book covered all the layers of the network, database, SaaS security and various principles of security , detection and advanced concepts of auto response and remediation of the security attacks and protecting critical resources in the Oracle Cloud.

Oracle Cloud Infrastructure (OCI) Security aims to simplify complex security concepts and provide a guide for all technical experts from beginners to advanced skill sets in the Oracle Cloud and security world with clear explanations and examples with navigation to implement and secure the mission critical data and resources.

This book is divided into **11 chapters** and they cover all the native tools and technologies offered by OCI and best practices and detailed steps for monitoring the threats and implementing controls for safeguarding cloud applications using advanced security concepts. The details are listed below.

Chapter 1: Introduction to Oracle Clud Infrastructure - Introduction to OCI introduces you to OCI basic concepts, benefits of using OCI Cloud and explains the security pillars, design principles, shared security model and OCI well architected framework. This chapter also describes security

guidance recommendations and best practices in Oracle Cloud Infrastructure.

Chapter 2: Mastering Identity and Access Management - **identity and access management (IAM)** chapter focuses on the fundamentals of IAM concepts, an overview of IAM in OCI, IAM groups, IAM roles and IAM components, access management, IAM policies, and various tools used for IAM.

Chapter 3: Navigating Network Security in OCI- This chapter focuses on network security and overview of networking, networking components, security zones, VCN, load balancers, dynamic routing gateway, internet gateway, local peering gateway, route tables and remote peering connections and other networking concepts..

Chapter 4: Infrastructure Security- Infrastructure security covers OCI load balancer and its components, region, compartment, availability domains, network firewall and firewall policies , security groups, gateway endpoints, interface end points, NAT devices , NAT gateways, recommendations and considerations.

Chapter 5: Database Fortification in Oracle Clud Infrastructure - Database security introduces to the fundamentals of database security, cryptography, key management services in the database such as encryption, fundamental concepts of securing data, various encryption methods, vault, audit vault and database firewall.

Chapter 6: Application Security Unleashed - Application security introduces you to various methods for securing web applications, you will walk through various potential threats like CSRF, SQL injection etc and corresponding recommendations,API security, web application firewall, user pool and identity pool.

Chapter 7: SaaS Applications Optimization and Security - Securing SaaS applications discusses recipes to various SaaS access controls,implementation of secure data isolation, SaaS governance and best practices for protecting data within SaaS environments, DevSecOps access controls.

Chapter 8: Monitoring and Logging for Robust Security - Monitoring and logging chapter covers recipes to help us in troubleshooting,achieving

compliance and accountability, continuous monitoring and alerting and regular auditing, logging and detection control, cloud guard, SSL inspection and audit policies.

Chapter 9: Compliance, IDR, and Vulnerability Management in OCI -

Compliance, IDR and vulnerability management focuses on compliance, design strategy, monitor and auditing strategy,best security and compliances practices, various compliances tools to help us check compliance.

Chapter 10: Future of OCI Security - This chapter focuses on additional advanced security operations, best security practices to secure API Gateways, network firewall , advanced future evolution of OCI security , future cloud security trends , DevSecOps and future of security.

Chapter 11: Best Practices for OCI Security- Best practices for OCI security covers as comprehensive guide to implementing robust security measures across key components within OCI. This chapter elevates the security posture by delving into best practices for securing vital elements of your OCI environment.

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CHAPTER 1

Introduction to Oracle Cloud Infrastructure

Introduction

In this chapter, we will introduce you to **Oracle Cloud Infrastructure (OCI)** by explaining essential cloud concepts, highlighting the benefits of using OCI, and discussing its robust security architecture. Prepare to discover crucial elements such as security pillars, design principles, the shared security model, and the OCI Well-Architected Framework. Furthermore, we will provide valuable insights into security guidance recommendations and best practices.

Structure

This chapter covers the following topics:

- Technical requirements
- Overview of Oracle Cloud Infrastructure services
- Getting started with OCI and using OCI console
- Benefits of OCI cloud
- Security pillars
- Design principles
- Shared Security Model
- Security in the cloud: OCI's responsibility

- Security in the cloud: Customer responsibility
- Controls in shared responsibility
- Security services
- OCI Well-Architected Framework
- Important OCI security service offerings
- Security guidance

Objectives

This chapter presents an introduction to the OCI, and services offered by OCI. This chapter is an introductory chapter to all the services and options available in the OCI.

By the end of this chapter, readers will have acquired a solid foundation in the basics of cloud services offered by OCI. This chapter covers the benefits of OCI cloud and security model on the OCI along with a well-architected framework.

Technical requirements

To fully engage with the content of this chapter on identity and access management, readers should have a basic understanding of computer systems, networking concepts, and information technology.

Additionally, the following technical requirements are recommended:

- **Internet access:** Readers should have a reliable internet connection to access online resources, references, and examples related to cloud computing.
- **Computing device:** A desktop computer, laptop, tablet, or smartphone with a modern web browser is necessary to read the chapter content and access any online materials.
- **Web browser:** The latest version of a modern web browser, such as *Google Chrome*, *Mozilla Firefox*, *Microsoft Edge*, or *Safari*, is recommended. This ensures compatibility and optimal viewing experience of web-based resources and interactive content.
- **Familiarity with basic security and cloud services:** Some familiarity with cloud services and their basic functionalities will enhance the understanding of the chapter.

Overview of Oracle Cloud Infrastructure services

OCI provides a wide range of services across multiple categories:

Here is a brief summary:

- **Compute:**

- **Virtual machines (VMs):** Flexible and scalable VMs with various shapes and configurations to cater to diverse workloads.
- **Bare metal compute:** High-performance, dedicated servers for demanding applications.
- **Container Engine for Kubernetes (OKE):** Manage and deploy containerized applications at scale.
- **Functions:** Serverless functions for event-driven workloads, eliminating the need for infrastructure management.

- **Storage:**

- **Block storage:** High-performance, persistent block storage for VMs and containers.
- **Object storage:** Scalable, cost-effective storage for large datasets like backups and archives.
- **File storage:** Secure and scalable file storage for sharing data across applications and users.
- **Data archive storage:** Long-term, low-cost storage for rarely accessed data.

- **Networking:**

- **Virtual Cloud Network (VCN):** Create and manage private networks within OCI.
- **Load balancers:** Distribute traffic across multiple servers for high availability and scalability.
- **FastConnect:** Dedicated, private connection between your on-premises network and OCI.
- **Global transit:** Securely connect OCI resources to other cloud providers or your network.

- **Databases:**

- **Autonomous database:** Self-driving, self-patching database service for various database types.
 - **Database service:** Manage traditional Oracle databases in the cloud, including MySQL, PostgreSQL, and MariaDB.
 - **NoSQL Database Cloud Service:** Scalable NoSQL database for high-performance applications.
 - **Exadata cloud service:** High-performance database infrastructure for demanding workloads.
- **Management and governance:**
 - **Identity and access management (IAM):** Control access to resources and enforce security policies.
 - **Resource manager:** Organize and manage resources within OCI for better control and cost optimization.
 - **Monitoring:** Monitor resource performance and health for proactive issue identification and resolution.
 - **Logging:** Collect and analyze logs for troubleshooting, auditing, and security purposes.
 - **Other services:**
 - **Artificial intelligence and machine learning:** Build and deploy AI models with various services like *Oracle Cloud AI Services* and *Data Science Workbench*.
 - **Analytics:** Analyze data using services like big data services and data catalogs.
 - **Internet of Things (IoT):** Build and manage IoT applications with services like *IoT Core* and *IoT Fleet Management*.
 - **Application development:** Develop, deploy, and manage applications with services like container engine for *Kubernetes* and *Functions*.

Getting started with OCI and using OCI console

OCI services are managed using the OCI console; if you have an organization OCI account, you can continue to use the console using the organization login credentials and explore the services.

If you do not have the organization's OCI account, you can set up a free account to access the OCI services for a temporary period of time.

In order to gain access to an OCI account, we need to create a free tier account which allows access to services with certain limits.

Note: OCI Free Tier comes with certain limitations on the number of services and capacity of the resources.

Follow the below steps to create the OCI free account and access the OCI services:

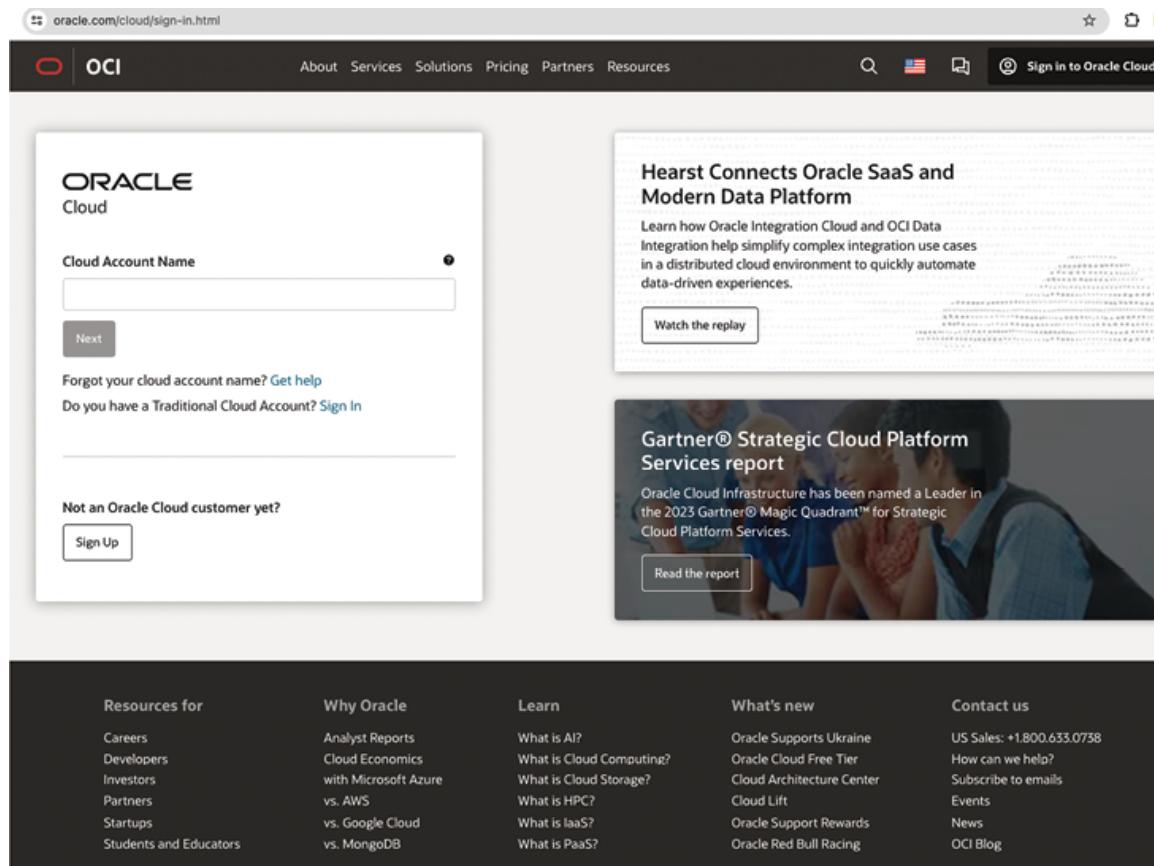


Figure 1.1: Oracle cloud first page to create the OCI free account

1. Provide below information to create the free account for the OCI services:

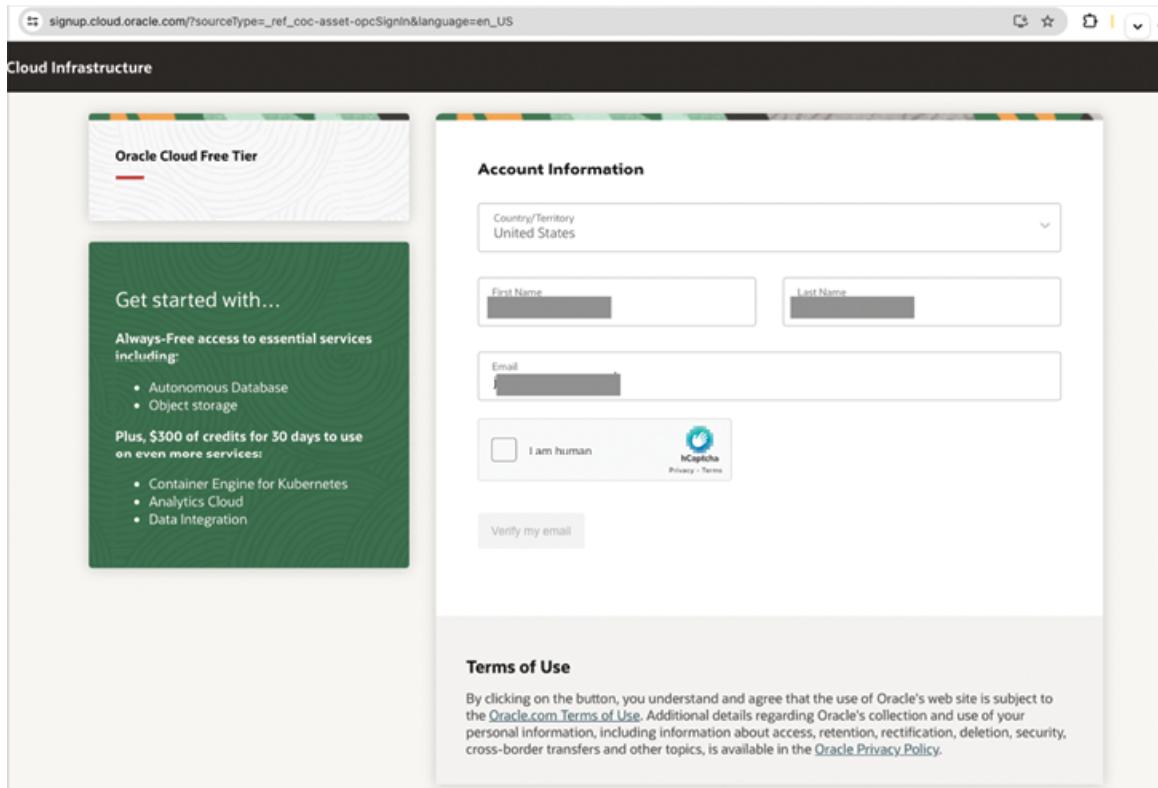


Figure 1.2: Oracle cloud account creation page

- Once registration is completed by providing valid information, a free tier account will be created with 300\$ for 30days to perform trial services on the OCI account.

Once you login to the first page with all the services listed, it looks like below:

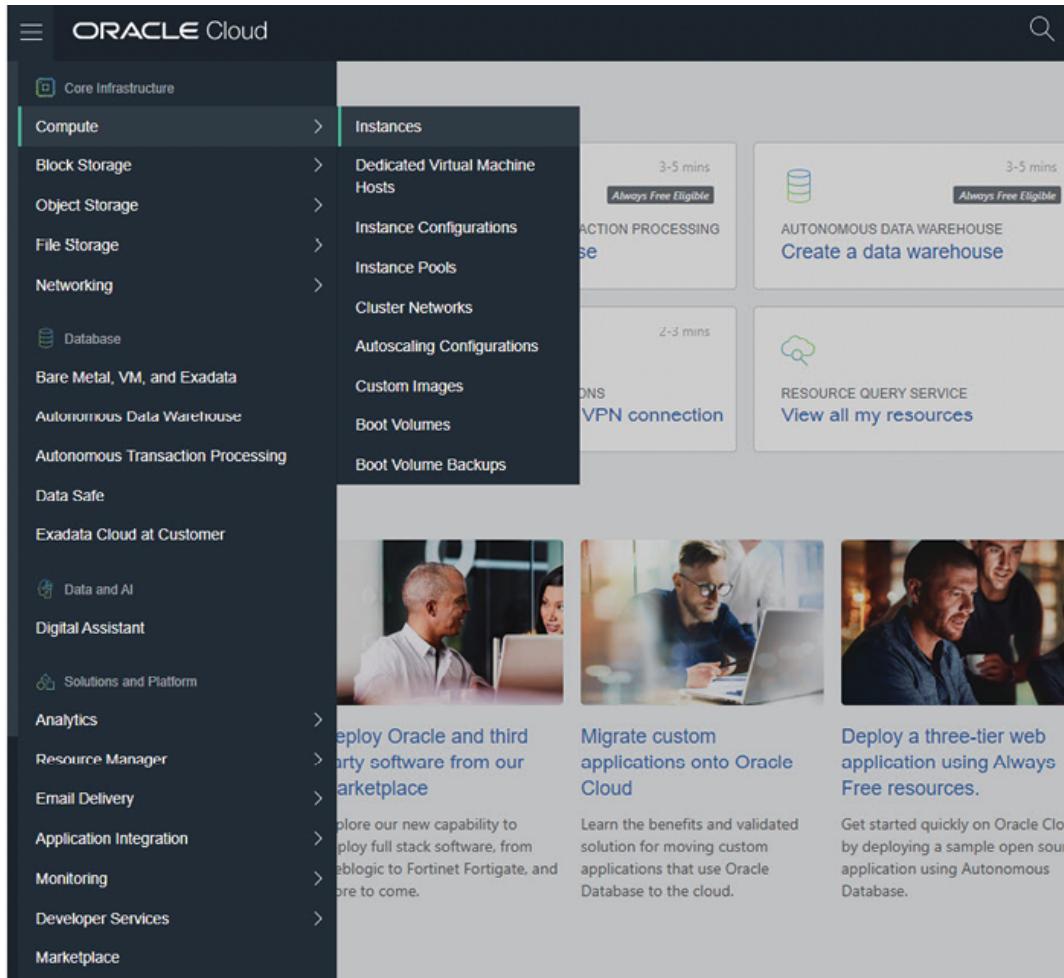


Figure 1.3: Oracle OCI console login home page.

Benefits of OCI Cloud

OCI offers several benefits to all types of organizations:

- **High performance:** OCI is designed to provide high performance and low latency, making it ideal for running demanding workloads such as databases, enterprise applications, and high-performance computing. OCI offers a range of compute options, including virtual machines, bare metal servers, and **graphics processing unit (GPU)** instances, which can be customized to meet your specific performance needs. Additionally, OCI provides a high-speed network fabric that allows for fast data transfer between resources, further reducing latency and improving overall performance.
- **Security:** OCI includes a range of security features to help protect your data and applications. For example, OCI provides network segmentation

capabilities that allow you to isolate your resources into different **virtual cloud networks (VCNs)** to reduce the attack surface. OCI also includes firewalls and other security controls to help prevent unauthorized access to your resources. Additionally, OCI supports encryption both in transit and at rest, and provides identity and access management capabilities to ensure that only authorized users have access to your resources.

- **Flexibility:** OCI allows you to choose from a variety of compute, storage, and networking options to meet your specific needs. You can select from a range of pre-configured virtual machine shapes or create custom shapes that are optimized for your workload. OCI also provides a range of storage options, including block storage, object storage, and file storage, allowing you to choose the best option for your needs. Additionally, OCI allows you to scale up or down as needed, providing flexibility to handle changing workload demands.
- **Compatibility:** OCI is compatible with on-premises Oracle solutions, allowing you to easily move workloads between on-premises and cloud environments. This compatibility makes it easier to migrate existing applications to the cloud and also enables hybrid cloud scenarios where some workloads run on-premises while others run in the cloud.
- **Cost-effective:** OCI offers competitive pricing and flexible billing options, allowing you to pay only for what you use and avoid unnecessary costs. OCI provides a range of pricing models, including pay-as-you-go, pre-paid, and **bring-your-own-license (BYOL)**, which can help you optimize your costs based on your specific needs. Additionally, OCI provides tools to monitor and manage your costs, helping you avoid unexpected expenses.
- **Reliability:** OCI is built on a highly available and resilient infrastructure, ensuring that your applications and data are always available when you need them. OCI provides multiple **availability domains (ADs)** within each region, which are physically separate data centers that are connected by a high-speed network. This design provides redundancy and fault tolerance, ensuring that your resources remain available even in the event of a failure in one AD.
- **Support:** OCI provides comprehensive support services, including 24/7 technical support, consulting services, and training and certification programs. These services can help you get the most out of your OCI

investment and ensure that your cloud environment is optimized for your specific needs.

Security pillars

OCI is primarily built on seven core pillars as described below:

- **Identity and access management (IAM):** This pillar is focused on ensuring that only authorized users have access to cloud resources. It includes capabilities such as user authentication, authorization, and auditing. User authentication involves verifying the identity of a user before granting them access to cloud resources. Authorization involves specifying what actions a user is allowed to perform once they have been authenticated. Auditing involves tracking and recording user activity to ensure that they are following established policies and procedures.
- **Security governance:** This pillar is focused on establishing policies, procedures, and controls to ensure that security risks are managed effectively. It includes capabilities such as risk assessment, compliance management, and incident management. Risk assessment involves identifying potential threats and vulnerabilities and evaluating their likelihood and impact. Compliance management involves ensuring that the organization is following all relevant laws, regulations, and industry standards related to security. Incident management involves responding to security incidents in a timely and effective manner.
- **Network security:** This pillar is focused on securing the network infrastructure that supports the cloud environment. It includes capabilities such as firewalls, VPNs, and network segmentation. Firewalls are used to control traffic entering and leaving the network, while VPNs are used to create secure connections between remote locations. Network segmentation involves dividing the network into smaller segments to reduce the attack surface and limit the spread of a security breach.
- **Data encryption:** This pillar is focused on protecting sensitive data both in transit and at rest. It includes capabilities such as encryption, key management, and data masking. Encryption involves converting data into a code that can only be deciphered with a key or password. Key management involves generating, storing, and managing the keys used for encryption. Data masking involves replacing sensitive data with non-sensitive data to protect it from unauthorized access.

- **Application security:** This pillar is focused on ensuring that applications running in the cloud environment are secure. It includes capabilities such as vulnerability scanning, penetration testing, and application firewalling. Vulnerability scanning involves identifying weaknesses in applications that could be exploited by attackers. Penetration testing involves simulating an attack on the application to identify any vulnerabilities that may have been missed. Application firewalling involves using a firewall specifically designed to protect web applications from attacks.
- **Business continuity and disaster recovery:** This pillar is focused on ensuring that cloud services can continue to operate in the event of a disaster or other disruption. It includes capabilities such as backup and recovery, failover, and disaster recovery planning. Backup and recovery involve creating copies of critical data and applications that can be used to restore service in the event of a disaster. Failover involves automatically switching to a standby system or site when the primary system or site fails. Disaster recovery planning involves developing a plan for recovering from a disaster and testing it regularly to ensure that it will work as expected.
- **Operations security:** This pillar is focused on ensuring that the operations supporting the cloud environment are secure. It includes capabilities such as change management, configuration management, and patch management. Change management involves controlling changes to the cloud environment to ensure that they do not introduce security risks. Configuration management involves tracking and managing the configuration of cloud resources to ensure that they are configured securely. Patch management involves applying security updates and patches to cloud resources to fix known vulnerabilities.

Design principles

OCI cloud design principles are around the security first design approach where all the infrastructure, databased services are designed with robust security philosophy. The principles include isolation of the network and physical infra segregation, layers security approach for all the services, which helps to reduce the risk from most advanced and sophisticated security attacks.

Shared Security Model

The OCI Shared Security Model is a framework that outlines the respective responsibilities of OCI and its customers in securing the cloud environment. It divides security tasks between both parties to ensure comprehensive protection.

Security of the cloud: OCI's responsibility

In this section, we will discuss the security of the cloud:

- **Securing the underlying infrastructure:** OCI is responsible for protecting the physical data centers, networks, and hardware that make up the cloud infrastructure. This includes measures such as securing access to the facilities, monitoring for intrusions, and ensuring the integrity of the hardware and software components.
- **Providing baseline security controls and services:** OCI provides a range of security services and tools to help customers secure their resources. These include network firewalls, encryption, identity and access management, and security logging and monitoring.
- **Maintaining system integrity and patching vulnerabilities:** OCI is responsible for maintaining the integrity of the cloud platform and addressing any vulnerabilities that are discovered. This includes applying security patches and updates to the underlying infrastructure, as well as providing guidance to customers on how to secure their own resources.
- **Responding to security incidents affecting the platform:** OCI has a dedicated security team that monitors the platform for security threats and responds to incidents as needed. This includes investigating potential security breaches, containing and mitigating the impact of any incidents, and reporting findings to affected customers.

Security in the cloud: Customer responsibility

While OCI provides a robust security infrastructure, securing your assets in the cloud is a shared responsibility between OCI and the customer. Here is an elaboration of key areas where customer responsibility comes into play:

- **Data and application security:** Customers are responsible for implementing encryption for data at rest and in transit using OCI Key Management Service. They also need to define granular access controls and permissions for users and applications using IAM policies and resource groups. Securing resources by following best practices for secure

configuration of VMs, databases, and network components is also crucial. Regularly scanning resources for vulnerabilities and promptly patching them is necessary for effective vulnerability management. Monitoring activity within resources and applications for suspicious behavior is also important.

- **Security policies and processes:** Customers must develop and enforce security policies that define clear rules and guidelines for secure cloud usage within their organization. Ensuring users understand their security responsibilities and how to follow security policies through user education and training is essential. Having a plan for responding to security incidents effectively is also critical.
- **Specific services and features:** Customers should leverage available security services like security monitoring and logging, threat detection service, and data flow for enhanced security monitoring and threat detection. Taking advantage of the granular control OCI offers over security settings for resources is also important. Integrating OCI with existing security tools and processes for a comprehensive security posture is recommended.
- **Additional responsibilities:** Customers must adhere to any relevant industry regulations or compliance requirements. Implementing backup and disaster recovery solutions to protect data and applications from outages and incidents is also necessary. Ensuring the security of any third-party applications or services used within the OCI environment is important.

Controls in shared responsibility

In the shared responsibility model of cloud security, both the cloud provider (such as OCI) and the customer have specific controls they are responsible for implementing. These controls work together to create a comprehensive security environment for your data and applications.

In a broader sense, controls can be classified as below:

- **Inherited controls:** Inherited controls are controls which are inherited from the OCI cloud; some examples of inherited controls are data sharing and storing controls, physical and logical security, and infrastructure hardening controls.

- **Shared controls:** Shared controls are applicable to both the customer environment and infrastructure; example is controls set up by the customer on top of the infrastructure provided by OCI.
- **Fully controlled by the customer:** These controls are fully set up on customer data, applications or resources. This is fully controlled and owned by the customer.

Here is a breakdown of the types of controls in shared responsibility:

- **Customer controls:**
 - **Data security:** Implementing encryption at rest and in transit for data within your resources, defining granular access permissions, using IAM policies to restrict access to authorized users only, classifying data based on sensitivity, and implementing appropriate security measures accordingly.
 - **Application security:** Following secure coding principles to develop applications with minimal vulnerabilities, regularly scanning applications for vulnerabilities and patching them promptly, and implementing a **web application firewall (WAF)** to protect against common web attacks.
 - **Resource configuration:** Following best practices for securing resources like VMs, databases, and network components, disabling unnecessary services and ports, and configuring logging and monitoring for suspicious activity.
 - **Identity and access management:** Implementing strong password policies and multi-factor authentication, regularly reviewing, and revoking unused or expired user access, and monitoring user activity for suspicious behavior.
 - **Security policies and processes:** Having clear security policies outlining acceptable use and responsibilities, providing security awareness training to users, and having an incident response plan for handling security breaches.
- **Cloud provider controls (OCI example):**
 - **Physical security:** Ensuring physical security of data centers and infrastructure, implementing access controls, and monitoring for physical facilities.

- **Infrastructure security:** Patching and maintaining the underlying infrastructure for vulnerabilities, implementing network security controls like firewalls and intrusion detection systems.
- **Service security:** Providing secure and encrypted cloud services with built-in security features, regularly auditing and testing security controls of their services.

It is important to note that the specific controls may vary depending on the cloud service model (IaaS, PaaS, SaaS) and the specific cloud provider. Understanding both your and the provider's responsibilities is crucial to ensure optimal security in your cloud environment.

Security services

OCI offers a range of security services to help customers secure their cloud environment. These services are designed to provide comprehensive protection for your data and applications in the cloud, while also meeting compliance requirements. Here are some of the key OCI security services:

- **Identity and access management:** IAM is a critical security service that allows you to manage user access to your cloud resources. With IAM, you can create and manage users, groups, and roles and assign permissions to control access to your resources. You can also use IAM to enforce multi-factor authentication, password policies, and other security measures to ensure that only authorized users have access to your resources.
- **Network security:** OCI provides several network security features to protect your cloud resources from unauthorized access and attacks. These include virtual firewalls, network segmentation, and security lists. Virtual firewalls allow you to define and enforce security policies for your **virtual private cloud (VPC)**, while network segmentation enables you to isolate your resources into different subnets based on their security requirements. Security lists allow you to control traffic flow between resources in different subnets.
- **Encryption:** OCI offers encryption at rest and in transit to protect your data in the cloud. Encryption at rest ensures that your data is encrypted when it is stored in OCI's storage services, such as object storage or block storage. Encryption in transit ensures that your data is encrypted when it is transmitted over the network. You can encrypt your data using keys managed by OCI or bring your own keys.

- **Key management service (KMS):** KMS is a fully managed service that allows you to manage and protect your cryptographic keys used to encrypt your data in the cloud. With KMS, you can create, import, rotate, and delete keys, and control access to them. KMS uses **hardware security modules (HSMs)** to protect your keys and provides audit logs to help you meet compliance requirements.
- **Security monitoring and logging:** OCI provides monitoring and logging services to help you detect and respond to security threats in real-time. Cloud logging allows you to collect, analyze, and store log data from your cloud resources, while cloud monitoring enables you to monitor the health and performance of your resources. Cloud events allow you to react to changes in your cloud environment in real-time.
- **Threat detection:** OCI's threat detection services use machine learning algorithms to identify and alert you to potential security threats in your cloud environment. Cloud Guard is a fully managed service that continuously monitors your cloud resources for security threats and compliance violations. Oracle Identity Cloud Service is a managed identity and access management service that provides centralized authentication and authorization for your cloud resources.
- **Compliance and governance:** OCI provides tools and services to help you meet compliance requirements and govern your cloud environment. Cloud audit provides audit logs of all API calls made to your cloud resources, while cloud tagging allows you to tag your resources with metadata to help you track and manage them.

OCI Well-Architected Framework

The OCI Well-Architected Framework is a set of guidelines and best practices for designing, operating, and continuously improving infrastructure in the cloud. It provides a structured approach to ensure that your cloud architecture meets the desired requirements for security, reliability, performance efficiency, cost optimization, and operational excellence.

The framework consists of five pillars:

- **Security:** This pillar focuses on protecting your cloud resources from unauthorized access, disclosure, modification, or destruction. It includes best practices for identity and access management, network security, data encryption, and incident response.

- **Reliability:** This pillar focuses on ensuring that your cloud resources are available and perform as expected. It includes best practices for fault tolerance, scalability, and disaster recovery.
- **Performance efficiency:** This pillar focuses on using cloud resources efficiently to meet the demands of your workload. It includes best practices for selecting the right instance type and size, optimizing database performance, and monitoring resource utilization.
- **Cost optimization:** This pillar focuses on minimizing the cost of running your cloud resources while still meeting your performance and reliability requirements. It includes best practices for selecting the right pricing model, identifying and eliminating unused resources, and optimizing resource utilization.
- **Operational excellence:** This pillar focuses on operating your cloud resources with excellence, including automation, monitoring, and continuous improvement. It includes best practices for automating infrastructure deployment, monitoring resource health and performance, and implementing continuous delivery and continuous integration pipelines.

By following these pillars, organizations can ensure that their cloud infrastructure is designed and operated to meet their specific needs and goals while also adhering to industry best practices and standards. The framework helps organizations identify areas for improvement and optimize their cloud infrastructure for better performance, security, and cost efficiency.

Diagram of OCI architected framework is as below in *Figure 1.4*:



Figure 1.4: Diagram of OCI architected framework

Important OCI security service offerings

OCI offers a range of security services to help customers secure their cloud environment. Here are some of the important OCI security service offerings:

- **Identity and access management:** OCI's IAM service allows customers to manage user access to their cloud resources. The service provides features such as user authentication, authorization, and auditing to ensure that only authorized users have access to sensitive data and applications.
- **Encryption:** OCI provides encryption capabilities to protect customer data both in transit and at rest. The service includes encryption for data in motion (such as data transmitted over the internet) and data at rest (such as data stored on disk).
- **Firewall:** OCI's firewall service allows customers to create and manage network security rules to control traffic flow between different resources in their cloud environment. The service provides features such as stateful inspection, IP address filtering, and application-level gateway to protect against unauthorized access.
- **Virtual private network (VPN):** OCI's VPN service allows customers to establish a secure connection between their on-premises infrastructure and the cloud environment. The service uses strong encryption to protect data in transit and provides a secure way to access cloud resources from remote locations.
- **Load balancing:** OCI's load balancing service distributes incoming traffic across multiple instances to improve application availability and scalability. The service includes features such as **Secure Socket Layer (SSL)** termination, health checks, and session persistence to ensure high performance and reliability.
- **Cloud Guard:** OCI Cloud Guard is a security service that is self-service, which helps to identify and remediate any security issues with the OCI environment. Customers can use this tool for real-time security monitoring and responding to threads and issues.
- **Vault:** OCI Vault is a self-service platform that is used to store and manage encryption keys, secrets, and other sensitive resources. OCI vault along with keys and secrets supports AES, RSA and ECDSA algorithms.

- **Bastion:** OCI Bastion service offers a free serverless server to secure access resources, i.e., we can expose resources to private and use Bastion service to access them securely without the need to expose them to the public.
- **Vulnerability Scanning:** OCI Vulnerability Scanning is a service that helps scale all the hosts and containers for vulnerabilities and provides reports to understand the vulnerabilities and remediate them.
- **Security Advisor:** OCI Security Advisor allows organizations to leverage Oracle's security best practices and resources for improving the security posture of the services in OCI.
- **Threat Intelligence:** OCI Threat Intelligence service gathers threat information from various sources and provides guidance for threat detection and prevention in OCI services.
- **Audit and trail:** OCI Audit service provides an audit trail of the database, API, and other services; this information can be used for the audit logs for security events, usage, and monitoring of the changes of the OCI resources.
- **Monitoring and logging:** OCI's Monitoring and Logging services provide real-time visibility into the security posture of the cloud environment. The services include features such as log collection, analysis, and alerting to help customers detect and respond to security threats.
- **Key management service (KMS):** OCI's KMS service provides centralized management of cryptographic keys used to encrypt data in the cloud environment. The service includes features such as key rotation, access control, and auditing to ensure the confidentiality and integrity of sensitive data.

Security guidance

OCI provides security guidance to help customers secure their cloud environment. This guidance includes recommendations and best practices for securing your data and applications in the cloud:

- **Use strong passwords and multi-factor authentication:** Passwords should be unique, complex, and changed regularly to prevent unauthorized access. Multi-factor authentication adds an extra layer of security by requiring users to provide a second form of verification, such as a code sent to their phone or a biometric scan.

- **Implement network security:** Network security measures such as virtual firewalls, network segmentation, and security lists can help protect your cloud resources from unauthorized access and attacks. Virtual firewalls can be used to define and enforce security policies for your VPCs, while network segmentation can help isolate your resources into different subnets based on their security requirements. Security lists can control traffic flow between resources in different subnets.
- **Encrypt sensitive data:** Encryption can help prevent unauthorized access to your data at rest and in transit. OCI's KMS can be used to manage and protect your encryption keys. You can also use OCI's Data Encryption service to encrypt data stored in OCI's Object Storage and other cloud services.
- **Monitor and log activities:** Monitoring and logging activities in your cloud environment can help you detect and respond to security threats in real-time. OCI's Security Monitoring and Logging services can collect, analyze, and store log data from your cloud resources. You can also use third-party security tools such as **security information and event management (SIEM)** solutions to monitor and analyze log data.
- **Patch and update software:** Keeping your software up to date with the latest security patches and updates can help prevent vulnerabilities that could be exploited by attackers. OCI's Patch Management service can automate patching and updating of your cloud resources.
- **Implement access controls:** Access controls can ensure that only authorized users have access to your cloud resources. OCI's IAM service can be used to define and enforce access control policies based on user identity, role, and group membership. You can also use OCI's Resource Manager service to manage and track your cloud resources.
- **Use third-party security tools:** Third-party security tools can enhance the security of your cloud environment. Firewalls can be used to block unauthorized access to your cloud resources, IDPS can detect and prevent intrusion attempts, and SIEM solutions can monitor and analyze log data to identify potential security threats.

Conclusion

In conclusion, the OCI introduction chapter covers the basic information about the OCI services, elaborating on how to create an OCI account and how to log in to

the OCI console. We discussed the security models and security service offerings of the OCI services.

This chapter covered OCI's well-architected framework in detail, security aspects of the OCI cloud, and an introduction to security models in the OCI.

In the next chapter, we will discuss Oracle's identity and access management and fundamental concepts, powerful features, and strategic considerations that define IAM's role in securing Oracle Cloud Infrastructure.

Points to remember

- OCI services are managed using the OCI console, if you have an organization OCI account, you can continue to use the console using the organization login credentials and explore the services. If you do not have the organization's OCI account, you can set up a free account to access the OCI services for a temporary period of time.
- OCI is designed to provide high performance and low latency, making it ideal for running demanding workloads such as databases, enterprise applications, and high-performance computing. OCI offers a range of compute options, including virtual machines, bare metal servers, and GPU instances, which can be customized to meet your specific performance needs. Additionally, OCI provides a high-speed network fabric that allows for fast data transfer between resources, further reducing latency and improving overall performance.
- OCI includes a range of security features to help protect your data and applications. For example, OCI provides network segmentation capabilities that allow you to isolate your resources into different VCNs to reduce the attack surface. OCI also includes firewalls and other security controls to help prevent unauthorized access to your resources. Additionally, OCI supports encryption both in transit and at rest and provides identity and access management capabilities to ensure that only authorized users have access to your resources.
- The OCI Shared Security Model is a framework that outlines the respective responsibilities of OCI and its customers in securing the cloud environment. It divides security tasks between both parties to ensure comprehensive protection.

- The OCI Well-Architected Framework is a set of guidelines and best practices for designing, operating, and continuously improving infrastructure in the cloud. It provides a structured approach to ensure that your cloud architecture meets the desired requirements for security, reliability, performance efficiency, cost optimization, and operational excellence.

Multiple choice questions

- 1. Which OCI IAM policy is incorrect and not a valid case?**
 - Allow dynamic-group frontend to manage instance-family in compartment Project-A.
 - Allow any-user to inspect users in tenancy.
 - Allow group A-Admins to manage all-resources in compartment Project-A.
 - Allow group A-Developers to create volumes in compartment Project-A.
- 2. Which OCI covers the data security in the storage layer?**
 - Data encryption at rest.
 - Data encryption in transit.
 - TLS1.3 data encryption.
 - Certificate based authentication.

Answers

- 1. b**
- 2. a**

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CHAPTER 2

Mastering Identity and Access Management

Introduction

In the ever-evolving landscape of cloud computing, the paramount importance of securing. Digital assets have become a cornerstone for organizations embracing the benefits of cloud services. We have many enterprises and organizations involved in migrating their infrastructure and applications to the Oracle Cloud. This migration made the **identity and access management (IAM)** strategy very important and crucial.

Oracle Cloud Infrastructure (OCI) IAM ensures correct individuals have appropriate and correct access to valid and correct resources precisely when needed. This is considered not only a best practice but also an essential foundation for a secure and efficient cloud environment.

This chapter serves as a gateway into the world of IAM within the Oracle Cloud ecosystem. We will delve into the fundamental concepts, powerful features, and strategic considerations that define IAM's role in securing Oracle Cloud Infrastructure. From user authentication to finely tuned access controls and federated identity management, each facet plays a pivotal role in establishing a robust security posture for your cloud assets.

We will discuss the layers of IAM, shedding light on its practical applications, real-world scenarios, and best practices. Whether you are a cloud architect designing a secure infrastructure, a system administrator managing user access, or a security professional responsible for compliance, this chapter will equip you

with the knowledge to navigate the intricacies of IAM within Oracle Cloud Infrastructure.

We will start by understanding how OCI IAM empowers you to not only control access but to do so with precision, adaptability, and the utmost security.

By the end of the chapter, they will comprehend the historical context, significance, and fundamental principles of IAM. This knowledge will empower them to navigate the intricate landscape of OCI in subsequent chapters.

Structure

In this chapter, we will go through the following topics:

- Technical requirements
- Fundamentals of IAM and identity
- Overview of IAM: OCI
- Identity and access management components
- Resource based policies
- Cross-tenancy access roles
- Federation
- Best practices for IAM domains
- Best practices for IAM

Objectives

By the end of this chapter, readers will have acquired a solid foundation in the basics of IAM, understand the significance of IAM in cloud security, grasp the fundamental role of IAM in ensuring the security and integrity of cloud environments, recognize the implications of inadequate IAM practices on data protection, compliance, and overall cloud security.

The chapter's narrative paves the way for readers to delve into more specialized topics, ensuring they are well-equipped to explore the multifaceted dimensions of IAM in the chapters that follow.

The goal of this chapter is to furnish extensive guidance and instructions for overseeing access control throughout the OCI ecosystem. This encompasses grasping essential IAM principles, overseeing the creation and management of

users and groups, establishing access policies, harnessing **role-based access control (RBAC)**, bolstering security via **multi-factor authentication (MFA)** and federation, monitoring IAM activities, and implementing optimal practices to safeguard the security and integrity of OCI resources. By engaging with this chapter, users will acquire the knowledge and proficiency necessary to proficiently manage access to OCI resources while upholding security standards and compliance regulations. By achieving these objectives, readers will be well-equipped to implement and manage robust IAM strategies within Oracle Cloud Infrastructure, contributing to a secure and well-organized cloud environment.

Technical requirements

In order to actively participate and understand the contents of the chapter *Identity and Access Management*, readers should be equipped with an understanding of computer systems, concepts in networking, and basic knowledge of information technology. In addition to the above technical requirements, readers are advised to have an understanding of the below specification for technical needs:

- **Internet access:** To utilize online resources, references, and examples related to cloud computing, readers need a stable internet connection.
- **Computing device:** Additionally, a computing device such as a desktop computer, or laptop equipped with a modern web browser is essential for reading the chapter content and accessing any online materials.
- **Web browser:** It is recommended to have the latest version of web browsers, which ensure compatibility and optimal and best viewing experience of web-based resources and interactive content, Here are a few web browsers recommended: *Google Chrome*, *Mozilla Firefox*, *Microsoft Edge*, or *Safari*.
- **Familiarity with basic security and cloud services:** Having knowledge of any cloud services and their basic functionalities will enhance the understanding of the chapter.

Fundamentals of IAM and identity

In this section, we cover a detailed overview of the basic and fundamental principles underlying Identity access management within the Oracle Cloud Infrastructure. These fundamentals are very important to understand how to secure and manage access to cloud resources effectively.

The concept of identity in OCI IAM Stresses the need of managing and securing user identities and their associated attributes within the Oracle Cloud environment. Defining and controlling these identities allows administrators to implement the fine-grained access control, ensuring that users have the appropriate needed permissions to perform their tasks in addition to maintaining the overall security of the OCI resources.

Below are the key fundamentals. We will walk through each of the fundamentals used in IAM by defining them in the section below:

- **Users:**

- Users are individuals who need access to Oracle Cloud resources. Each user is associated with a unique identity.
- Users can be assigned specific roles, determining the actions they are allowed to perform within OCI.

- **Groups:**

- Groups are logical collections of users. Users can be added to groups, making it easier to manage permissions for multiple users simultaneously.
- Groups are assigned specific policies, defining the actions that group members can perform on resources.

- **Policies:**

- Policies can be defined as a set of rules that specify the type of access users or groups have to resources. They are written in a declarative language.
- Policies consist of statements that include the effect (allow or deny), the action (e.g., read, write), and the target resource.

- **Compartments:**

- Compartments are logical containers used to organize and isolate cloud resources. Resources within a compartment share the same access controls.
- Compartments are important for structuring and securing resources, providing a way to control and limit access to specific sets of resources.
- Compartments are utilized to clearly differentiate resources for tracking usage and billing, controlling access through policies, and ensuring

isolation by segregating resources for various projects or business units. One of the common approaches is to create a compartment for each major part of your organization.

- **Authentication:**

- Oracle Cloud IAM supports various authentication methods. This comprises traditional username/password authentication and token-based authentication.
- Strong authentication mechanisms are vital for ensuring that only authorized users can access OCI resources.

- **Authorization:**

- Authorization is managed through IAM policies. IAM policies define the permissions granted to users, groups, or dynamic groups.
- IAM policies offer fine-grained access control, allowing precise definition of actions and resources for each identity.

- **Federation:**

- Oracle Cloud IAM supports federated identity management, allowing integration with external **Identity Providers (IdPs)** such as Microsoft Active Directory or other SAML-based IdPs.
- Federation simplifies user management by leveraging existing identity systems and centralized authentication.

- **Dynamic groups:**

- Dynamic groups are based on predefined rules, automatically adding users to a group based on their attributes.
- Dynamic groups provide a scalable way to manage access by dynamically including users as they meet specified criteria.

- **Audit logging:**

- IAM provides detailed and comprehensive audit logging capabilities. This logging allows organizations to track user activities, changes to policies, and other relevant events.
- Audit logs are essential for compliance, security monitoring, and troubleshooting.

- **ACL:**

- A software authorization system allows control over user access to a server. Users can establish ACL rules tailored to files or directories, determining access permissions for individuals or groups.

- **Delegation:**

- Delegation refers to the capability to grant specific permissions or access rights to another entity within the OCI tenancy.

- **Cross account roles:**

- Cross-account roles refer to a feature that allows users in one OCI tenancy to assume roles in another OCI tenancy.

The Fundamentals listed as above are important for readers to implement and manage IAM within Oracle Cloud Infrastructure. These components work together to establish a secure and well-organized environment, aligning with best practices in cloud security.

Overview of IAM: OCI

The IAM offered by OCI provides a powerful set of capabilities, such as Authentication and Single Sign-on. IAM principles are applicable not only to Oracle applications but also to both Oracle and non-Oracle applications developed by other software vendors or in-house by organizations. These non-Oracle applications are **Software as a Service (SaaS)**, cloud-hosted, or on-premises. This will let employees, customers and business partners access the applications at any point in time, from anywhere, any location and on any device in a highly secured and safeguarded approach.

IAM seamlessly connects with existing identity stores within an organization. Examples of Identity stores include databases or directories that contain user information and credentials.

IAM can also integrate with external IdPs, this refers to external services or systems responsible for authenticating users. IAM is designed to work seamlessly with various applications, whether they are hosted on-premises or in the cloud. This kind of IAM integration with applications across cloud and on-premises ensures that irrespective of the application's deployment location, IAM provides highly consistent and highly secure access control, thereby creating a unified identity management solution.

In summary, IAM is a major pillar and acts/serves as a foundational security platform for OCI, thereby providing a centralized mechanism for managing user

access, policies, and authentication.

Getting started with policies

This section outlines and details how policies work and highlights their essential attributes.

Policies determine who can access resources within a specific group or compartment and guide the level of access. In OCI, access is granted by default, following the principle of least privilege. Deny actions are not explicitly stated, and if something is not allowed, it is automatically denied.

Oracle defines the possible verbs which you can use in your policies. These are as below:

- **Inspect:** Allows listing resources without accessing metadata or confidential information. Note that with network resources, all information is still accessible.
- **Read:** Similar to Inspect but includes access to metadata and the resource itself.
- **Use:** Extends Read permissions, providing the ability to utilize the resource. This varies by resource type and includes the update of the resource, excluding cases where updating is identical to creating (e.g., updating a security list).
- **Manage:** Encompasses all permissions related to the resource, providing comprehensive control and the ability to perform various actions, including updates.

It is very critical to understand that OCI adheres to the principle of least privilege. Therefore, for a user to have the ability to read, inspect, use, or manage resources within the OCI tenancy, the user must be a member of a group and a corresponding policy must be configured to grant the necessary permissions to that group.

Policy syntax is as follows:

**Allow group <group-name> to <actions> on <resources>
where <condition>**

Example:

Allow group **DataEngineers** to manage all-resources in tenancy.

In the above example, the syntax grants the group named **DataEngineers** permission to manage (perform any action) all resources in the tenancy.

Few more examples are as follows:

Let us consider a scenario where our company's administrator creates a group called **OfficeAdmin**. Let us assume **OfficeAdmin**, in this example, is responsible for managing users and administering their credentials. We can implement a policy that facilitates the previously mentioned criteria outlined below:

Allow group **OfficeAdmin** to manage users in tenancy.

In the above scenario, as users are located within the tenancy (the root compartment), the policy explicitly mentions the term tenancy without mentioning the compartment phrase or word ahead of it.

Next, let us explore alternative examples where you have a compartment called *Project-Imp*, and a group called *Imp-Admins* which is responsible for managing all resources within the compartment of the Oracle Cloud Infrastructure. Below is the illustrative policy which enables these criteria.

Allow group Imp-Admins to manage all-resources in compartment Project-Imp.

Identity access control policy statements

In this section, we will define the IAM Policy statement. Within Oracle Cloud Infrastructure, an IAM policy statement is an important component which establishes permissions and access controls for users, groups, and resources within your OCI tenancy. These policy statements are implemented in **JavaScript Object Notation (JSON)** format and serve to articulate what actions are permitted or denied on specific OCI resources.

Below are the components of the IAM policy statement:

- **Policy document:**
 - An IAM policy statement is part/subset of an IAM policy document.
 - The policy document comprises one or more policy statements. Each statement defines a set of permissions.
- **Resource:**
 - A resource in OCI primarily refers to any cloud-based entity, such as a compute instance, storage bucket, virtual network, database, or any other OCI service.

- IAM policies are associated with specific resources or types of resources, allowing for fine-grained control over access to different components of the OCI infrastructure.

- **Permission actions:**

- IAM policy statements include a list of permission actions which can be executed on a specified resource.
- These actions define precisely what users or groups are allowed to do with the associated resource. Examples of actions include *read*, *write*, *list*, *delete*, and more.
- By defining actions, IAM policies govern the permissible activities for a given resource.

- **Principals:**

- Principals represent the entities to which the policy statement applies. Examples of Principals include individual users, groups of users, or even public entities.
- IAM policy statements allow specifying one or more principals that have the permissions defined within the statement.

- **Conditions:**

- IAM policy statements can incorporate conditions to further refine when the policy applies.
- Conditions can be based on various attributes, including time of day, IP addresses, request sources, and more. The inclusion or addition of the conditions adds an additional layer of granularity to access controls, allowing administrators to define contextual constraints for policy enforcement.

Identity providers and federation

Components within the IAM service include IdPs and federation. Let us define IdPs and federation and the need for the same:

- **IdPs:** An IdP is a system which is responsible for creating, storing, and managing the digital identities. IdP can be considered as a service which authenticates users and issues identity tokens, confirming the user's identity. IDPs can be integrated to allow users in your organization to use their

existing credentials to log in to OCI. This integration streamlines the user authentication process and enables seamless **single sign-on (SSO)** across diverse systems.

- **Federated identity:** This refers to trust relationship between two entities for using authentic information from one system in order to grant access to another system without asking for authentication information multiple times.

In OCI, following are the steps which involve integration of IdP and federation:

1. **Configuration:** Administrators configure OCI to trust a specific IdP. This process involves exchanging metadata, establishing a trust relationship, and defining the rules for user authentication and authorization.
2. **User authentication:** Users authenticate through their organization's IdP, which then confirms their identity to OCI.
3. **SSO:** Once authenticated by the IdP, users can access OCI resources without the need for additional login credentials. This process is referred to as SSO, where users seamlessly move between different systems without re-authenticating.
4. **Centralized identity management:** Integration with IdPs and Federation allows organizations to centralize identity management, ensuring consistent and secure access control across different platforms and services.

Overall, IdPs and Federation in OCI contributes to a more streamlined and secure IAM experience for users and administrators.

Identity and multi factor authentication

Multi factor authentication (MFA) is an authentication approach that requires the use of multiple factors to confirm a user's identity. Upon activating MFA during the application sign-in, users initially provide their username and password, representing the first factor—something which they already know. Subsequently, users are required to supply a second form of verification. The combination of these two factors augments security by introducing an extra layer of protection. This can entail additional information or the participation of a second device to authenticate the user's identity and complete the sign-in process.

One of the important things to be noted, If MFA is configured in a 3rd-party IdP, such as Microsoft Azure Active Directory abbreviated as Azure AD or Okta, there is no need to configure MFA through IAM or Via Oracle Identity Cloud Service.

Identity and access management components

In this section we will define and understand all the major components of IAM in Oracle Cloud Infrastructure. Below is a comprehensive and detailed list of various components and tools of IAM which collectively form the integral structure of the framework of IAM. In this section we will define and understand all the major components of IAM in Oracle Cloud Infrastructure.

Compartments

Compartments can be referred to as a logical group of OCI resources. Policies are applied to compartments, defining access controls for the resources contained within them.

Compartments can be viewed as a collection of resources linked to a set of group-based permissions. Resources linked with a compartment can easily be reallocated with a different compartment. This is straightforward to reassign resources from one compartment to another, allowing for easy restructuring and organization.

Note: A root tenancy compartment is automatically generated and is intended for creating OCI users, including roles such as OCI administrator, security analyst, or solutions architect. Utilize the default root tenancy compartment that is pre-existing for this purpose.

Below are the steps (Refer *Figure 2.1*) to create, list or manage compartments:

1. Click the OCI menu positioned at the page's upper-left corner.
2. Click **Identity & Security | Compartments** under the **Identity** section (you can select from the list to manage a compartment (including the root default tenancy) or create a new compartment).

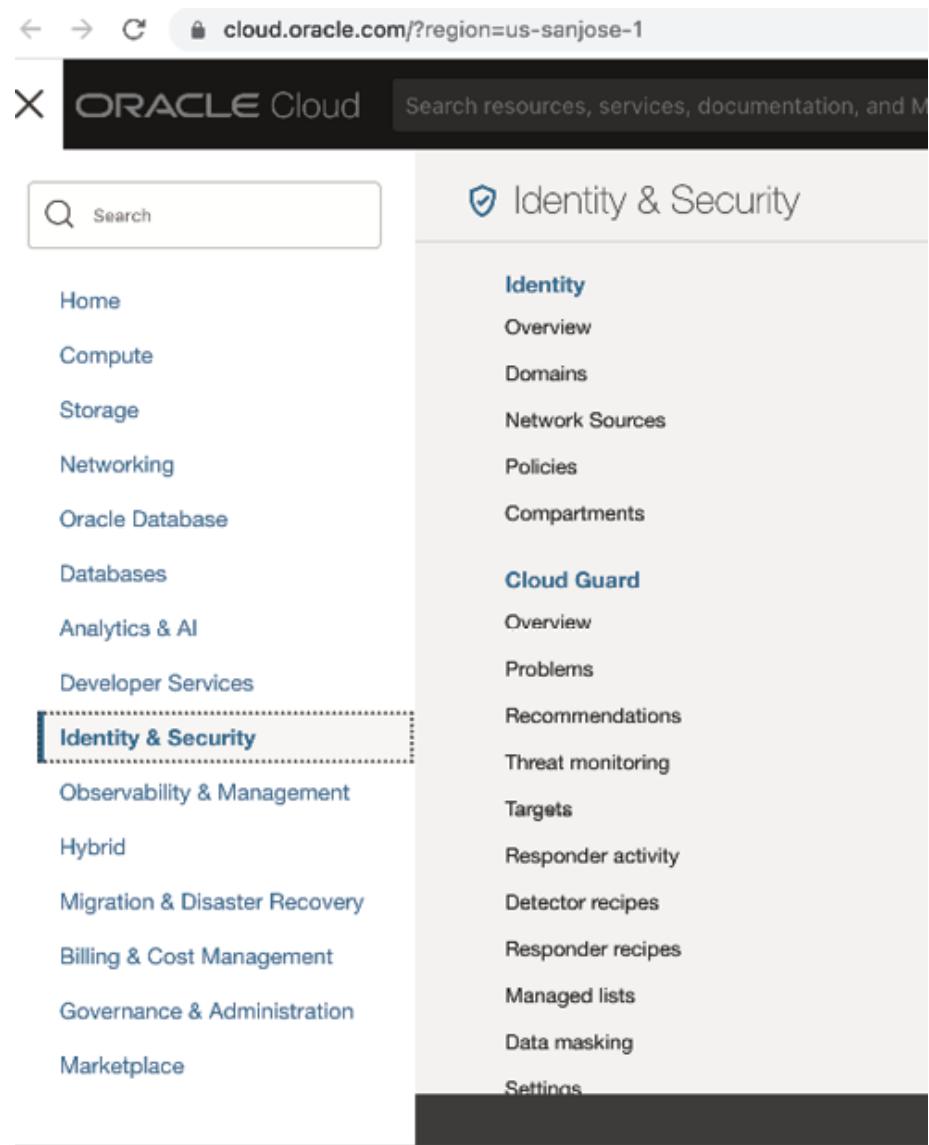


Figure 2.1: Identity and security screen in OCI

3. Click the **Create Compartment** button. (As mentioned in below [Figure 2.2](#)):
 - a. Type name
 - b. Type description
 - c. Select group compartment from the dropdown list (if creating a child compartment)
4. Click create:

Create Compartment

Name
dinesh_demo_compartment

Description
Demo

Security Zone: - [\(i\)](#)

Parent Compartment
dineshbudagam (root)

Add tags to organize your resources. [What can I do with tagging?](#)

Tag namespace	Tag key	Tag value
None (add a free-form tag) ▼		

[Add tag](#)

[Create Compartment](#) [Cancel](#)

Figure 2.2: Screenshot for creating the compartment

Users and groups

Users are individual entities associated with a unique identity in OCI. Users may need to execute tasks such as initiating instances, managing remote disks, and handling virtual cloud networks. On the other hand, a group can be described as an assembly of users, all requiring similar access to a specific set of resources or compartments.

Below are the steps to create users:

1. Click the OCI menu located on the top left corner of the page.
2. Click **Identity & Security | Domains** under the **Identity** section | Click **Default** or current domain list box.
3. To create a new user, click **Users** under the **Identity** domain section:

Display name
Dinesh_Demo_Domain

The only characters allowed are letters and numbers (for example, a-z, A-Z, 0-9), an underscore (_), a period (.), and a hyphen (-).

Description
Demo Domain

Domain type

- Free**
Authentication and Access Management for Oracle Cloud (IaaS and PaaS services) with limits on usage and functionality.
 - Limit of 2000 users.
 - Limited feature support.
 - Limit of 2 non-Oracle apps.
 - Limit of 3 external Identity Providers.
- Oracle Apps Premium**
Authentication and Access Management for all of your Oracle apps.
 - Unlimited support for Oracle Apps including hybrid IAM.
 - Limit of 6 non-Oracle apps.
 - Unlimited external Identity Providers.
- Premium**
Enterprise Identity & Access Management for employee workforce scenarios.
 - Includes all features.
 - Broad support for hybrid IAM use-cases.
 - Unlimited support for Oracle and non-Oracle Apps.
 - Unlimited external Identity Providers.

External User
Identity storage, Access Management, and API security for consumer and non-employee use-cases.

- Provides social logon, self-service, and consent management.
- Limited enterprise and hybrid IAM features.
- Excludes App Catalog provisioning connectors.

Create domain Cancel

Figure 2.3: Screenshot for creating domain

4. Click the **Create User** button. (refer to [Figure 2.4](#)):

- Enter the user's **First Name** and **Last Name**.
- Select the check box, use the email address as the username to have the user sign in with their email address. Unselect the checkbox, use the email address as the username to have the user sign in with username and then type in the username.

The following characters are allowed:

- a-z
- A-Z
- 0-9
- Special characters ! @ # \$ % ^ & * () _ + = - { } [] | \ : " ' ; < > ? / . ,
- Blank spaces

5. In the **Select groups to assign this user to** section, mark the checkbox for your selection, as shown [Figure 2.4](#).

6. Click **Create** (As per the steps mentioned in *Figure 2.4*):

Create User

Name
Dinesh_Budagam
No spaces. Only letters, numerals, hyphens, periods, underscores, +, and @.

Description
Test user creation

Email *Optional*

Confirm Email

[Hide advanced options](#)

Tags
Add tags to organize your resources. [What can I do with tagging?](#)

Tag namespace	Tag key	Tag value
None (add a free-form tag)	<input type="text"/>	<input type="text"/>

Create [Cancel](#) Create Another User

Figure 2.4: Creating the user screen

Resources

Resources can be defined as cloud objects which company's or organization employees create and use while interacting with Oracle Cloud Infrastructure. This encompasses various examples such as virtual clouds, subnets, route tables, compute instances, block storage volumes, and more.

Dynamic group

Dynamic group can be considered as a special type of group which contains resources that match rules which we define. Examples of resources are compute instances. Compute instances serve as the principal entities and can execute API calls to services based on policies authored for the dynamic group. Using dynamic groups in OCI can be considered as the best way to enhance your solution security and stop managing keys on the server side. Dynamic groups should definitely be part of your strategy if you need to access OCI services from your instances.

Dynamic groups must be assigned a distinctive and immutable name that is unique across all groups within your tenancy. The dynamic group remains without permissions until we define at least one policy granting it access to resources within the tenancy or a specific compartment. In the policy, the dynamic group can be identified using either its unique name or its **Oracle Cloud Identifier (OCID)**.

Tenancy

Within OCI, a tenancy can be characterized as a virtual compartment serving as the root compartment for an organization's resources. A tenancy is established when an organization subscribes to an OCI account, serving as the topmost level of resource organization within OCI. It can include multiple compartments, providing a structure for further organization and resource management.

In nutshell, tenancy in OCI denotes the utmost or maximum level of organization and isolation or can be viewed as the representation of an organization's top-level account or subscription for accessing and managing OCI resources.

Tenancy offers many benefits, such as isolation and security, granular access controls, a unified and comprehensive view of resource utilization, costs and expenditures, and resource management and organization, to name a few.

Below are the steps to create tenancy (Refer to *Figure 2.5*):

1. Login into OCI
2. Go to **Menu | Governance & Administrations | Organization Management | Tenancies.**

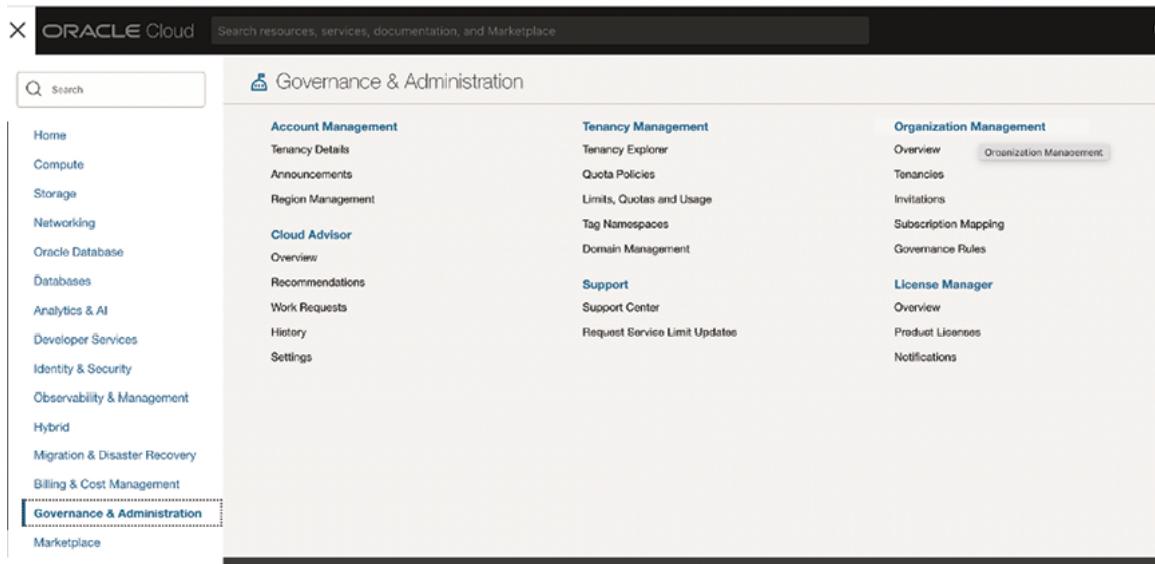


Figure 2.5: Creating the tenancy

3. Click **Add Tenancy** (Refer to [Figure 2.6](#)):

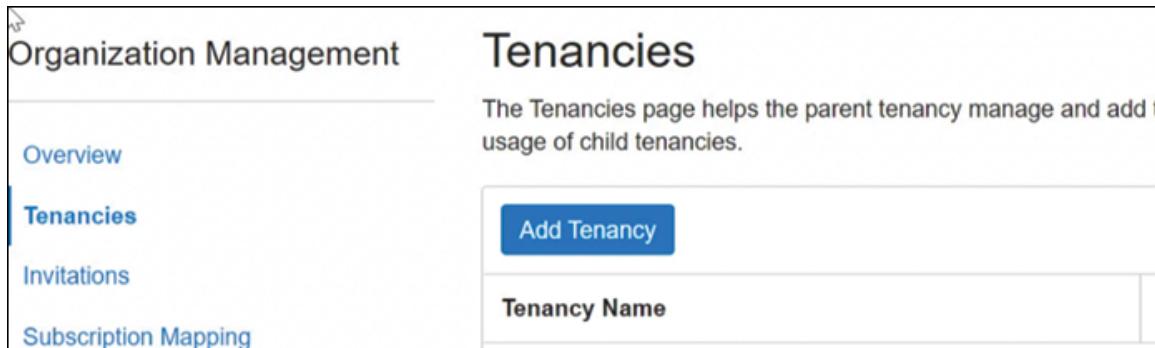


Figure 2.6: Screenshot for Adding Tenancies

Home region

The home region can be referred to as the region where your IAM Resources reside. These IAM resources are global and accessible across all regions, while a master set of definitions exists in a single region, which can be referred to as the home region. The changes made to IAM resources in the home region will be propagated automatically to all the regions.

Resource based policies

In resource-based policy, as the name implies, a policy will be attached to resources. This policy defines who can access it and what respective actions they

can perform. In nutshell, resource-based policy specifies who can access the resource.

Resource identifiers

Oracle assigns a unique identifier for most of the resources. This unique identifier is termed as Oracle Cloud ID which is abbreviated as OCID.

There are different ways by which we can identify resource identifiers in OCI. We will discuss the most common way to identify resources termed OCID in this section.

As previously explained, Oracle assigns a unique and distinct identifier to the majority of resources in the OCI, which is termed OCID. This identifier is an integral part of the resource's information, accessible in both the console and API.

Syntax of OCID is as follows:

**ocid1.<RESOURCE TYPE>.<REALM>. [REGION] [.FUTURE USE] .
<UNIQUE ID>**

In the following section, we will walk through where we can find the tenancy and explain each term.

To successfully authenticate API requests, it is essential to possess the OCID of the tenancy, and it is mandatory when we utilize the OCI API. Tenancy ID is also required if we want to implement some of the IAM API operations.

Following are the steps to navigate to **Tenancy details** page as referred in *Figure 2.7*:

1. Access the OCI console by logging into **Console** page.
2. Navigate the **Profile** menu as shown in the screen below and click **Tenancy: <your_tenancy_name>**. In this example is Tenancy:dineshbudagam.

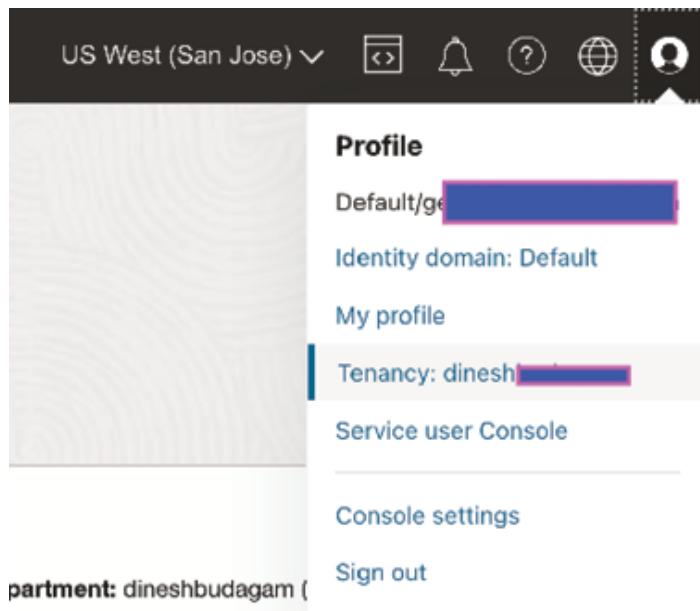


Figure 2.7: Navigation to Tenancy details

- Find the tenancy OCID in the **Tenancy Information** section. Click **Show** to display the complete ID, or choose **Copy** to copy it to your clipboard. Refer to [Figure 2.8](#):

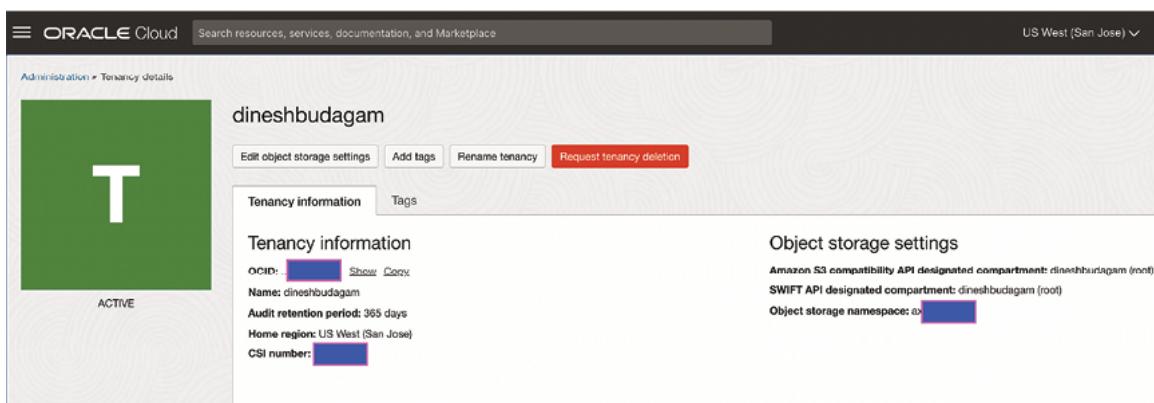


Figure 2.8: Navigation to Administration and Tenancy details

In this example, OCID is specified as:

ocid1.tenancy.oc1..aaaaaaaaamytj6abvpxrzwlvsbi2v3e2vbxwsc4om7clw5onjtys5xikv7xa

Where

aaaaaaaaamytj6abvpxrzwlvsbi2v3e2vbxwsc4om7clw5onjtys5xikv7xa refers to **UniqueID** and can be written as in the below syntax.

Syntax: ocid1.<RESOURCE TYPE>. <REALM>. [REGION] [. FUTURE USE] .<UNIQUE ID>

Let us understand the terminology used in the syntax:

- **Resource type** can be anything related to the type of resource. Ex: Instance, subnet, group, volume, etc.)
- **Name:** Each IAM resource is assigned a unique and immutable name. The name must be distinct within the context of the specific resource type. For instance, there can only be one user with a particular name. (for example, you can only have one user with the name **DineshBudagam**)
- **Description:** Along with providing a name, it is essential to allocate a description to every IAM resource. This can be an empty string. This information facilitates the straightforward identification of the resource. Unlike name, the description does not have to be unique, and you have feasibility to change it whenever you like.
- **Realm:** A realm can be defined as a set of regions that share entities.

In the above example, oc1 is related to realm.

Examples of realms include but are not limited to oc1 for the commercial cloud realm and oc2 for the government cloud realm.

For instance, the regions within the commercial realm (OC1) are associated with the domain oraclecloud.com, while the regions in the government cloud (OC2) are linked to the domain oraclegovcloud.com.

- **Region:** Within Oracle Cloud Infrastructure, a region denotes a geographically confined area having one or more data centers, known as availability domains. Each region operates autonomously, ensuring fault isolation. Regions empower customers to deploy and operate their applications in a designated geographic location, leveraging the scalability, reliability, and performance offered by OCI's expansive global cloud infrastructure.

This component is included in the OCID exclusively for regional resources or those specific to a single availability domain. If the resource is not associated with a region, this segment may be empty. see the example tenancy ID below.

- **Future use:** This is reserved for future use. In this particular situation it is currently empty.

- **Unique ID:** The distinctive segment of the ID. Depending on the type of resource or ID, format will be changing.

Resource based policies vs. IAM based policies

Unlike resource-based policy where policy is attached to resource, In IAM based policies, an identity-based policy is attached to IAM users, groups, or roles and defines their allocated permissions.

In Oracle Cloud Infrastructure, IAM policies enable situational restrictions in contrast to time-based and network or location-based rules. For instance, an operations team can limit restarts of cloud compute instances to a specific time period.

Identity-based policies generally provide broader access control. This is because these are applied to multiple resources for a specific IAM entity, whereas for resource-based policies, this offers fine-grained control over individual resources. They specify principals (including specific IAM users) and conditions, allowing resource owners to manage access more precisely.

In simple words, **identity-based policies** govern the activities that users and groups can undertake throughout the OCI tenancy, whereas **resource-based policies** regulate access to individual OCI resources and the permissible actions on those resources.

Cross-tenancy access roles

We discussed the concept called **compartments**, which enable you to partition resources into logical groups for security isolation and access control, which is applicable for a **single tenancy**. In certain scenarios or use cases, it may be necessary to authorize an external entity (individual or system) beyond your OCI tenancy to access your resources. This could involve a third-party vendor tasked with managing resources within your OCI tenancy. Within OCI, there exists a concept known as **cross-tenancy** policies. In OCI, IAM policies employ the concepts of admit and endorse.

Let us define the words **endorse**, **admit** and **define**:

- **Endorse:** This is referred to as a group in one tenancy can perform a set of abilities in other tenancies.
- **Admit:** This refers to identifies a group of users who require resource access from the source tenancy

- **Define:** This action involves assigning an alias to a tenancy OCID for both Endorse and Admit policy statements. It should be incorporated within the same policy entity as the Endorse or Admit statement.

Let us discuss the above concept using a small example where you want to grant permission for the vendor development team in the tenancy of a third-party vendor (**vendorTHIRDPARTY**) to facilitate read/write data from buckets in your OCI tenancy (**companyOURTENANCY**). In this example, administrators in both tenancies must establish IAM policies.

The following are steps to be performed to configure IAM policies:

1. IAM policies need to be configured:

In OCI tenancy, which we defined earlier, below are the steps to be performed:

- a. Acquire the OCIDs for both the tenancy and IAM groups from your third-party vendor. In this case, it is (**vendorTHIRDPARTY**).
- b. Employ the **define** statement to designate an alias for both the tenancy and IAM group related to the third party.
- c. Utilize the **admit** statement to authorize the IAM group within the third-party vendor's tenancy.
- d. Below are the statements to be added.

```
define tenancy vendorTHIRDPARTY as
ocid1.tenancy.oc1..thirdparty

define group VendorIntegrationTeam- as
ocid1.group.oc1..thirdparty

admit group VendorIntegrationTeam- of tenancy
vendorTHIRDPARTY to inspect compartments in
tenancy.

admit group VendorIntegrationTeam- of tenancy
vendorTHIRDPARTY to read object-family in
tenancy.

admit group VendorIntegrationTeam- of tenancy
vendorTHIRDPARTY to read compartments in
tenancy.
```

```
admit any-user of tenancy vendorTHIRDPARTY- to  
read buckets in compartment SampleData where  
ALL {request.principal.type = 'disworkspace',  
request.operation = 'GetBucket'}
```

2. In the OCI tenancy of the third party, below are the steps to configure IAM policies:

- a. Provide your tenancy OCID to a third-party vendor.
- b. Employ the defined statement to assign an alias for the customer (companyOURTENANCY) tenancy.
- c. Facilitate the use of the endorsed statement to control which group can access resources in the customer tenancy.
- d. Below are the statements to be added.

```
define tenancy companyOURTENANCY as  
ocid1.tenancy.oc1..tnc  
endorse group VendorIntegrationTeam to read  
object-family in tenancy companyOURTENANCY  
endorse group VendorIntegrationTeam to read  
compartments in tenancy companyOURTENANCY  
endorse any-user to read buckets in tenancy  
companyOURTENANCY where ALL  
{request.principal.type = 'disworkspace',  
request.operation = 'GetBucket'}  
endorse any-user to manage objects in  
tenancy companyOURTENANCY where ALL  
{request.principal.type = 'disworkspace'}
```

The development team in the third-party vendor's tenancy (**vendorTHIRDPARTY**) can subsequently traverse the boundary and gain access to OCI Object Storage resources in your tenancy (**companyOURTENANCY**) using the OCI Data Integration console pages or by executing tasks from their workspaces!

With this approach, users have the capability to utilize OCI CLI, SDK, or API to access resources in a different tenancy by properly defining the Endorse and Admit IAM policies. It is important to mention that cross-tenancy policies are not

supported by all OCI services and APIs. Thus, it is highly recommended that we need to make sure we test the policies and validate the results to have this implemented. Below *Figure 2.9* illustrates the cross-tenancy access role use case:



Figure 2.9: Screenshot for cross tenancy access role use case

Federation

Federating in cloud computing usually refers to a process that involves the incorporating of several cloud providers to provide users with a seamless, integrated experience. The concept of federation offers various benefits, such as scalability, flexibility in cloud deployments, and better resource utilization. This also allows organizations to spread and distribute workloads across various cloud environments and thereby prevents vendor lock-in mechanisms.

Identity providers and federation

Below is the list of concepts we need to be familiar with to understand how the federation works in OCI:

- **IdP:** An IdP manages user login/passwords and thereby facilitates authenticating users for accessing secure websites, services, and resources.

- **Service provider:** A service can be anything which calls upon an IdP to authenticate the users. Examples include websites, applications, etc. In our scenario, OCI can be considered as a service provider.
- **Federation trust:** Federation trust is referred to as an association established between an IdP and a service provider by an administrator. This relationship can be established by Infrastructure Console or API. In the process, the specific IdP is federated to that SP, which is the same as adding an IdP to the tenancy. The user who logs in to use the OCI console through a federated IdP can be defined as Federated user and a non-federated user is referred to as local user. Local users login to use the OCI console with a login and password created in OCI.

We have different vendors and ways to Federate. Some examples include but are not limited to Federating with Oracle Identity Cloud Service, Microsoft Active Directory, Federating with Azure AD and SAML 2.0 IdPs. In this section, we can discuss the steps for Federating with Azure AD and different ways of federating with Security Assertion Markup Language with version 2.0 IdPs.

Federating with Azure AD

To establish this, it is necessary to have a fundamental SAML single sign-on application configured in Azure AD. Federation with Azure AD is established by configuring OCI as a basic SAML single sign-on application in Azure AD. In order to configure the application, we need to have some steps implemented in Azure AD and some of the steps executed in OCI console.

Below are the steps to be implemented by the administrator in Azure AD:

1. In the Azure AD,
 - a. configure OCI Console as an enterprise application.
 - b. Set up the enterprise application for single sign-on in Oracle Cloud Infrastructure.
 - c. Set up the claims and user attributes.
 - d. SAML metadata document to be downloaded from Azure AS and assign user groups to the application.
2. Below are the steps to be implemented by administrator in OCI:

In OCI,

- a. Download the federation metadata document.
 - b. Establish Azure AD as an IdP.
 - c. Map your Azure AD groups created above to OCI groups.
 - d. Configure the relevant IAM policies to manage access for your Azure AD groups.
3. Users shall be provided the login URL of OCI

Federating with SAML 2.0 identity providers

This Section explains the general steps to federate Oracle Cloud Infrastructure with any identity provider that supports the Security Assertion Markup Language (SAML) 2.0 protocol. Below are the steps to be implemented at OCI:

1. In OCI, Obtain the federation metadata necessary to establish a trust relationship with the IdP.
2. Set up OCI as an application within the IdP.
3. In the next step, assign users and groups to your newly created OCI application, obtaining the necessary information required by Oracle Cloud Infrastructure. This both the actions needed to be implemented at IDP.
4. In OCI, add the IdP to your tenancy and map the IdPs groups to respective IAM groups.
5. Setup IAM policies for the groups, which enables us to control access to OCI resources.
6. Finally, share the users the OCI tenant details and the URL for the console.

Despite the manifold advantages and benefits of a federation in computing, there are also challenges and considerations that organizations must address:

- Federations must necessitate common standards and protocols to ensure interoperability and collaboration.
- Establishing trust is crucial to ensuring the security and integrity of shared data, resources, and services.
- Determining decision-making processes within the federation is essential.

- Implementing governance structures is necessary to manage collaboration effectively.
- Ensuring data privacy and security while sharing data across multiple organizations and systems is a key concern.

Challenges of federation

In the above section, we discussed various benefits of the federation. However, it is worth noting what are the challenges and considerations that organizations must look into before implementing.

Below are a few challenges and considerations:

- Organizations should be aware that federations necessitate shared standards and protocols to guarantee interoperability and collaboration and most of the time, it involves having governance structures to manage this.
- Data will be shared across multiple organizations and systems, and this essentially requires data privacy and security.
- Privacy leads organizations to instill confidence in safeguarding the security and integrity of shared data, resources, and services.

Best practices for IAM domains

Below are the best recommendations to be followed for IAM domains:

- Minimize the number of tenancy administrators.
- Automate the user life cycle management.
- Highly recommended to enable MFA for all local users who are logging into OCI console.
- Need to use the SIEM system to collect, capture and retain the Identity domain audit logs. This can be used later for analysis of security threats.
- Enforce users to use a strong password policy. It is advisable to associate a robust and strong password policy with Identity Domain Administrators or other local users.

Best practices for IAM

As per the top 10 OWASP awareness document, we recommend below best practices for IAM in OCI:

- **Zero trust model:** Always enforce the least privilege and implement the zero-trust model.
- **Implement tag-based control policies:** One of the primary use cases of tagging is Access Control. You can use resource metadata in IAM policies to refine access policies and control who has CRUD permissions on the resources.
- **Resource policies:** Implement resource tag-based access policies.
- **Multi-factor authentication:** Enforce multi-factor authentication and enable single sign-on.
- **Enable password management:** Adopt self-service password reset. Do not rely on the default password policy. Instead, create a password policy by using the custom policy template which enables you to tailor it to your organization's compliance requirement.

Conclusion

In conclusion, the IAM chapter within OCI stands as a foundational element for shaping a secure and streamlined cloud environment. IAM, equipped with its comprehensive suite of tools and features, empowers organizations to oversee user access, safeguard sensitive data, and bolster overall security measures. The chapter covers the fundamentals of IAM, provides an overview of IAM, and stresses the challenges and best recommendations to be implemented for IAM. IAM not only enhances security but also fosters operational efficiency by simplifying user management and access policies. The inclusion of MFA provides an additional layer of security, ensuring resilient defense mechanisms against unauthorized access. As organizations embrace cloud technologies, IAM emerges as a crucial component in orchestrating secure and seamless interactions between users and resources.

Looking forward, the prospects of integration with external IdPs and the potential for federated identity management underscore the scalability and adaptability of Oracle Cloud IAM. In the evolving landscape of technology, IAM maintains its prominence in organizational governance, compliance adherence, and serving as a robust defense against cyber threats.

To optimize the benefits of IAM, readers are encouraged to apply the concepts discussed in this chapter to their OCI implementations. By adopting IAM best

practices and staying abreast of emerging security considerations, organizations can establish a sturdy foundation for a secure, compliant, and operationally efficient cloud environment. As we progress through OCI, the fundamental principles and insights obtained from this IAM chapter will undoubtedly provide a strong framework for navigating the complex network security of OCI in the upcoming chapter.

Multiple choice questions

- 1. Which OCI IAM policy is incorrect and not a valid case?**
 - a. Provide access for dynamic-group front-end to manage instance-family in compartment Project-A.
 - b. Allow any-user to inspect users in tenancy.
 - c. Do not allow group A-Admins to manage all-resources in compartment Project-A.
 - d. Deny group A-Developers to create volumes in compartment Project-A.
- 2. Your manager asked you to set up instance principals so that an application running on an instance can call OCI public services. He mentioned there is no need to configure user credentials while setting up. A coder in your team has already set the application built using an OCI SDK to authenticate using the instance principal's provider. Which is NOT a necessary step to complete this set up?**
 - a. Generating the Authorization Tokens to enable instances in the dynamic group to authenticate with API's.
 - b. Creating a policy denying permissions to the dynamic group.
 - c. Deploy the application and the SDK to all the instances that belong to the dynamic group.
 - d. Create a dynamic group with deferring rules to filter instances that can make API calls against defined services.
- 3. Your Security IT team has asked you to provision an Autonomous Database in OCI, but they want it to operate similarly to what you have currently on-premises. What are the prerequisites for successfully deploying an Autonomous Dedicated Database in OCI?**

- a. Teradata infrastructure
- b. IAM policies
- c. Object storage
- d. Autonomous container database

Answers

- 1. B
- 2. C
- 3. B

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CHAPTER 3

Navigating Network Security in OCI

Introduction

In the ever-evolving landscape of cloud computing, the imperative of robust network security cannot be overstated. With organizations progressively transitioning their critical workloads to the cloud, **Oracle Cloud Infrastructure (OCI)** comes into focus, offering a comprehensive suite of services and features to construct, secure, and scale cloud environments.

This chapter thoroughly explores the intricacies of network security within OCI, discussing the foundational principles, best practices, and advanced mechanisms utilized to safeguard the integrity, confidentiality, and availability of data and services. By understanding and deploying effective network security measures, organizations can fortify their infrastructure against potential threats, ensuring a resilient and secure environment for their applications and data.

This chapter is structured to guide you through the essential aspects of network security in OCI. We will cover topics such as network architecture, security controls, compliance considerations, and practical implementation strategies. Each section is crafted to equip you with the knowledge needed to design and maintain a secure network environment within OCI. In this chapter, we establish the network security objectives to ensure the robust protection of our infrastructure. These objectives guide the implementation of security measures and contribute to the overall resilience of our network.

Let us discuss OCI's network security landscape, understanding how to leverage the platform's capabilities to fortify our digital assets and ensure a resilient and secure cloud infrastructure.

Structure

The chapter covers the following topics:

- Technical requirements
- Overview of security zones
- Security zone concepts
- Features provided by security zones
- Methods of accessing security zones
- Cloud guard
- Networking overview
- Networking components
- Subnets
- Public subnets
- Private subnets
- Ways to secure network
- Overview of load balancers

Objectives

The objective of this chapter is to provide a comprehensive understanding of the principles, practices, and mechanisms associated with securing the network infrastructure within OCI. The chapter aims to equip readers with the knowledge and insights necessary to design, implement, and manage a secure network environment within the OCI platform. Specific objectives may include an overview of Security zones, Features provided by Security zones, Cloud Guard, Networking overview and components of networking. The chapter's objective is to provide an overview of OCI, Highlight the significance of network security in the context of cloud computing, and outline the fundamental goals of network security, such as confidentiality, integrity, availability, and compliance. Emphasize the importance of achieving these goals within the OCI framework. The chapter also focuses on the architecture of the network in OCI, including **Virtual Cloud Networks (VCNs)**, subnets, and related components, and explains how these architectural elements contribute to overall network security.

Technical requirements

In order to actively participate and understand the contents of the chapter, the readers should be equipped with an understanding of computer systems, concepts in networking, and basic knowledge of information technology.

In addition to the above technical requirements, readers are advised to have an understanding of the below specifications for technical needs:

- **Internet access:** To utilize online resources, references, and examples related to cloud computing, readers need a stable internet connection.
- **Computing device:** Additionally, a computing device such as a desktop computer or a laptop equipped with a modern web browser is essential for reading the chapter content and accessing any online materials.
- **Web browser:** It is recommended to have the latest version of web browsers, which ensures compatibility and optimal and best viewing experience of web-based resources and interactive content. Here are a few web browsers recommended: *Google Chrome, Mozilla Firefox, Microsoft Edge, or Safari*.
- **Familiarity with basic security and cloud services:** Having knowledge of any of cloud services and their basic functionalities will enhance the understanding of the chapter.
- **Networking concepts:** Knowledge of fundamental networking concepts such as IP addressing, subnets, routing, and firewall principles.
- **OCI Identity and Access Management (IAM):** Familiarity with OCI IAM for managing users, groups, and policies to control access to OCI resources.
- **Logging and monitoring:** Familiarity with OCI logging and monitoring services to capture and analyze network activity and security events.

Overview of security zones

This section explains the fundamentals and overview of security zones in OCI. These fundamentals are very important to understand how to secure and manage access to cloud resources effectively. Let us define what is a security zone and the need for a security zone before understanding the concepts and implementation of security zones.

Oracle Security zones serve as a preventative control measure, aiming to prevent the implementation of choices that could compromise the security posture. OCI

Security zones implement stringent security rules primarily focused on the best practices, ensuring they are immutable and cannot be altered, thereby fortifying your security stance.

Security zones guarantee the security and adherence to Oracle Security principles for resources in Oracle Cloud, including but not limited to compute, networking, storage, and database. This automated security feature operates within a cloud compartment thereby ensuring a streamlined and robust security framework.

Security zones not only ensure security of cloud resources but also prevent security misconfigurations. It is worthwhile to note that the security zone is associated and linked with one or more compartments. By default, a compartment and its sub-compartments share the same security zone. However, OCI also provides the flexibility and ease to create a separate security zone for a sub compartment. One of the key benefits of a Security zone is, it is a free service offered by OCI and is available across all commercial zones.

To define the term **recipe**, let us understand the actual definition of security policy.

In OCI, a security policy refers to a set of rules and configurations which defines the access controls and permissions for various resources within the OCI environment. These policies are a fundamental component of the IAM service in OCI and play an important role in defining who (principals) can perform what actions (permissions) on which resources, and under what conditions. These concepts of IAM are discussed in [Chapter 2, Mastering Identity and Access Management](#). Recipe, on the other hand, can be defined as a collection of security zone policies. It is important to note that Security zone will take precedence over an IAM policy that grants access. As an example, consider a scenario where a user possesses the authorization to manage a bucket. Nevertheless, within a Security zone, if the *Deny public buckets policy* statement is active, the user is restricted from making the bucket public. This is due to the Security zone taking precedence over an IAM policy that permits access, as discussed earlier.

Based on the above example, if the security zone is considered to be heavily protected, how does the data transfer in and out of the security zone? This can be accomplished by creating a secure connection, such as a Bastion server. This can be easily set up and launched through the OCI Bastion from the console.

Prerequisite of creating a security zone is to have oracle cloud guard enabled.

A prerequisite for creating a security zone is to have oracle cloud guard enabled. Primary purpose of Cloud Guard is it helps to detect and identify policy violations in pre-existing resources created before the implementation of the security zone. We can discuss Cloud Guard in upcoming sections.

Note: It is important to understand that security zone will take precedence over an IAM policy that grants access.

Security zone concepts

In this section. We will deep dive into various concepts involved in security zones and understand each of the components involved in security zones. As defined above Oracle Security Zones serve as a preventative control measure, aiming to prevent the implementation of choices that could compromise the security posture.

Security zone has the following characteristics:

- Associated with a single compartment sharing the identical name as a security zone. This implies that a compartment cannot be linked to more than one security zone.
- Security zones are assigned to the security recipe. By assigning these security zones to the security recipe, the organization ensures that each zone adheres to its defined security policies, providing a structured and effective approach to network security.

Security zone policy and security zone recipe:

- A security requirement is applicable to resources within a security zone. Enabling a policy within a security zone results in the denial of any action that violates the respective policy. The primary difference between security policy and IAM is that the security zone policy is validated irrespective of the user executing the operation.
- For instance, IAM policies are created by administrators to grant specific roles to manage resources in a compartment, while security zone policy enforces and ensures these operations are in compliance with best standard practices and are in alignment with Oracle Maximum Security Architecture. The collection of security zone policies constitutes a security recipe.

The following are the steps to view policies in a recipe:

1. Navigate to **Identity & Security** and select **Recipes** under **Security Zones**:

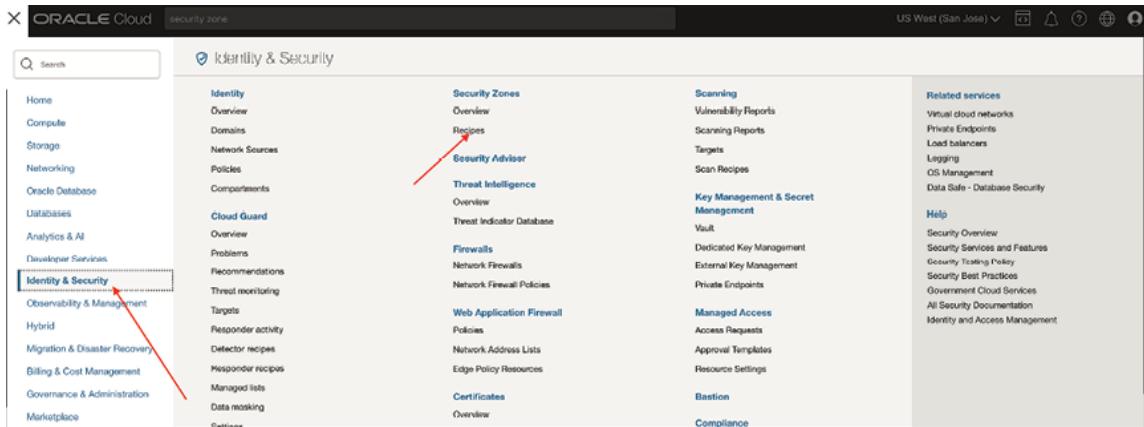


Figure 3.1: Identity and security screen in OCI

2. Click **Recipes** as shown in the figure:

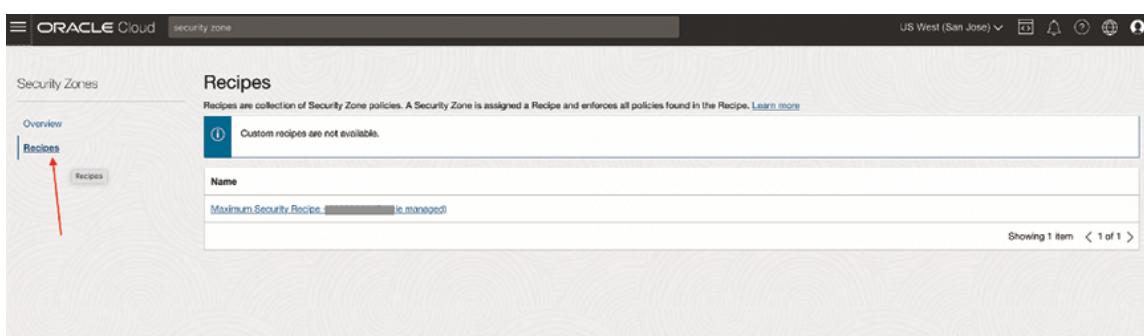


Figure 3.2: Security Recipes screen in OCI

3. To view the security zones or policies linked to a particular recipe, you can click on the recipe name and subsequently select **Associated OCI Security Zones and Policies**:

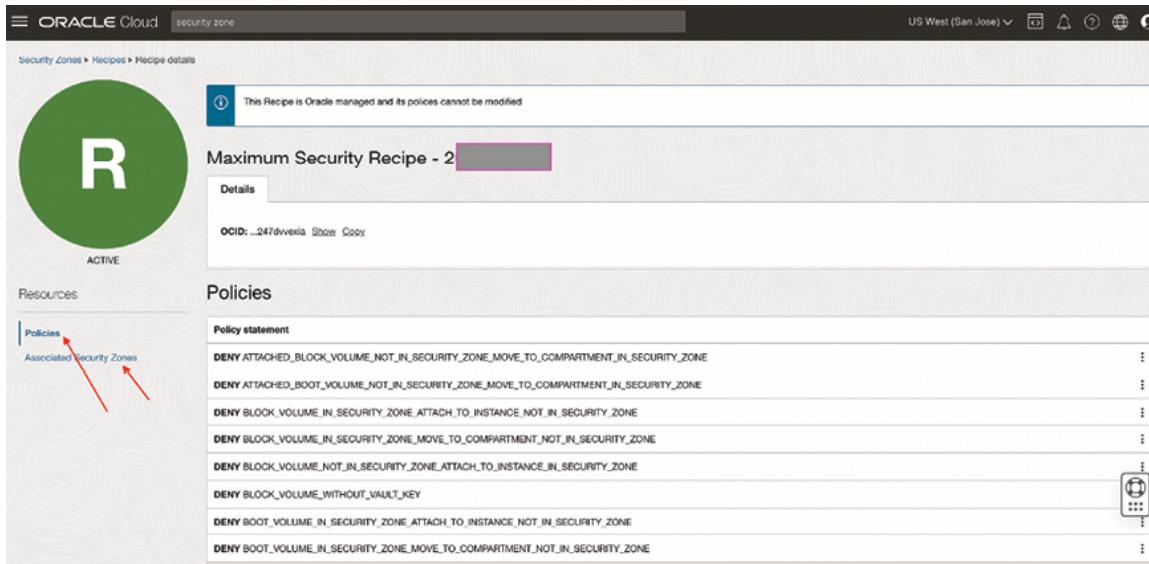


Figure 3.3: Recipes Policies screen in OCI

Features provided by security zones

Security zones in OCI offer a robust and comprehensive set of security features to protect cloud assets. These zones empower organizations to quickly adopt best practices in cloud setups, thereby substantially minimizing the likelihood of potential security breaches or misconfigurations. Below are some of the pivotal features delivered by OCI Security Zones:

- Security zones are equipped with pre-defined policies established by Oracle. These policies guarantee adherence to security best practices for all resources within a given security zone. This concept of policy enforcement is considered one of the key features of the security zone.
- Security protocols are implemented by ensuring both data at rest and in transit are encrypted. More details of data security are covered in the coming chapters.
- Logical isolation of resources in a security zone provides an extra layer of security.
- Proactive security incident responses can be achieved by configuring the alerts and monitoring the key and important metrics and events.
- Integrated audit logs are included with security zones. These audit logs enable you to monitor all the modifications and transactions occurring within a zone. This helps in maintaining a robust and enhanced security posture and simplifies compliance. Any resource which does not comply with the

security policies of the security zone will be corrected automatically and flagged for manual review. This can be achieved by configuring the settings in the security zone. The Audit service automatically captures log entries for calls made to all API endpoints of public Cloud Guard, encompassing operations related to security zones. The Events service enables development teams to automatically take action in response to changes in the state of a security zones resource.

- The original release of security zones automatically generated a new compartment when a zone was created, ensuring an empty compartment. However, the current method of attaching a security zone recipe to an existing compartment introduces the challenge of managing pre-existing resources within that compartment. OCI has addressed such challenges by improving the integration between Cloud Guard and Security zones, enabling the automatic creation of a new target in Cloud Guard with a matching security policy when a security zone is created and a recipe is attached to an existing compartment.
- Security target, on the other hand, refers to a specific entity or resource within your cloud environment that is subject to security controls, policies, and compliance requirements. Security targets can encompass a wide range of assets and components, including compute instances, databases, storage buckets, networking components, and entire services or applications.
- The concept of Cloud Guard is explained in detail in upcoming sections.

Methods of accessing security zones

We have multiple methods available to access security zones in OCI, and the choice depends on our specific needs and the type of information we are opting for. Security zones can be accessed through the console, which is a browser-based interface, REST APIs, the **command line interface (CLI)**, or programmatically using SDKs. Let us discuss a few in the following section:

- **OCI Console:**

Access security zones through the OCI Console by navigating to the **Identity & Security** section. You can find security zones in the figure below. Supported browser details are discussed in the technical requirements section:

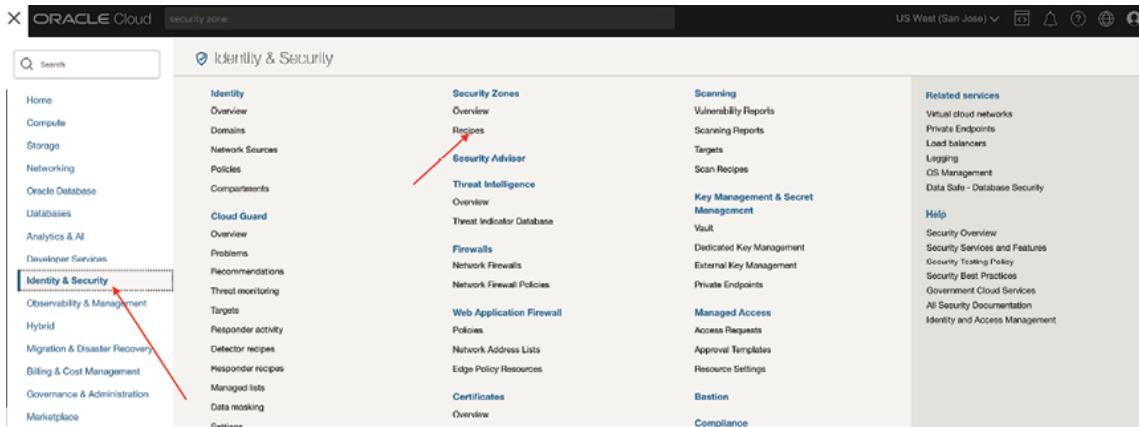


Figure 3.4: Identity & Security-Recipes Policies screen in OCI

- **OCI Command Line Interface:**

Core Capabilities of CLI are similar to OCI Console. CLI provides additional commands which extend the Console's functionality. You can run OCI CLI commands to list, create, or manage security zones. The CLI is a convenient option for developers or individuals who favor using the command line over a **graphical user interface (GUI)**.

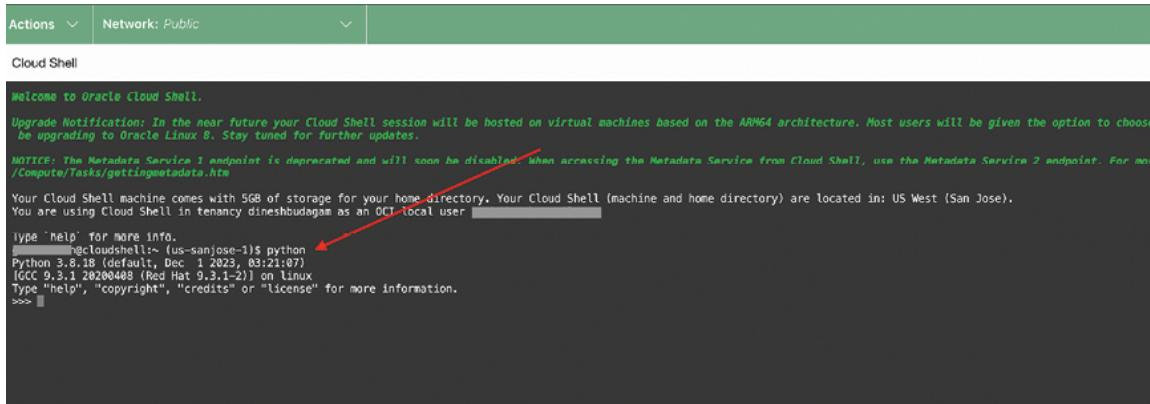
Below is the link for OCI CLI documentation for quick reference.

<https://docs.oracle.com/en-us/iaas/Content/GSG/Tasks/gettingstartedwiththeCLI.htm>

It is important to note that the command line interface comes pre-configured with your credentials and is ready to use directly within the cloud shell.

To enter the console and access the Cloud Shell:

1. Sign in to the Console.
2. Select **Cloud Shell** from the drop-down menu by clicking on the **Cloud Shell/Code Editor** icon located in the **Console** header. Please note that OCI CLI running within the Cloud Shell will carry out commands based on the region chosen in the Console's Region selection menu. Before proceeding with your tasks, it is important to understand how regional settings impact command execution within the Cloud Shell.



Welcome to Oracle Cloud Shell.

Upgrade Notification: In the near future your Cloud Shell session will be hosted on virtual machines based on the ARM64 architecture. Most users will be given the option to choose between upgrading to Oracle Linux 8. Stay tuned for further updates.

NOTICE: The Metadata Service 1 endpoint is deprecated and will soon be disabled when accessing the Metadata Service from Cloud Shell, use the Metadata Service 2 endpoint. For more information, see [Compute/Tasks/gettingmetadata.htm](#).

Your Cloud Shell machine comes with 5GB of storage for your home directory. Your Cloud Shell (machine and home directory) are located in: US West (San Jose). You are using Cloud Shell in tenancy dineshbudagam as an OCI local user [REDACTED]

```
type 'help' for more info.
@cloudshell:~ (us-sanjose-1)$ python
Python 3.8.18 (default, Dec 1 2023, 03:21:07)
[GCC 9.3.1 20200408 (Red Hat 9.3.1-2)] on linux
Type "help", "copyright", "credits" or "license" for more information.
>>> [REDACTED]
```

Figure 3.5: Cloud Shell screen in OCI

The following are a few examples of CLI commands:

oci --help

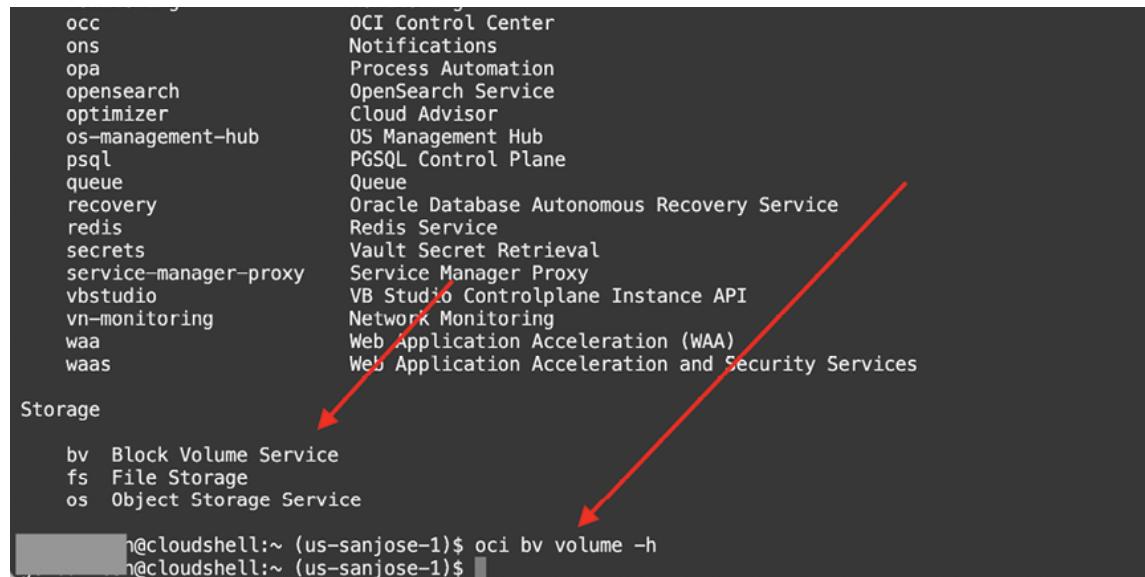
oci os bucket create

This command creates a bucket in the given namespace with a bucket name and optional user-defined metadata. Entering sensitive and confidential information in bucket names should be avoided.

oci bv volume -h

A detachable block volume device enables you to dynamically increase the storage capacity of an instance.

The following is the example of how CLI looks for the above case:



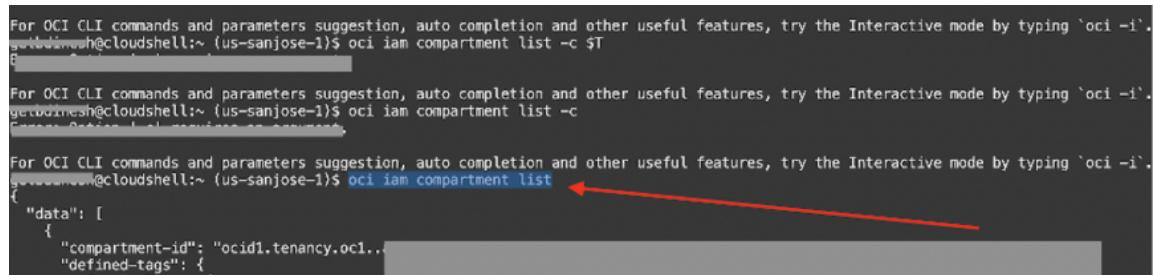
```
occ          OCI Control Center
ons          Notifications
opa          Process Automation
opensearch   OpenSearch Service
optimizer    Cloud Advisor
os-management-hub US Management Hub
pgsql        PGSQL Control Plane
queue        Queue
recovery     Oracle Database Autonomous Recovery Service
redis        Redis Service
secrets      Vault Secret Retrieval
service-manager-proxy Service Manager Proxy
vbstudio     VB Studio Controlplane Instance API
vn-monitoring Network Monitoring
waa          Web Application Acceleration (WAA)
waas         Web Application Acceleration and Security Services

Storage
  bv  Block Volume Service
  fs  File Storage
  os  Object Storage Service

@cloudshell:~ (us-sanjose-1)$ oci bv volume -h
@cloudshell:~ (us-sanjose-1)$ [REDACTED]
```

Figure 3.6: Cloud Shell screen in OCI

OCI IAM compartment list command is used to list the compartments within a specified tenancy or parent compartment. This is particularly useful for managing cloud resources effectively, facilitates the assignment of permissions and policies to different compartments and assists in tracking usage and costs by compartment.



```
For OCI CLI commands and parameters suggestion, auto completion and other useful features, try the Interactive mode by typing 'oci -i'.
getoimnsh@cloudshell:~ (us-sanjose-1)$ oci iam compartment list -c $T
For OCI CLI commands and parameters suggestion, auto completion and other useful features, try the Interactive mode by typing 'oci -i'.
getoimnsh@cloudshell:~ (us-sanjose-1)$ oci iam compartment list -c
For OCI CLI commands and parameters suggestion, auto completion and other useful features, try the Interactive mode by typing 'oci -i'.
getoimnsh@cloudshell:~ (us-sanjose-1)$ oci iam compartment list
{
  "data": [
    {
      "compartment-id": "ocid1.tenancy.oc1...
      "defined-tags": {
```

Figure 3.7: Cloud Shell screen in OCI

- **© OCI Software Development Kits (SDKs):**

This way of creating, managing, or accessing the security zones is accomplished by Integrating the OCI SDKs into your custom applications programmatically.

Utilize SDKs to construct and deploy applications that seamlessly integrate with OCI services. Each SDK is equipped with the essential tools for app development, offering code samples and comprehensive documentation for creation, testing, and troubleshooting. Furthermore, if it allows actively contributing to the enhancement of the SDKs, they are all open source and accessible on GitHub.

we have different SDK's used for each of the programming language. Based on our use cases. we can opt for SDK for specific programming languages. For example, for Java we have Java run time environment SDK, for Python we have package manager SDK, for Go we have complier SDK.

There are various services supported by the Python SDK. A few of them to list are as follows:

- Access governance
- Account management
- API gateway
- Audit
- Application performance monitoring

- Cloud migrations
- Essential services like networking
- Block volume
- Compute
- Database migration
- Monitoring
- Work requests such as compute and database
- Blockchain platform and big data service
- Governance rules
- Fusion applications as a service and generative AI

For the section, we will discuss *SDK for Python*. Python SDKs are used to develop applications using the Python programming language, often providing additional libraries and tools specific to a particular platform or framework.

The OCI SDK for Python allows you to write your customized code to manage OCI resources.

SDK for Python can be downloaded from GitHub or from **Python Package Index (PyPI)**.

Below is the reference:

GitHub: <https://github.com/oracle/oci-python-sdk/releases>

PyPI installation: <https://pypi.org/project/oci/>

We encourage you to check the correct package for the release, as this package version changes for each release. Similar to OCI Command Line Interface, which enables the use of Cloud Shell, SDK for Python also comes with pre-configured Cloud Shell. It comes pre-configured with your credentials, ready for immediate use within Cloud Shell.

We will illustrate two examples using *SDK for Python* below:

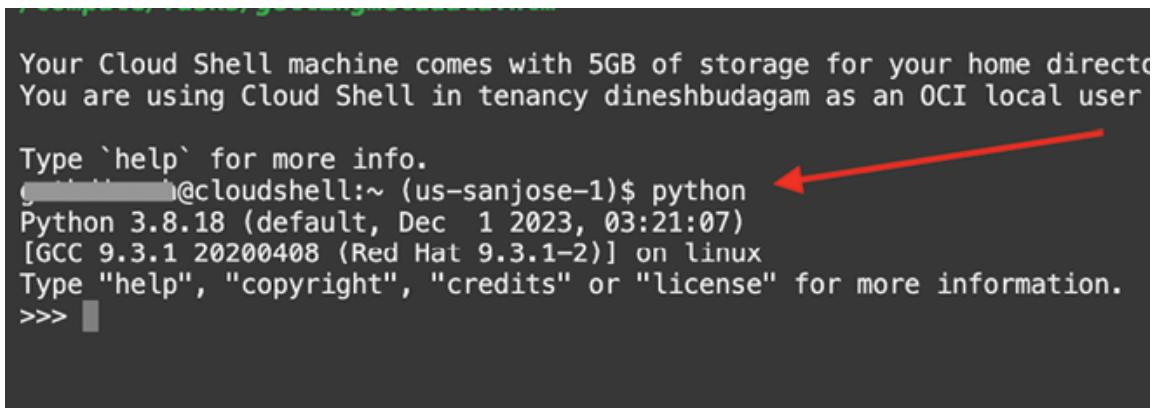
Example 1: Let us write a Python code that returns the actual OCI tenancy OCID.

Please refer the [*Figure 3.8*](#) for logging into Cloud shell in OCI:

1. Sign into the console.
2. Select the **Cloud Shell** icon in the **Console** header. It is important to understand that Cloud Shell will perform commands based on the region

chosen in the Console's Region selection menu at the time when Cloud Shell was initiated. Please refer the figure ***** for logging into Cloud shell in OCI.

3. Run Python:



A screenshot of a terminal window titled "Cloud Shell". The window shows the following text:
Your Cloud Shell machine comes with 5GB of storage for your home directory.
You are using Cloud Shell in tenancy dineshbudagam as an OCI local user
Type `help` for more info.
dineshbudagam@cloudshell:~ (us-sanjose-1)\$ python ←
Python 3.8.18 (default, Dec 1 2023, 03:21:07)
[GCC 9.3.1 20200408 (Red Hat 9.3.1-2)] on linux
Type "help", "copyright", "credits" or "license" for more information.
>>> █

Figure 3.8: Cloud Shell screen in OCI to run Python

4. Execute the below commands in the editor to print the actual tenancy OCID:

Code:

```
import oci

# Set up your OCI configuration (config file with
# user, tenancy, and compartment details)
config = oci.config.from_file()

# Get the tenancy OCID from the config
tenancy_ocid = config["tenancy"]

# Print the tenancy OCID
```

The statement `print(f"Tenancy OCID: {tenancy_ocid}")` as in below is a Python command that prints out the message "**Tenancy OCID:** " followed by the value contained in the variable `tenancy_ocid`. This technique leverages f-strings for clean and efficient string formatting.

```
print(f"Tenancy OCID: {tenancy_ocid}")
```

```

Your Cloud Shell machine comes with 5GB of storage for your home directory. Your Cloud Shell (machine and home direct
You are using Cloud Shell in tenancy dineshbudagam as an OCI local user [REDACTED]

Type `help` for more info.
[REDACTED]@cloudshell:~ (us-sanjose-1)$ python3
Python 3.8.18 (default, Dec 1 2023, 03:21:07)
[GCC 9.3.1 20200408 (Red Hat 9.3.1-2)] on linux
Type "help", "copyright", "credits" or "license" for more information.
>>> import oci
>>> # Set up your OCI configuration (config file with user, tenancy, and compartment details)
>>> config = oci.config.from_file()
>>> # Get the tenancy OCID from the config
>>> tenancy_ocid = config["tenancy"]
>>> # Print the tenancy OCID
>>> print(f"Tenancy OCID: {tenancy_ocid}")
Tenancy OCID: ocid1.tenancy.oc1..[REDACTED]
>>>

```

Figure 3.9: Cloud Shell screen in OCI to run Python

Example 2: Let us write a Python code which retrieves the list of compartments in your tenancy and prints their names:

Code:

```

import oci

# Set up your OCI configuration (config file with user,
tenancy, and compartment details)
config = oci.config.from_file()

# Create an identity client
identity_client = oci.identity.IdentityClient(config)

# Get the list of compartments
compartment_response =
identity_client.list_compartments(config["tenancy"])

# Iterate through compartments and print names
for compartment in compartment_response.data:

```

The statement **print(f"Compartiment Name:**

{compartment.name}"), as mentioned below, is a Python command that prints out the message "**Compartiment Name:** " followed by the value of the **name** attribute of the **compartment** object. This is done using an f-string for efficient and readable string formatting.

```
print(f"Compartiment Name: {compartment.name}")
```

```

>>> config = oci.config.from_file()
>>> # Get the tenancy OCID from the config
>>> tenancy_ocid = config["tenancy"]
>>> # Print the tenancy OCID
>>> print(f"Tenancy OCID: {tenancy_ocid}")
Tenancy OCID: ocid1.tenancy.oc1..[REDACTED]
>>> # Create an identity client
>>> identity_client = oci.identity.IdentityClient(config)
>>> # Get the list of compartments
>>> compartment_response = identity_client.list_compartments(config["tenancy"])
>>> # Iterate through compartments and print names
>>> for compartment in compartment_response.data:
...     print(f"Compartment Name: {compartment.name}")
...
Compartment Name: dinesh_demo_compartment
Compartment Name: ManagedCompartmentForPaaS
>>>

```

Figure 3.10: Cloud Shell screen in OCI to run Python

Common errors which usually occur during the execution of Python code are either **ConnectTimeout** exception or **RequestException** error.

ConnectTimeout exception contains a message which has verbiage as **ConnectTimeoutError**. Similarly, the **RequestException** exception contains a message that has verbiage as '**Read timed out**'.

Cloud Guard

Cloud Guard is a security monitoring service offered for the cloud and is a governance service within OCI. It provides features and capabilities to enhance the security posture of OCI environments. **Cloud Guard** helps to identify possible security issues and security zones to create secure compartments without writing manual policies. One of the key points to be noted is Cloud Guard is not available for free OCI tenancies. Before readers attempt to enable Cloud Guard, we need to ensure that we have a paid tenancy and tenancy account type should be either one of these '**default_dbaas**', '**enterprise_dbaas**' or '**enterprise**'. For a new security zone, it can take up to three hours before any violations are detected.

Cloud Guard performs the following major activities:

- It continuously monitors cloud environments for security threats, misconfigurations, and anomalies. Continuous Security Monitoring is one of the primary functions of Cloud Guard.
- Cloud Guard utilizes ML algorithms and predefined policies to automatically detect and alert potential security threats and vulnerabilities. We can automate threat detection.

- This will provide insights into security incidents and thus offer guidance on remediation steps to address security.
- Enforces security policies to ensure that resources in your OCI tenancy comply with security best practices and regulatory requirements.
- Cloud Guard expands security monitoring capabilities across multiple Oracle Cloud regions and cloud providers.
- Integrates with OCI Logging service to capture and analyze logs for security events and incidents.
- In summary, Cloud Guard offers both API and console access for configuring and managing security policies, monitoring alerts, and reviewing security recommendations. It provides a security score that reflects the overall security posture of your environment and offers corrective actions and recommendations for improvement based on your configuration.
- **Security Score** and **Risk Score** are two key metrics provided by Cloud Guard. The Security Score is a standardized metric, ranging from 0 to 100, which evaluates the overall strength of the security posture based on the quantity, types, and severity of identified issues. Risk Score, on the other hand, calculates the number of total resources being monitored, the sensitivity of each resource type, and the severity of any problems related to the resources to determine the total risk exposure of a tenant.

Cloud Guard and **security information and event management (SIEM)** are complementary services. While Cloud Guard focuses on providing the Security posture assessment and security monitoring of OCI tenancy, SIEM focuses on ingesting the log data from various resources and various applications and thus provides support for search/analytics engines to perform forensic investigations and identify new indicators of risk or custom event discovery. [Figure 3.11](#) shows the visual representation of Cloud Guard user interface.

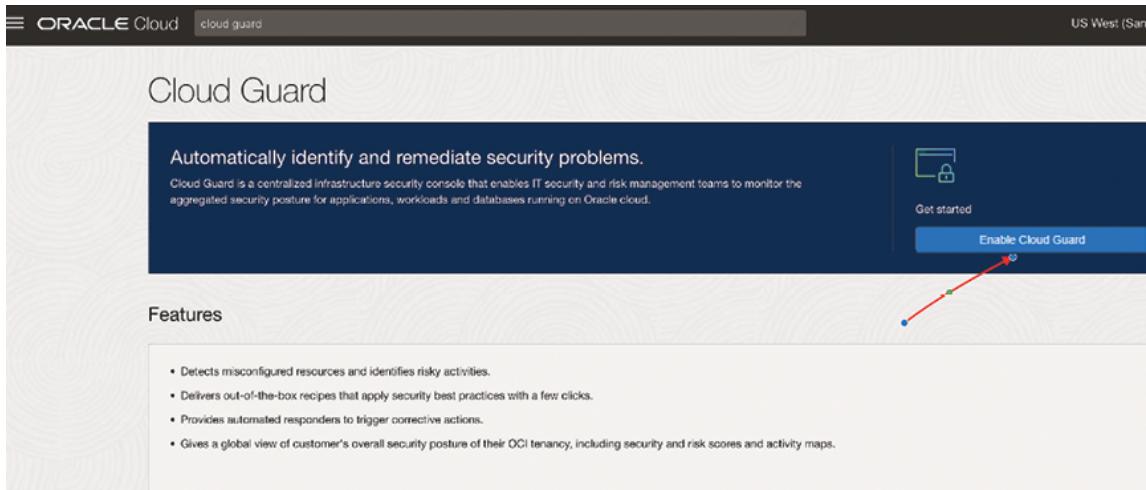


Figure 3.11: Cloud Guard in OCI

Figure 3.12 references the location to enable Cloud Guard.

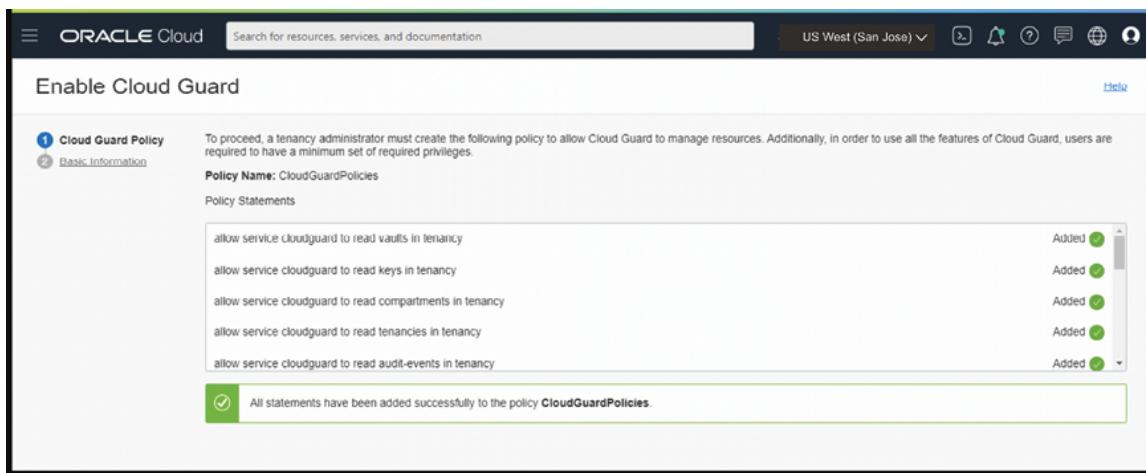


Figure 3.12: Enable Cloud Guard Screen in OCI

Figure 3.11 and *Figure 3.12* shows the navigation to **Enable Cloud Guard**.

We will explain various terminologies required to understand the concepts of Cloud Guard:

- **Target:** In Cloud Guard, the target essentially outlines the range of parameters or scope that Cloud Guard examines. In the case of OCI, the extent of this scope is linked to the compartment in which the target is specified, including all subsequent child compartments until another target is identified.
- **Detector and detector rules:** The detector conducts regular checks, identifying potential security issues based on their type and the implemented

configuration. This has detector rules. Detector rules are predefined or custom configurations that Cloud Guard uses to identify security threats, vulnerabilities, and misconfigurations in your OCI environment.

- **Responders and responder recipe:** Responders are automated actions or remediation steps that Cloud Guard can take in response to detected security incidents. These actions help mitigate security risks and bring resources back into compliance with security policies.
- **Responder recipes**, on the other hand, can be considered as a set of actions to be taken in response to a problem that a detector has identified.
- **Reporting region:** This is the default region for your Cloud Guard tenancy or this can be considered as the first region defined when your Cloud Guard tenancy was enabled. One of the key things to be noted is Your organization is required to adhere to all legal obligations in the country where the reporting region is hosted.

Networking overview

OCI Networking allows you to establish virtual versions of conventional and traditional network elements and network components. In this section, we will describe a high-level overview of different components of infrastructure networking.

The OCI is built on the following five pillars:

- IAM
- Networking
- Storage
- Compute
- Database

Networking is a key and important module to be discussed in OCI. Networking facilitates communication between various resources in the OCI environment.

In [*Chapter 2, Mastering Identity and Access Management \(IAM\)*](#). we have provisioned a new tenancy in OCI by creating a root compartment.

In this chapter and section, we will walk through the steps to create a networking environment, VCN, private and public subnets. In OCI, the VCN facilitates

communication between various resources in OCI, both within and beyond a specific region.

A typical or traditional OCI networking architecture comprises the following key components explained in the next section. Let us define and understand VCN, public subnet, internet gateway, and service gateway. Refer [*Figure 3.13*](#) for overview of network components:

- **VCN:** It is defined as a software defined version of a traditional physical network which includes components such as subnet, route tables and gateways on which your instances run.
- **Subnet:** Subnets can be referred to as subdivisions we define in a VCN. A subnet can be either a public or a private subnet.
- **Route table:** Route tables serve the purpose of directing traffic beyond the VCN, whether it be towards the Internet, on-premises locations, or other peered VCNs
- **Security list:** Security list refers to a common set of firewall rules associated with a subnet and is applicable to every compute instance within that subnet Network.
- **Network security group:** The network security group is a virtual firewall that manages the allowed inbound and outbound traffic for resources such as compute, database, and load balancer within the VCN.
- **Internet gateway:** The internet gateway establishes a route or path for network traffic between VCN and the Internet.
- **Dynamic routing gateway (DRG):** The facilitates private traffic between the VCN and destinations outside the internet, such as on-premises locations or other VCNs.
- **Load balancer:** The load balancer facilitates the automated distribution of traffic from a single-entry point to multiple servers within the VCN.

In this chapter, we will explore the VCN, exploring both Private and Public Subnets. The subsequent chapter will cover network security groups, internet gateway, dynamic routing gateway, and load balancer.

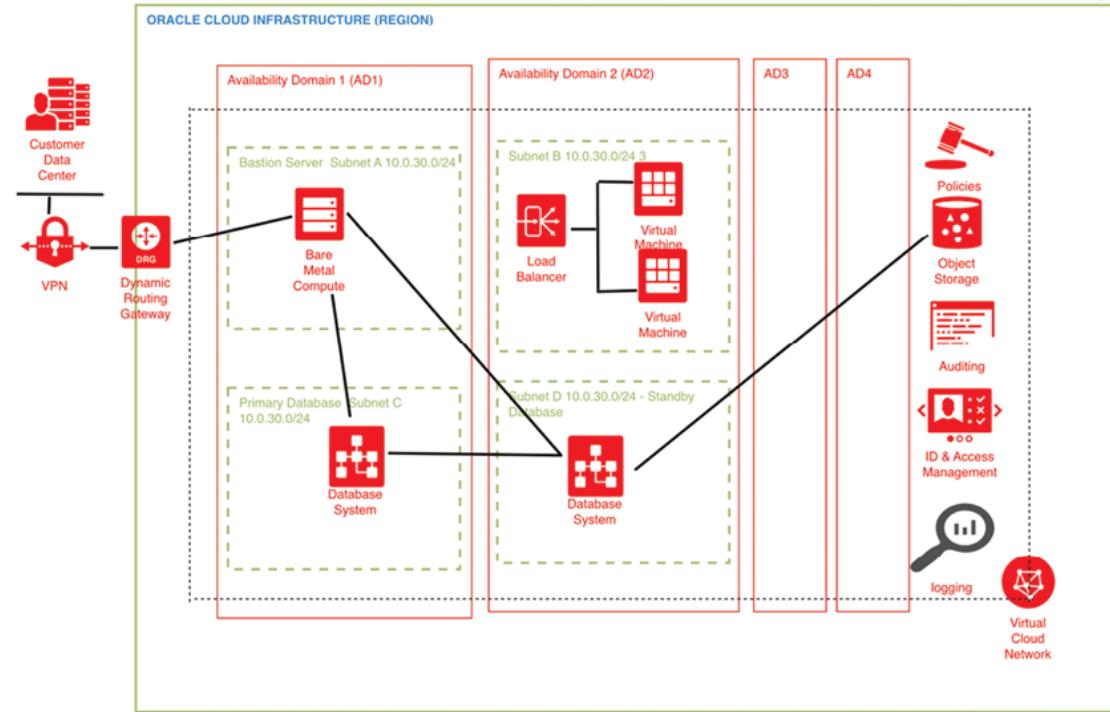


Figure 3.13: Networking components overview

Networking components

VCN is a virtual, private network which we configure in Oracle data centers. This serves as an important component that enables you to set up, configure and manage your private network within the Oracle Cloud. Just as a conventional network function in an on-premises data center, VCNs provide features such as separation, segmentation, and control over your cloud resources. You can visualize it as your network inside the larger OCI environment. This can be treated as a customized, secured area of the cloud where you may allocate and assign resources and manage the network infrastructure. It closely resembles a traditional network incorporating Firewall regulations and distinct communication gateways that you have the option to utilize. A VCN is confined to a single OCI region and encompasses one or more CIDR blocks provided if IPv4 and IPv6 are enabled. The VCN is located within a single Region but can extend across multiple **availability domains (AD)**.

The main features of VCN are as follows:

- They are scalable and flexible. VCN allows you to add or remove resources easily to your VCN based on needs.
- VCNs are private and secure, meaning, your defined VCN is distinct and unique from other VCNs which are defined in OCI. Your resources can only

be accessed by users and applications that have been authorized to enhance security and thereby prevent data breaches.

- One of the important and key features of VCN is that we can exercise complete control over the IP address ranges, route tables, subnets and **security lists (SL)** within your VCN. This can be treated as a customizable isolated network.

Let us define the steps to create our first VCN in OCI:

1. Sign into your Oracle Cloud Console.
2. To begin configuring your network settings in Oracle Cloud Infrastructure, navigate to the **Networking** section and click **VCNs**:

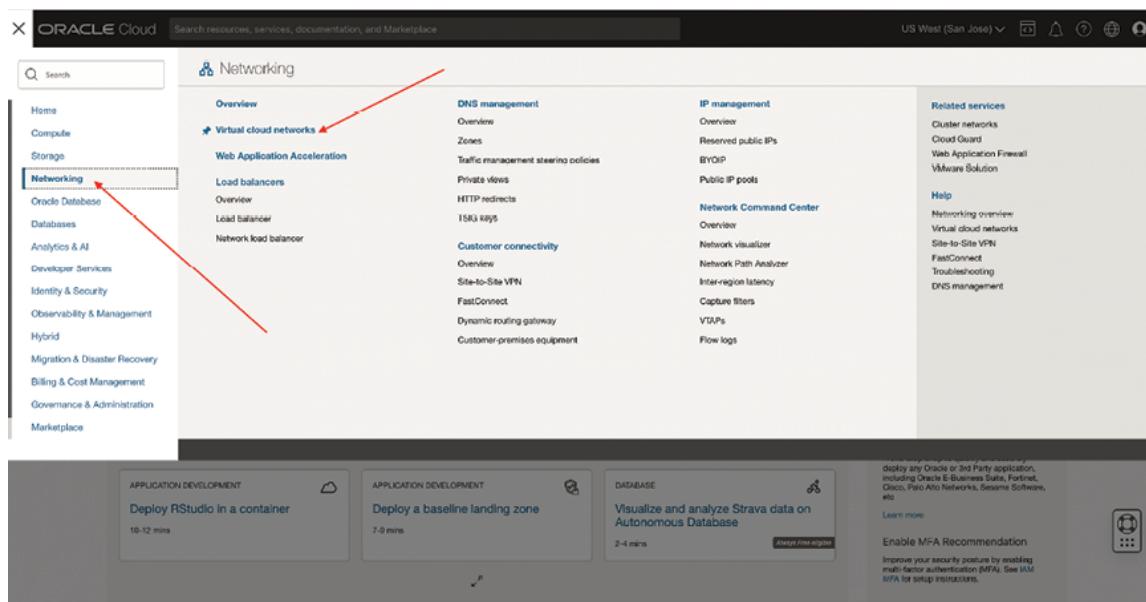


Figure 3.14: Networking and VCNs screen in OCI

3. Click create VCN by selecting the respective compartment as shown in the following figure:

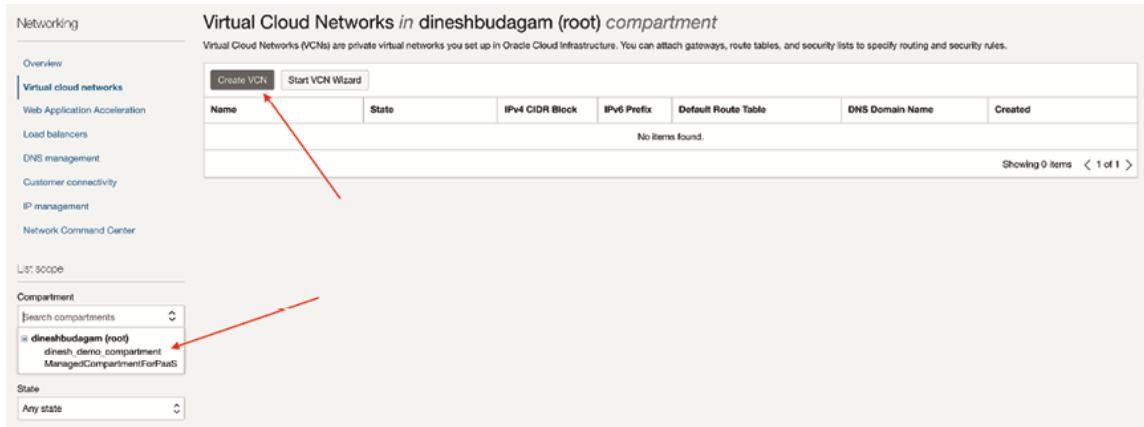


Figure 3.15: Creating VCN in OCI

- When creating a VCN, input the following information on the screen for **Create VCN**:

- Name:** Enter the respective name for VCN. (Ex. **"Dinesh_Demo_VCN"**)
- Create in compartment:** By default, this field is set to your current compartment.
- CIDR Block:** In this example, it is **10.0.0.0/16**.
- After confirming your settings as in above steps, the OCI console will initiate the creation of your VCN by selecting the **Create VNC** option.

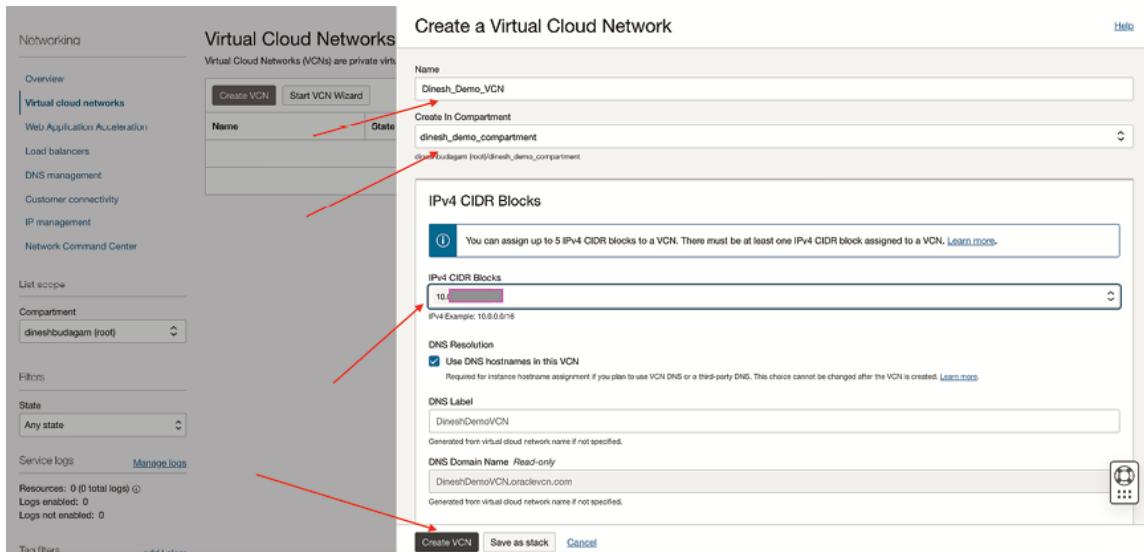


Figure 3.16: Creating VCN in OCI

- VCN, which we created in the above step, will display like below:

Dinesh_Demo_VCN

AVAILABLE

VCN Information

Compartment: dinesh_demo_compartment
Created: Sun, Feb 4, 2024, 19:38:08 UTC
IPv4 CIDR Block: 10.0.0.0/16
IPv6 Prefix: -

OCID: ...t5xskq Show Copy
DNS Resolver: -
Default Route Table: Default Route Table for Dinesh_Demo_VCN
DNS Domain Name: dineshdemovcn.oraclevcn.com

Resources

- Subnets (0)
- CIDR Blocks/Prefixes (1)
- Route Tables (1)
- Internet Gateways (0)
- Dynamic Routing Gateways Attachments (0)
- Network Security Groups (0)
- Security Lists (1)
- DHCP Options (1)
- Local Peering Gateways (0)

Subnets in dinesh_demo_compartment compartment

Name	State	IPv4 CIDR Block	IPv6 Prefixes	Subnet Access	Created
No items found.					

Showing 0 items < 1 of 1 >

Figure 3.17: VCN in OCI

6. We can view the **State** of VCN created in the figure below:

Virtual Cloud Networks in dinesh_demo_compartment compartment

Virtual Cloud Networks (VCNs) are private virtual networks you set up in Oracle Cloud Infrastructure. You can attach gateways, route tables, and security lists to specify routing and security rules.

Name	State	IPv4 CIDR Block	IPv6 Prefix	Default Route Table	DNS Domain Name	Created
Dinesh Demo VCN	Available	10.0.0.0/16	-	Default Route Table for Dinesh Demo VCN	dineshdemovcn.oraclevcn.com	Sun, Feb 4, 2024, 19:38:08 UTC

Showing 1 item < 1 of 1 >

Filters

State

- Any state
- Provisioning
- Available
- Terminating
- Terminated

Logs enabled: 0 Logs not enabled: 1

Figure 3.18: Creating VCN in OCI

Subnets

Subnets can be referred to as subdivisions we define in a VCN. They are important components of VCNs in OCI. Subnets function as logical subdivisions within your

VCN, establishing smaller and well-organized segments for your deployed resources. Each Subnet is a contiguous range or sequential range of IP addresses which do not overlap with other subnets in the VCN.

Subnets can be Categorized as either public subnet or private subnet. Public Subnets generally have a route to the Internet, enabling instances within the subnet to communicate with the Internet directly or through a NAT gateway. Conversely, Private subnets do not have a direct route to the internet and are often used specifically for backend services.

Public subnets

An OCI public subnet permits the use of public IP addresses for instances within the subnet. This means you have the option to allocate a public IP address to the **virtual network interface card (VNIC)** of your server. We will define VNIC in the next sections. When a subnet is created, it is automatically designated as public by default. This designation allows instances within the subnet to be assigned public IPv4 addresses, enabling internet communication by utilizing the internet gateway.

Steps for creating a public subnet:

Now, let us create a public subnet. We have already created a VCN in the above sections. Please find the below steps for creating a public subnet.

1. Access the navigation menu and select **Networking**.
2. In the **Overview** section, choose VCN and then select the desired VCN we created in the above sections.
3. Under **Overview**, click **VCN** and select the VCN we already created in the above sections.
4. Click **Create Subnet**. Select the respective compartment and enter the below details:

Name: **Public_Subnet**

IPv4CIDR: **10.0.0/24**

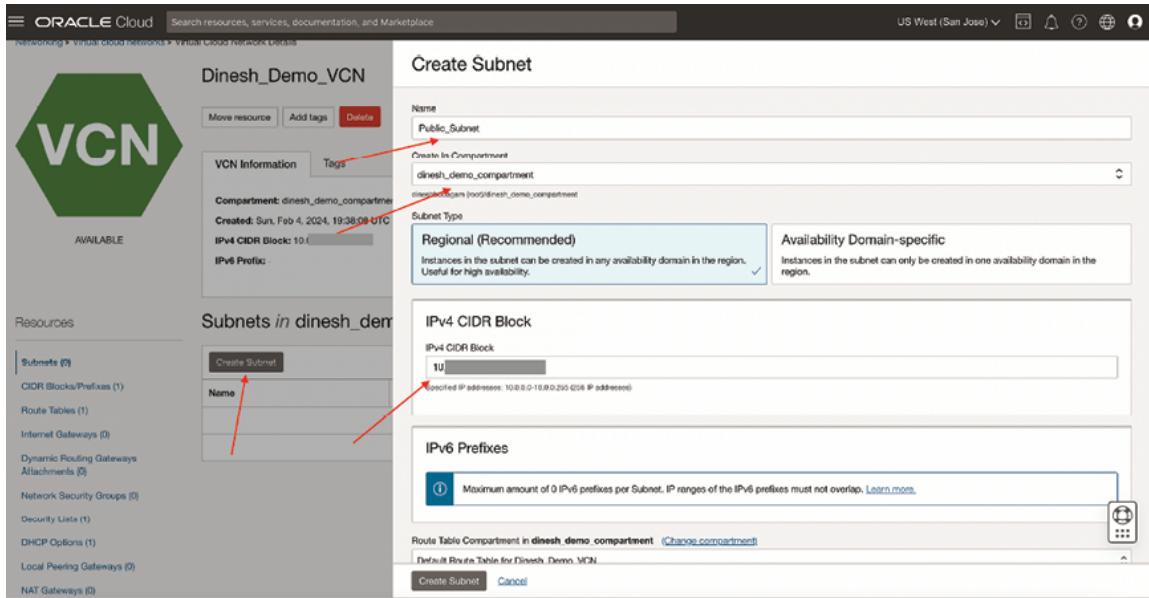


Figure 3.19: Creating subnet in OCI

5. Select the Route Table Compartment and Security List Compartment:

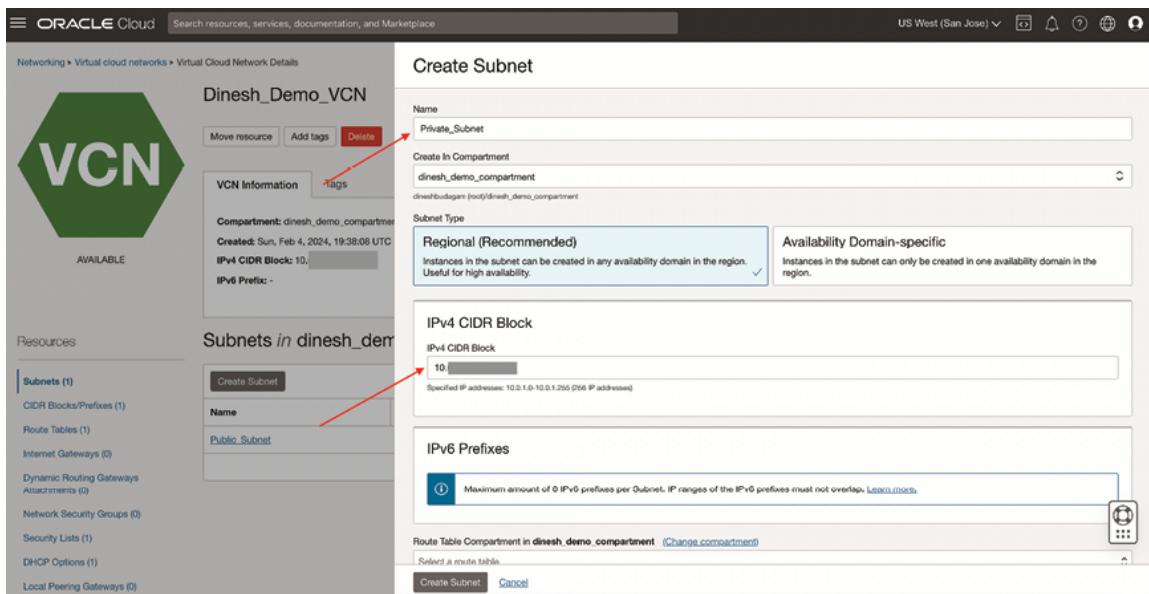


Figure 3.20: Creating subnet in OCI

6. This will create **Public Subnet** as in the below figure:

Dinesh_Demo_VCN

VCN Information

- Compartment: dinesh_demo_compartment
- Created: Sun, Feb 4, 2024, 19:38:08 UTC
- IPv4 CIDR Block: 10. [REDACTED]
- IPv6 Prefix: -
- OCID: ...15xskd Show Copy
- DNS Resolver: Dinesh_Demo_VCN
- Default Route Table: Default Route Table for Dinesh_Demo_VCN
- DNS Domain Name: dineshdemovcn.oraclevcn.com

Resources

Subnets (1)
CIDR Blocks/Prefixes (1)
Route Tables (1)
Internet Gateways (0)
Dynamic Routing Gateways Attachments (0)
Network Security Groups (0)
Security Lists (1)
DHCP Options (1)
Local Peering Gateways (0)
NAT Gateways (0)

Subnets in dinesh_demo_compartment compartment

Name	State	IPv4 CIDR Block	IPv6 Prefixes	Subnet Access	Created
Public_Subnet	Available	10. [REDACTED]	-	Public (Regional)	Sun, Feb 4, 2024, 20:13:31 UTC

Figure 3.21: Subnet in OCI

7. Details of **Public Subnet** created can be viewed below:

Subnet Information

- OCID: ...zbmruq Show Copy
- IPv4 CIDR Block: 10. [REDACTED]
- IPv6 Prefix: -
- Virtual Router MAC Address: 00: [REDACTED]
- Subnet Type: Regional
- Compartment: dinesh_demo_compartment
- DNS Domain Name: publicsubnet... Show Copy
- Subnet Access: Public Subnet
- DHCP Options: Default DHCP Options for Dinesh_Demo_VCN
- Route Table: Default Route Table for Dinesh_Demo_VCN

Resources

Security Lists (1)	
Logs	
IPv6 Prefixes (-)	
Tag filters	000 Clear
no tag filters applied	

Security Lists

Add Security List			
Name	State	Compartment	Created
Default_Security_List_for_Dinesh_Demo_VCN	Available	dinesh_demo_compartment	Sun, Feb 4, 2024, 19:38:08 UTC

Figure 3.22: Public Subnet in OCI

Private subnets

An OCI private subnet is designed for hosting private servers, such as database servers, and does not permit the use of public IP addresses. Instances within the private subnet can establish a connection to the internet through a **Network Address Translation (NAT)** gateway located within the VCN.

Steps to create private subnet:

Now, let us create a private subnet. We have already created a VCN and public subnet in the above sections.

Please find the below steps for creating a private subnet. Follow the same steps as outlined above for the public subnet, selecting the appropriate IPv4 CIDR Block.

1. Enter the details of Name, IPv4 CIDR Block, as shown below:

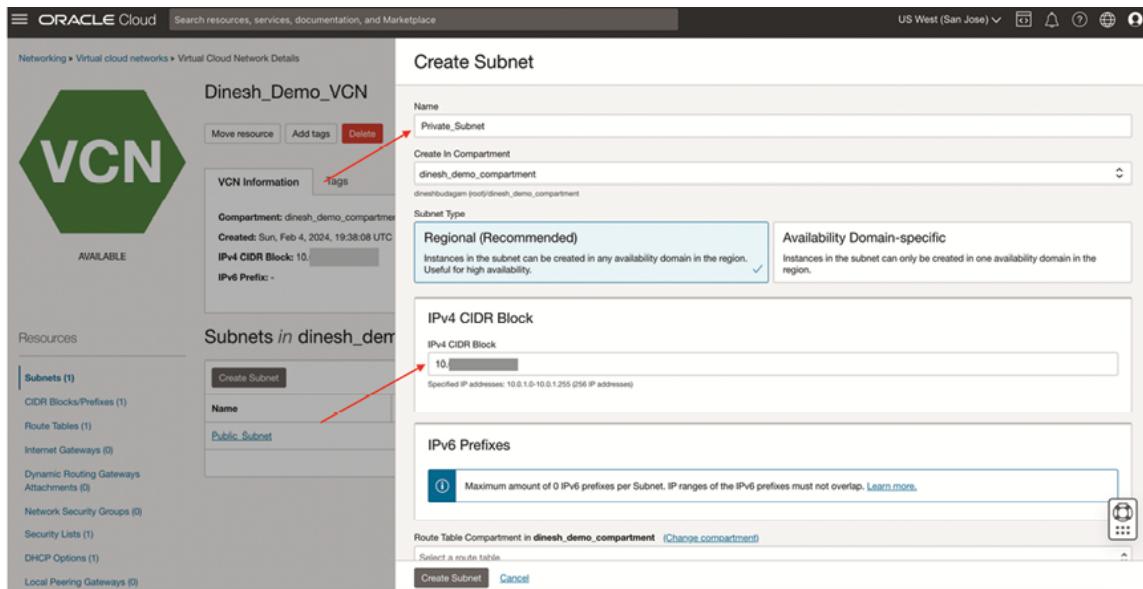


Figure 3.23: Creation of Private Subnet in OCI

Here are some examples of private IP CIDRs in OCI:

- **10.0.1.0/24:** This is a private subnet CIDR block
- **172.30.0.0/16:** A VCN CIDR block
- **172.30.1.0/24:** A subnet created under a VCN CIDR block

Here are some other things to know about private IP CIDRs in OCI:

- The specified value must fall within the CIDR block of the VCN.
- Ensure the value is distinct and does not overlap with the CIDR block of the public subnet.
- The CIDR cannot be changed once created
- The allowed range is /16 to /30
- The disallowed range is 169.254

2. Enter respective **Route Table**, **Subnet Access** and **Security list** and click **Create Subnet**:

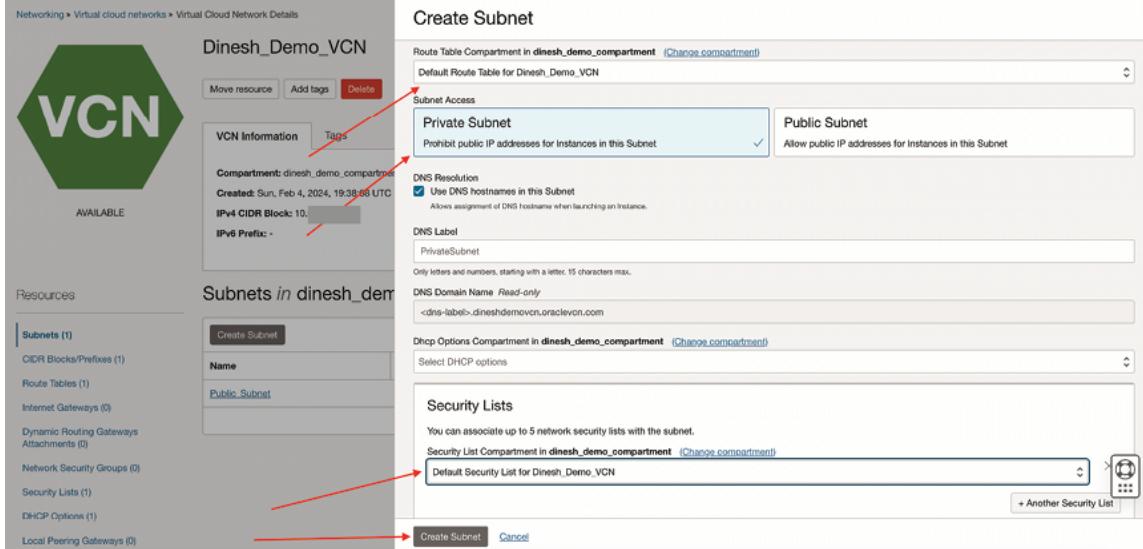


Figure 3.24: Creation of Private Subnet in OCI

3. The above step will create and provision **Private Subnet**, as shown in the figure:

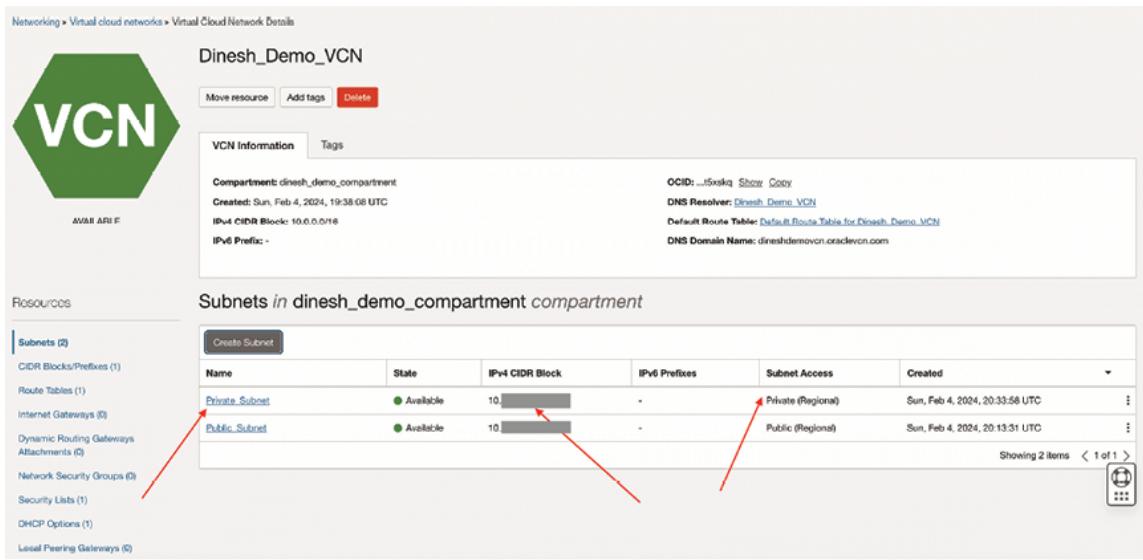


Figure 3.25: Creation of Private Subnet in OCI

4. Private subnet is created below:

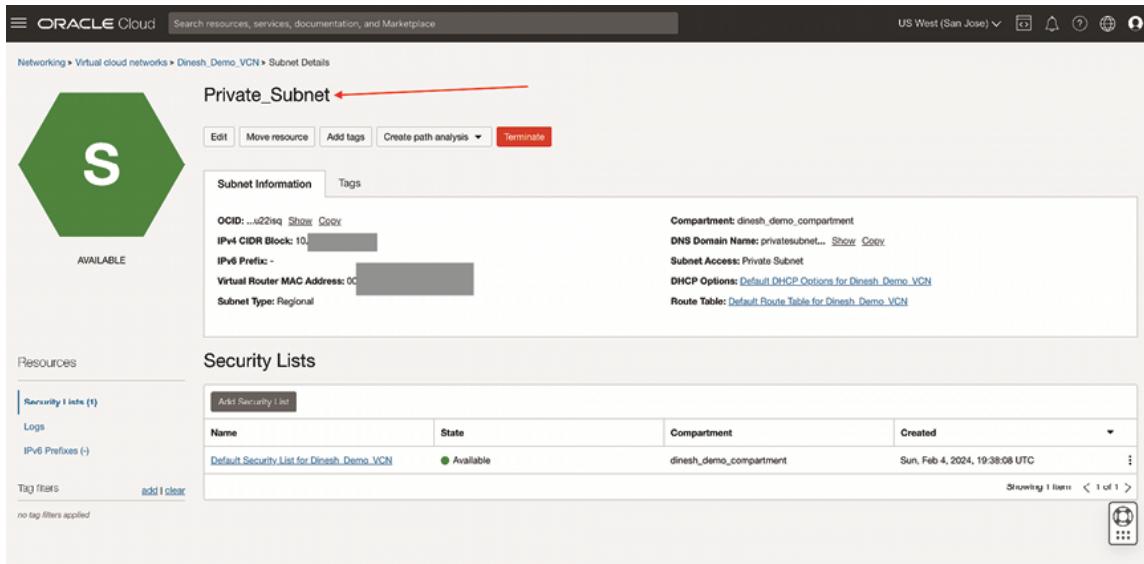


Figure 3.26: Private Subnet in OCI

Ways to secure network

This section details the process of securing cloud networks and compute instances within OCI. In the above sections, we discussed the concept of private and public subnets, IAM policies and security zones. Let us deep dive into the best ways to secure a network. In this chapter, we will focus on a high level of securing networks. In [Chapter 4, Deep Dive into Infrastructure Security](#) we will, in detail, cover all concepts, including configuration and setup.

The following are a few ways to Secure the network:

- We discussed the concept of **Private Subnet**. In **Private Subnet**, we can designate a subnet as private, indicating that instances within the subnet are not allowed to possess public IP addresses. This is one of the ways to secure a network.
- We can secure the network by implementing the **firewall rules**. Packet level traffic in and out of the instance can be controlled by implementing and configuring the firewall rules directly at the instance level.
- **Network access with access control lists:** Defining an **access control list (ACL)** result in the prevention of access to the database for all IP addresses not included in the ACL. Following the specification of an ACL, the autonomous database exclusively permits connections from addresses listed in the access control list while rejecting any connections from clients with addresses not present in the ACL.

- Gateways and route tables, IAM policies, and security zones are a few ways to secure a network. IAM policies and security zones are covered in prior sections. Concepts of gateway will be explained in detail in [Chapter 4, Deep Dive into Infrastructure Security](#).
- The flow of packet-level traffic to and from an instance can be managed by setting up security rules using the OCI API or console. These security rules can be facilitated and implemented by network security groups or SL
- There are two important features we need to understand. These are **SL** and **network security groups (NSGs)**.
- These are virtual firewall functionalities, both utilizing security rules to manage traffic at the packet level. Let us define what SL and NSGs are:
 - **SL:** This is denoted as the primary and original virtual firewall feature from the Networking service.
 - **NSGs:** A subsequent feature created for application components with varying security stances.

NGSs can be referred to as one of the alternative approaches to enforce security rules. NSGs act as a virtual firewall, safeguarding a collection of Cloud resources that share a unified security posture. The two features mentioned above provide diverse approaches for implementing security rules on a set of **virtual network interface cards (VNICS)** within the VCN.

Within NSGs, there are two primary components:

- VNICS:
 - Consisting of one or more VNICS such as those attached to a group of compute instances with matching security configurations. All VNICS within an NSG must belong to the same VCN to which the NSGs are associated.
- Security rules:
 - These rules enforce or dictate the permissible types of traffic entering and exiting the VNICS within the group. For example, security rules may define ingress TCP port 22 to govern SSH traffic from a specific source.

By combining VNICS and security rules within NSGs, a unified, well integrated and customized security framework is established, ensuring that resources sharing a common security posture are effectively protected.

Overview of load balancers

The Load Balancer automates the distribution of traffic from a single-entry point to multiple servers within the VCN. In *Nutshell*, load balancer automatically facilitates the distribution of traffic to enumerate backend servers in a healthy state based on two policies:

- Health check policy and
- Load balancing policy

The primary purpose of the health check policy is to validate and confirm the availability of servers in the backend, while the load balancing policy guides the load balancer in determining how to distribute incoming traffic across the backend servers.

There are primarily two types of load balancers in OCI:

- **Public load balancer:** The network load balancer service offers load balancing through a regional public or private IP address of your preference, allowing scalability without any bandwidth configuration requirements. To handle incoming traffic from the internet can be established by configuring a public network load balancer. This balancer Requires two subnets, each in a different availability domain. One subnet acts as a primary load balancer, while another load balancer acts as a Standby in case of an outage at the availability domain. In this concept, Public IP is attached to subnet1 (which is the primary load balancer). Load balancer and IP switch to subnet2 (Standby Load Balancer) in case of an outage at availability domain). In public load balancing mechanism, public load balancer provides Redundant and highly available in a region which is in two ADs.
- **Private network load balancer:** Private network load balancer isolates your network load balancer from the internet and simplifies your security posture. Unlike public load balancers, private load balancers provide redundancy and high availability within the availability domain, and there is no high availability in the case of availability domain outage.

Load balancers use the concept of DNS zones, which are administrative domains within the DNS namespace, typically corresponding to a specific domain or subdomain. Each DNS zone contains a set of DNS records that define the mapping between domain names and IP addresses or other resources. Within a DNS zone, you can create various types of DNS records, such as a record, CNAME records, or alias records, depending on the load balancer's requirements and the desired configuration. These records specify the association between domain names and

load balancer endpoints. By configuring DNS zones appropriately, you can effectively manage incoming traffic to your load balancers

You can access the private network load balancer through the following methods and technologies mentioned below:

- Using LPG peering. This is referred to as ‘Cross-VCN’.
- Using Remote Peering Connection from another region which enables private, low-latency communication between VCNs located in different regions, facilitating global connectivity, data replication, and disaster recovery across the OCI network.
- Using FC private peering from on-prem.
- Dynamic Routing Gateway.
- Local Peering Gateway which enables private, low-latency communication between Virtual Cloud Networks located within the same region, enhancing connectivity and facilitating the implementation of complex network architectures.

Conclusion

This chapter has provided a detailed explanation related to the critical aspects of network security within OCI, shedding light on the principles, practices, and advanced mechanisms that form the bedrock of a robust security strategy. As organizations increasingly leverage OCI for their cloud workloads, comprehending and implementing effective network security measures becomes of utmost importance.

We have discussed the foundational principles of network security, the architecture of VCNs with their subnets, and related components that have been examined to provide insights into designing a secure and segmented network infrastructure.

By adopting the principles and practices discussed in this chapter, you gain the capability to establish a resilient network security stance within OCI. This, in turn, enhances the overall success and durability of your cloud environment. In [*Chapter 3, Navigating Network Security in OCI*](#), we will explore the complexities of network security within OCI, covering essential principles, best practices, and advanced techniques to protect the integrity, confidentiality, and availability of data and services.

Multiple choice questions

- 1. Name the component in Cloud Guard that identifies issues with resources or user actions and alerts you when there is an issue found in the process.**
 - a. Tenant
 - b. Actions and availability domain
 - c. Detectors
 - d. Responders and regions

- 2. Which OCI feature provides Logical isolation for resources?**
 - a. Subnets
 - b. Security zones
 - c. Regions
 - d. Compartments

- 3. A company xyz needs to have some buckets as public in the compartment. You want Cloud Guard to skip the problem linked with the public bucket. Select the correct option.**
 - a. Install Cloud Guard
 - b. Enable the bucket as private in order for Cloud Guard to not to detect it
 - c. Dismiss the issues associated with these resources and configure logical groups for the detector to remediate the base line
 - d. Initially, consider making the bucket private and after few executions make the bucket public again

Answers

1. C
2. D
3. C

CHAPTER 4

Infrastructure Security

Introduction

In the dynamic landscape of cloud computing, robust network security is highly essential and mandatory to ensure the resilience and integrity of your digital infrastructure. As organizations increasingly rely on **Oracle Cloud Infrastructure (OCI)** to host their critical applications and data, understanding and implementing effective network security measures has never been more crucial.

We will address key aspects such as **Virtual Cloud Network (VCN)** design principles, network access controls, encryption methodologies, and best practices in network security. By the end of this chapter, you will not only have a solid understanding of the foundational principles of network security in OCI but also gain practical insights and actionable strategies to fortify your infrastructure against emerging threats.

Let us initiate this journey with us as we unravel the nuances of Infrastructure Network Security in OCI, empowering you to build and maintain a robust and secure cloud network environment. This chapter is structured to guide you through the essential aspects of network security in OCI. We will cover topics such as network architecture, security controls, compliance considerations, high availability concepts, securing networks with VCN, overview of DNS services and DNS management, securing tenancy and securing services, OCI components, and load balancer. Each section is crafted to equip you with the knowledge needed to design and maintain a secure network environment within Oracle Cloud Infrastructure. In this chapter, we establish the best network security recommendations to ensure the robust protection of our infrastructure. These

objectives guide the implementation of security measures and contribute to the overall resilience of our network.

Let us begin this exploration of OCI's network security landscape, understanding how to leverage the platform's capabilities to fortify our digital assets and ensure a resilient and secure cloud infrastructure.

Structure

The chapter covers the following topics:

- Technical requirements
- OCI Load Balancer and its components
- High availability
- Creating load balancer
- Securing networks with VCN and subnets
- Overview of DNS services and DNS management
- Securing tenancy and services
- Best recommendations and considerations

Objectives

The core objective of this chapter is to provide a comprehensive and detailed understanding of advanced network infrastructure security within OCI. By discussing the sophisticated strategies and best practices, we aim to equip readers with the knowledge and skills needed to elevate their network security posture in OCI to an advanced level. This includes in-depth coverage of advanced concepts such as Securing Networks with VCN and subnets, securing tenancy and services, OCI Load Balancer and its components, advanced access controls, and cutting-edge network design principles. Our goal is to empower readers to implement advanced security measures effectively, ensuring the resilience and integrity of their network infrastructure in the dynamic and evolving landscape of OCI.

By the end of this chapter, readers should possess the knowledge and insights necessary to implement advanced security measures, ensuring a robust and fortified network infrastructure in the dynamic environment of OCI and the best recommendations and considerations for securing OCI.

Technical requirements

To fully engage with the content of this chapter on navigating network security in Oracle Cloud Infrastructure, readers should have a basic understanding of computer systems, networking concepts, and information technology.

Additionally, the following technical requirements are recommended:

- **Internet access:** Readers should have a reliable internet connection to access online resources, references, and examples related to cloud computing.
- **Computing device:** A desktop computer, laptop, tablet, or smartphone with a modern web browser is necessary to read the chapter content and access any online materials.
- **Web browser:** The latest version of a modern web browser, such as Google Chrome, Mozilla Firefox, Microsoft Edge, or Safari is recommended. This ensures compatibility and optimal viewing experience of web-based resources and interactive content. Oracle Cloud Infrastructure supports the following browsers and versions:
Google Chrome 80 or later, Safari 12.1 or later, Firefox 62 or later (Private Browsing mode is not supported), Edge 104 or later. This is required for accessing or creating security zones, etc. in this chapter

- **Security best practices:** Acquaint yourself with general security best practices and principles applicable to cloud environments.
- **OCI Identity and Access Management (IAM):** Familiarity with OCI IAM for managing users, groups, and policies to control access to OCI resources.
- **Logging and monitoring:** Familiarity with OCI logging and monitoring services to capture and analyze network activity and security events.
- **Advanced networking concepts:** Gain knowledge of advanced networking concepts such as VCN design principles, routing, and subnetting.
- **Lab environment:** Set up a lab environment within OCI to practice configuring advanced network security features.

OCI Load Balancer and its components

In [Chapter 3: Navigating Network Security in OCI](#) we explained at a very high level the concept and purpose of load balancer, different types of load balancers:

Public and Private. This section explains the fundamentals of load balancer and deep dive into OCI Load Balancer and each of their components. Load balancer facilitates the distribution of traffic from one entry point to different servers in VCN. Let us summarize the below components before deep diving into load balancer:

- **Region:** The region the resource is in. This part is present in the OCID only for regional resources or those specific to a single availability domain. If the region is not applicable to the resource, this part might be blank.
- **Compartments:** Compartments are logical containers used to organize and isolate cloud resources. Resources within a compartment share the same access controls. Compartments are important for structuring and securing resources, providing a way to control and limit access to specific sets of resources.

Availability domain (AD) is referred to as one or more data centers situated within a region. A region as referred above is composed of three availability domains. Similar to VCN, services and resources are either **region-specific** or **availability domain specific** like compute.

A **fault domain** is a cluster of hardware and infrastructure within an availability domain. There will be three fault domains in each availability domain. Fault domains will enable you to distribute your instances in such a way that they are not on the same physical hardware within a single availability domain. The main purpose of fault domain is to protect against hardware failure and protect against scheduled service interruptions resulting from planned maintenance on compute hardware.

As shown in below [*Figure 4.1*](#), as shown this placement for a new instance has one **availability domain AD1**:

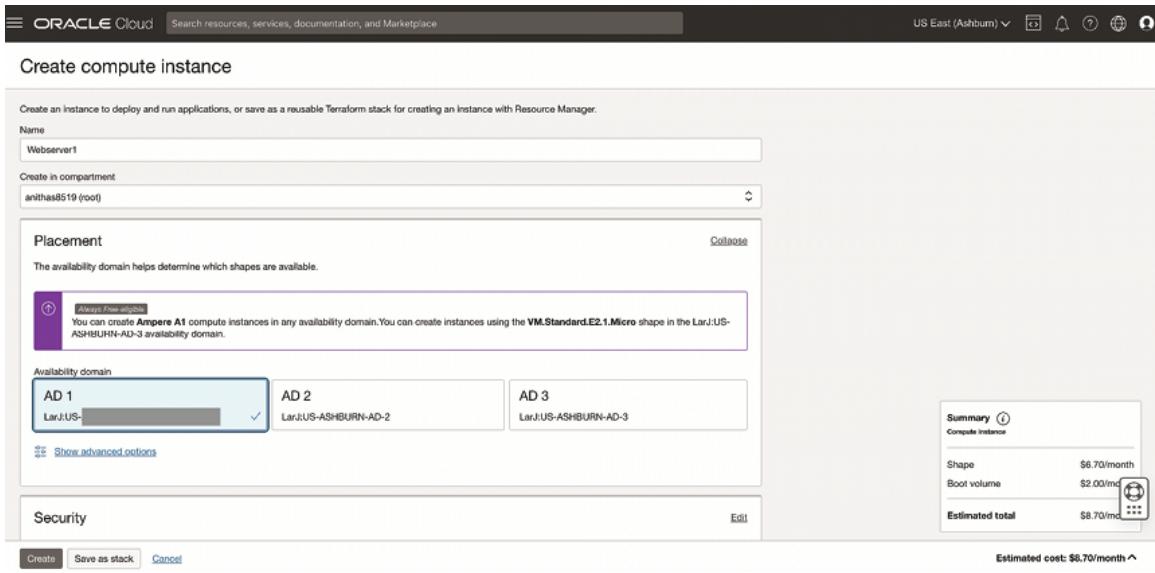


Figure 4.1: Create compute instance

OCI Availability Domain is one or more data centers located within a region. Every region can have up to three availability domains. After subscribing to the new region, you can navigate to Compute and proceed to create an instance.

- **VCN:** VCN is defined as a software defined version of a traditional physical network including subnet, route tables, and gateways on which instances run.
- **Subnet:** Subnets can be referred to as subdivisions we define in a VCN. A subnet could be either a public or private subnet.

Note: You cannot specify a private subnet for your public load balancer. For a private load balancer, create a VCN with at least one private subnet.

High availability

Maintaining the continuous availability of your cloud-based applications, and ensuring seamless operation of their workloads, is vital for round-the-clock (24/7) functionality. It is imperative to design services or applications with high availability to optimize uptime and accessibility, even in the event of potential outages in the cloud infrastructure. We can achieve HA at many different levels. These may be at the application level or cloud infrastructure level.

We need to focus on three pivotal elements whenever we design high-availability architecture.

These are monitoring, redundancy, and failover. This can be considered as the best practice. Let us explain these terms:

- Redundancy refers to the process where different components can perform identical tasks. This eliminates the problem of a single point of failure because redundant components can assume a task performed by a component that has failed. This cloud design eliminates a single point of failure by introducing the concept of redundancy.
- Monitoring ensures checking whether or not a component is working properly.
- Finally, Failover is the process by which a secondary component assumes the role of primary when the primary component fails to work or when the primary component is down.

Here are a few ways to achieve high availability in OCI:

- **Availability domains:** OCI regions are strategically organized into multiple ADs, with each AD representing a distinct and physically isolated data center. These data centers operate autonomously, featuring independent power sources, cooling systems, and networking infrastructure. The deployment of resources across these diverse ADs plays a pivotal role in fortifying the resilience and fault tolerance of your applications and services.

By distributing your resources across multiple availability domains, you introduce a layer of redundancy that safeguards against potential disruptions. In the event of any unforeseen issues or outages in one availability domain, the others remain unaffected, ensuring uninterrupted availability and reliability of your critical workloads.

Oracle strongly advocates for deploying your resources across a minimum of two availability domains. This strategic approach enhances high availability, providing a robust foundation for your applications and services to withstand various operational challenges, thus fostering a more resilient and dependable cloud infrastructure within the Oracle Cloud.

- **Load balancers:** OCI provides load balancing services that distribute incoming traffic across multiple instances or servers, ensuring that traffic is directed to healthy instances. This helps distribute the load and provides failover capabilities.

- **Autonomous database high availability (ADB):** The default setting for Oracle ADB ensures a high level of availability by adopting a multi-node configuration, effectively safeguarding against potential hardware failures within a localized context. Each application service in ADB is housed in a minimum of one Oracle Real Application Clusters instance. This design allows for seamless failover to an alternative Oracle RAC instance in the event of unplanned outages or scheduled maintenance activities. This capability significantly minimizes downtime, aiming for zero or near-zero interruptions to ensure continuous and reliable service.
- **Virtual machine (VM) HA:** You can set up VMs with different HA configurations, such as clustering, to ensure that your applications are highly available. Clustering technologies like Oracle Clusterware can be used for database and application HA.
- **Database HA:** Oracle Database on OCI can be configured for high availability using features like Oracle Data Guard and Oracle **Real Application Clusters (RAC)**. These technologies provide data replication and automatic failover capabilities.
- **Disaster recovery:** OCI offers disaster recovery solutions such as Oracle Cloud Infrastructure Disaster Recovery, which allows you to replicate your applications and data to a secondary region for disaster recovery purposes.
- **Backup and restore:** This can be achieved by implementing regular backup of your critical data and systems and ensuring that we have a well-defined recovery plan in place to minimize downtime in case of failures.
- **Network resilience:** Based on the above three best practices, design your network architecture with redundancy and fault tolerance in consideration, using features like VCNs and FastConnect for connectivity.

The following *Figure 4.2* shows a sample high availability configuration for a single region:

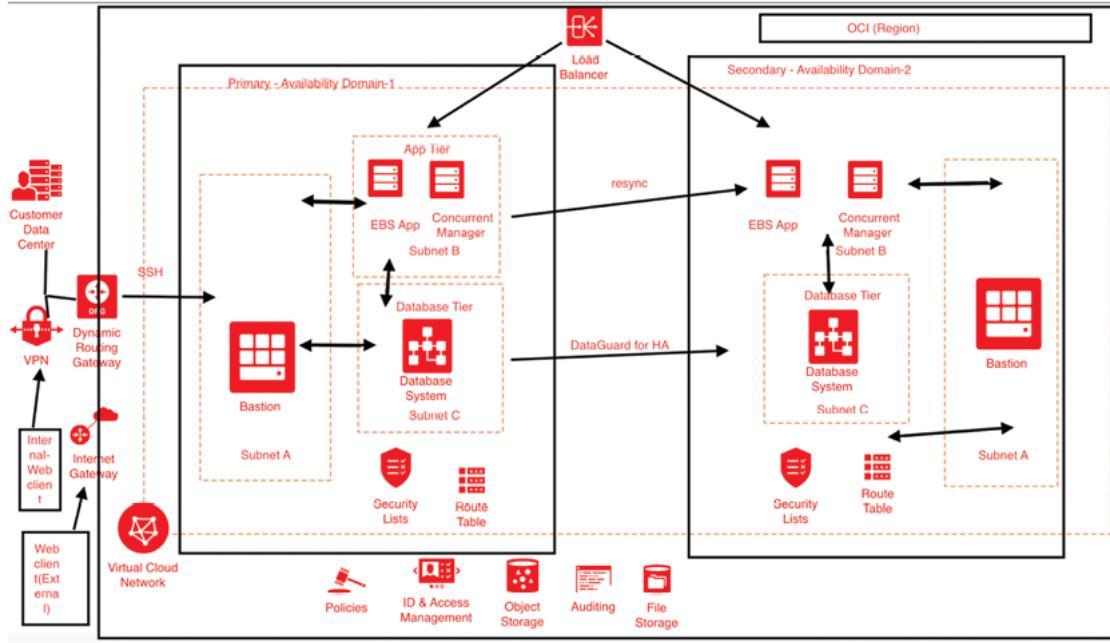


Figure 4.2: High availability configuration for a single region

Creating load balancer

In this section, let us create a basic load balancer. For our example, below are the prerequisites to create load balancer:

- A VCN
- Need to create two subnets each in a different availability domain along with the security list and route tables
- Need to have two instances running one in each subnet
- Creation of load balancer
- Creation of backend set
- Adding backends to backend set
- Set up the listener for load balancer

We have explained the steps to create VCN and subnets in [Chapter 3, Navigating Network Security in OCI](#). Let us revisit the VCN and subnets created below:

VCN: **dinesh_demo_vcn**

Compartment: **dineshbdemo**

Subnet_1: AD-1 corresponds to subnet created in Availability Domain-1

Subnet_2: AD-2 corresponds to subnet created in Availability Domain-2

The screenshot shows the Oracle Cloud interface for a Virtual Cloud Network (VCN). At the top, there's a large green hexagonal icon labeled 'VCN' with 'AVAILABLE' below it. The main title is 'dinesh_demo_vcn'. Below the title are buttons for 'Move resource', 'Add tags', and 'Delete'. A red arrow points from the text 'Subnet_1: AD-1 corresponds to subnet created in Availability Domain-1' to the 'dinesh_demo_vcn' title. The 'VCN Information' tab is selected, showing details like Compartment: dineshbdemo (root), Created: Wed, Feb 14, 2024, 03:30:52 UTC, IPv4 CIDR Block: 10.x.x.x/x, and DNS Domain Name: dineshbdemo. A red arrow points from the text 'Subnet_2: AD-2 corresponds to subnet created in Availability Domain-2' to the 'Created' timestamp for Subnet_1. The 'Resources' sidebar on the left lists Subnets (2), CIDR Blocks/Prefixes (1), Route Tables (1), Internet Gateways (0), Dynamic Routing Gateways (0), Attachments (0), Network Security Groups (0), and Security Lists (1). The 'Subnets' section shows two entries:

Name	State	IPv4 CIDR Block	IPv6 Prefixes	Subnet Access	Created
Subnet_2	Available	10.x.x.x/x	-	Public (Lan:US-ASHBURN-AD-2)	Wed, Feb 14, 2024, 03:38:08 UTC
Subnet_1	Available	10.x.x.x/x	-	Public (Lan:US-ASHBURN-AD-1)	Wed, Feb 14, 2024, 03:33:42 UTC

A red arrow points from the text 'Subnet_2: AD-2 corresponds to subnet created in Availability Domain-2' to the 'Subnet Access' column for Subnet_2.

Figure 4.3: Virtual Cloud Network screen

Below are the subnets created for reference for Subnet_1 and Subnet_2 along with availability domains and security lists. Detailed steps for the creation of Subnets are discussed in [Chapter 3, Navigating Network Security in OCI](#).

In the next figure, we can see the screen for Subnet_1 in availability domain:

The screenshot shows the Oracle Cloud interface for the 'Subnet_1' details screen. At the top, there's a large green hexagonal icon labeled 'S' with 'AVAILABLE' below it. The main title is 'Subnet_1'. Below the title are buttons for 'Edit', 'Move resource', 'Add tags', 'Create path analysis', and 'Terminate'. A red arrow points from the text 'Subnet_1: AD-1 corresponds to subnet created in Availability Domain-1' to the 'Subnet_1' title. The 'Subnet Information' tab is selected, showing details like OCID: ...jihwva, IPv4 CIDR Block: 10.x.x.x/x, IPv6 Prefix: -, Virtual Router MAC Address: 00:xx:xx, Subnet Type: Availability Domain-Specific, and Availability Domain: Lan:US-ASHBURN-AD-1. A red arrow points from the text 'Subnet_2: AD-2 corresponds to subnet created in Availability Domain-2' to the 'Availability Domain' field for Subnet_1. The 'Resources' sidebar on the left lists Security Lists (1), Logs, IPv6 Prefixes (-), Tag filters, and add/clear. The 'Security Lists' section shows one entry:

Name	State	Compartment	Created
Default Security List for dinesh_demo_vcn	Available	dineshbdemo (root)	Wed, Feb 14, 2024, 03:30:52 UTC

A red arrow points from the text 'Subnet_2: AD-2 corresponds to subnet created in Availability Domain-2' to the 'State' column for the Default Security List.

Figure 4.4: Screen for Subnet_1 in Availability Domain 1

In the following figure, we can see the screen for Subnet_2 in availability domain:

The screenshot shows the Oracle Cloud interface for managing subnets. At the top, it displays the navigation path: Networking > Virtual cloud networks > dinesh_demo_vcn > Subnet Details. The main title is "Subnet_2". Below the title, there are tabs for "Subnet Information" and "Tags". Under "Subnet Information", various details are listed: OCID, IPv4 CIDR Block, IPv6 Prefix, Virtual Router MAC Address, Subnet Type (Availability Domain-Specific), and Availability Domain (labeled as "2"). A red arrow points from the text "Subnet_2" in the heading to the subnet name in the title bar. Another red arrow points from the text "Availability Domain 2" in the "Availability Domain" section to the value "2" in the list. On the left side, there's a sidebar with sections like "Resources" (Security Lists, Logs, IPv6 Prefixes, Tag filters) and "Security Lists" (listing "Default Security List for dinesh_demo_vcn" as available). A third red arrow points from the text "Availability Domain 2" in the "Availability Domain" section to the "Available" status in the security list table.

Figure 4.5: Screen for Subnet_2 in Availability Domain 2

Let us create WebServer 1 and Webserver 2 in Availability Domain 1 and Availability Domain 2. We will cover steps for Web Server 1 as per below [Figure 4.5](#) in OCI, select **Compute** and click **Instances**:

The screenshot shows the Oracle Cloud Compute Instances page. The left sidebar has a "Compute" section highlighted with a red arrow. The main content area shows a table for "Instances" with columns: Name, State, Compartment, and Created. One row is listed: "Default Security List for dinesh_demo_vcn" (Available), "dineshbdemo (root)", and "Wed, Feb 14, 2024, 03:30:52 UTC". A red arrow points from the text "Compute" in the sidebar to the "Instances" link in the main content area. The bottom of the page includes a search bar, tag filters, and a table footer showing "Showing 1 item < 1 of 1 >".

Figure 4.6: First step in creating instance

1. Click **Create instances** in the respective compartment:

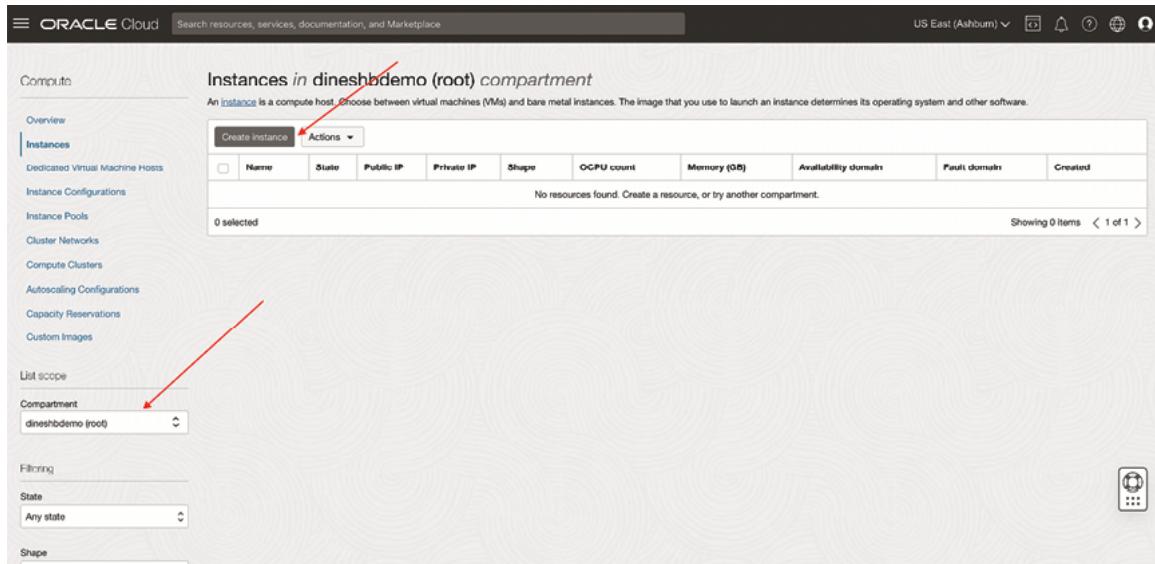


Figure 4.7: Second step in instance creation

2. Enter the name as **webserver_demo_1** in the respective compartment and AD 1 as below:

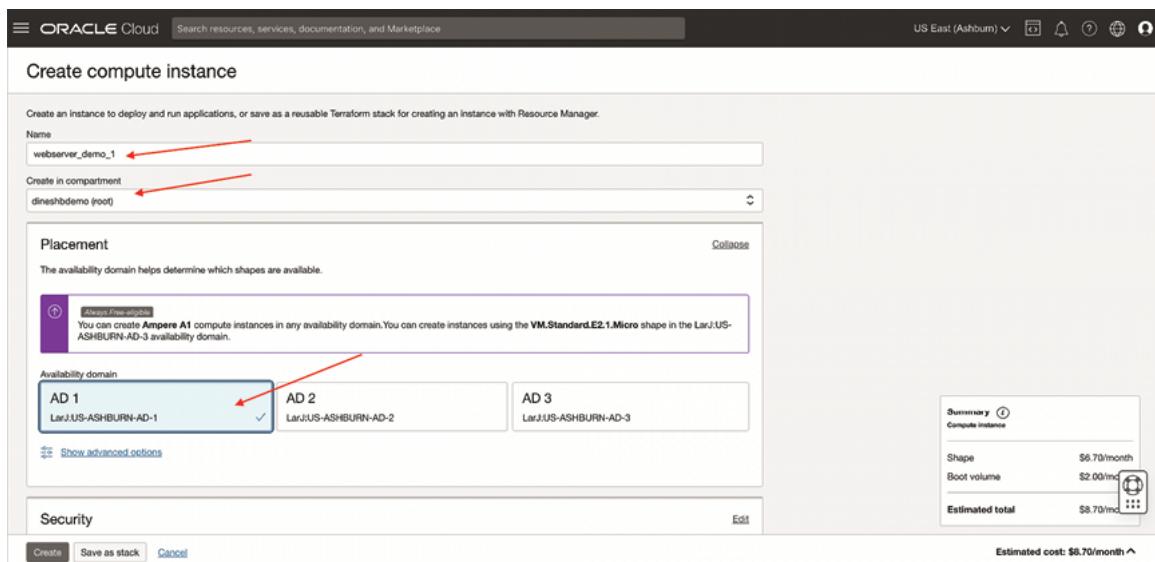


Figure 4.8: Instance creation for web server 1

3. Select the **Subnet** and **Virtual cloud network** in **Security** screen, as shown below:

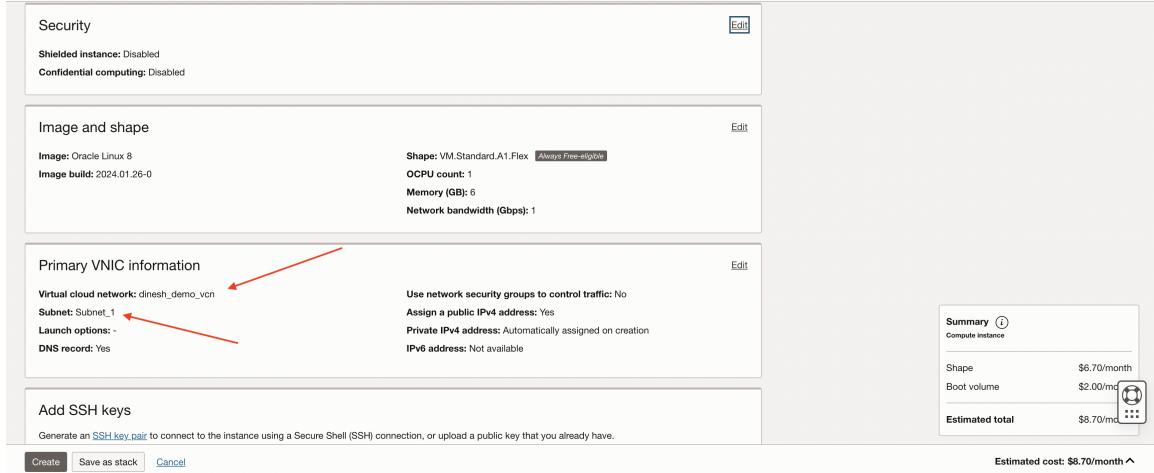


Figure 4.9: Instance creation for web server 1 (VNIC information)

4. The next step is to select **Image and Shape** as below. For example, in this case, we selected Image as Oracle Linux8:

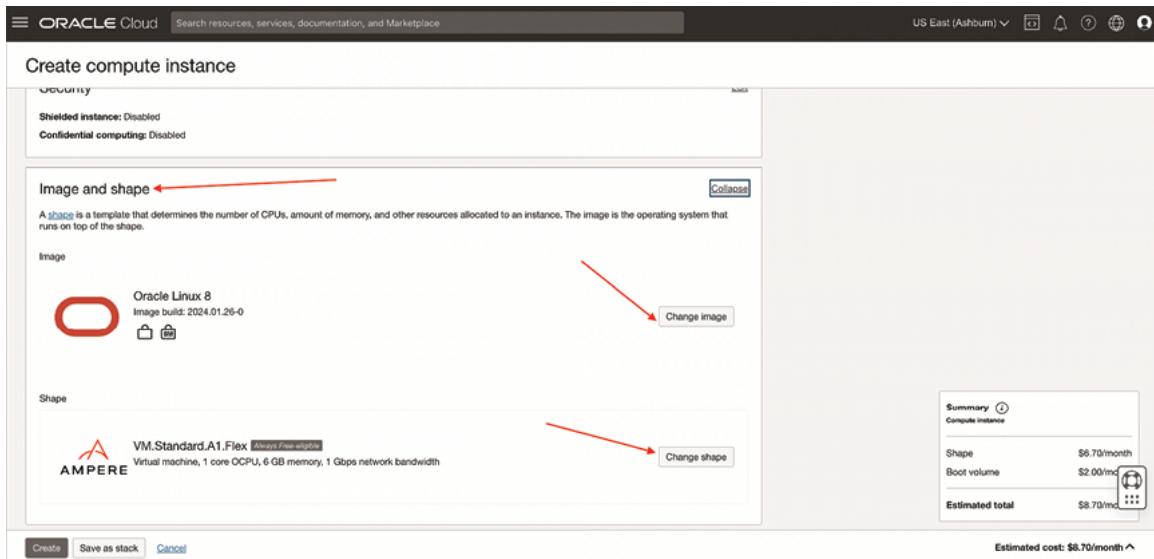


Figure 4.10: Selecting the Image and Shape from Selection list

5. Create **SSH Keys** and select the respective **Boot volume**. It is important to save the **private key** and **Save the public key** for the option **Generate a key pair for me**. This is needed to access the webserver and finally, click **Create**:

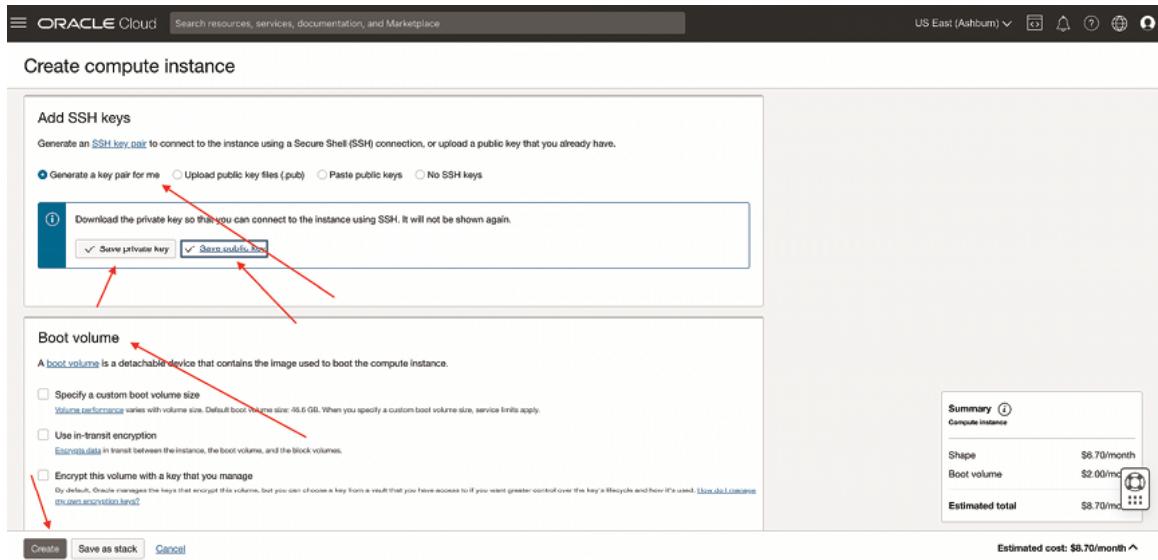


Figure 4.11: Adding SSH keys and boot volume in Create compute instance screen

6. The above step will create **webserver_demo_1** in **AD-1**, as shown here. This has all the details, such as username and public IP address, to access using keys generated in the above steps:

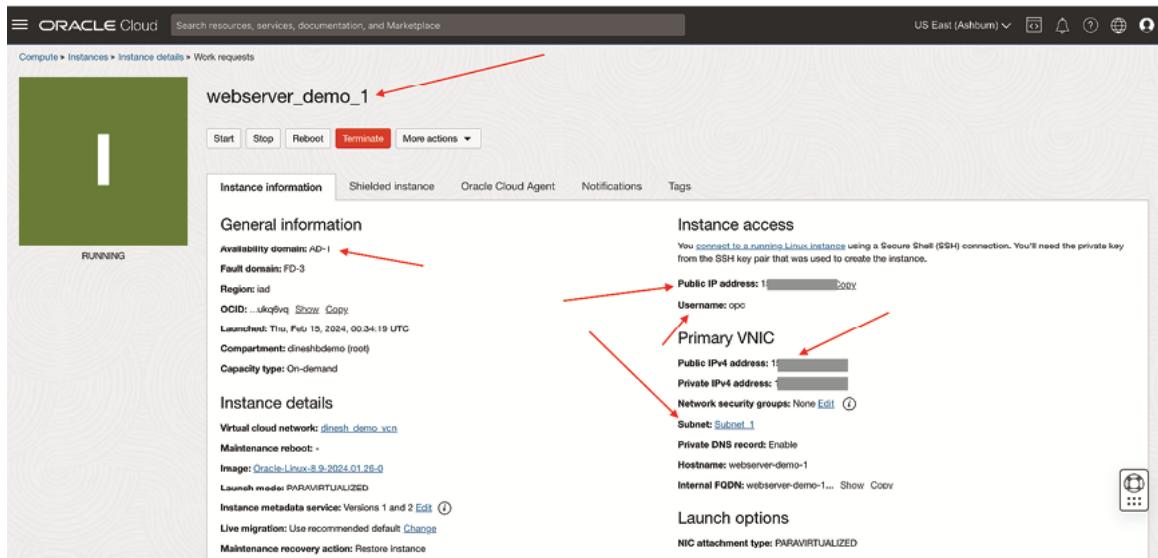


Figure 4.12: Figure representing webserver_demo_1 created in above steps

7. Similarly, we can create **webserver_demo_2** as below in **AD-2**:

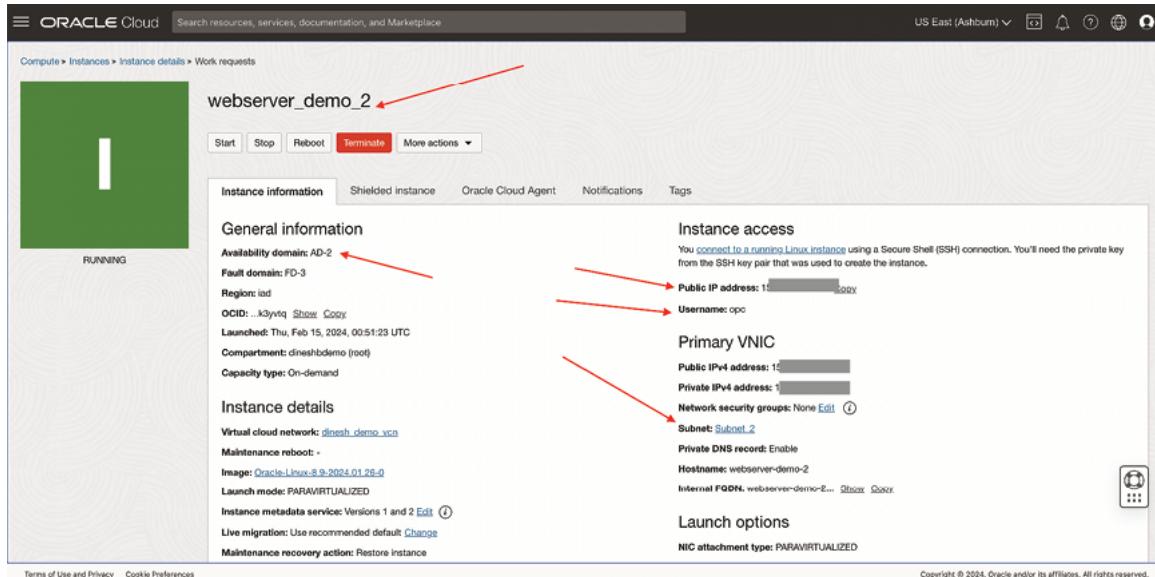


Figure 4.13: Figure representing webserver_demo_1 created in above steps

Below are the instances created, as shown in the figure:

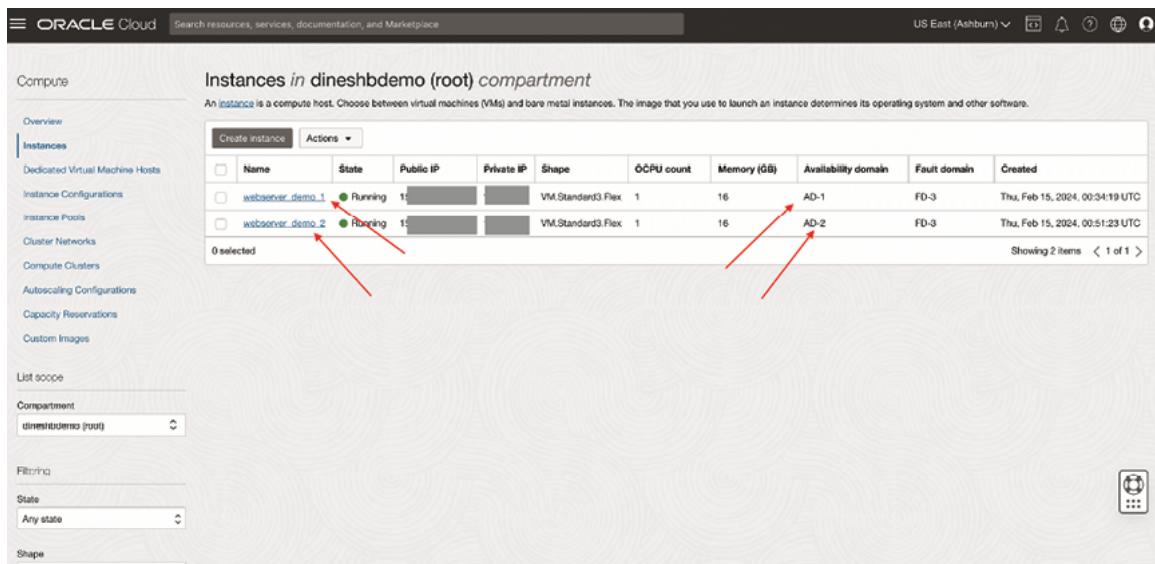


Figure 4.14: Screen depicting the instances showing in compartment

Note: We have used default security list and route table in the above cases.

- Now, let us create the load balancer. Navigate to **Networking** and select **Load balancers**:

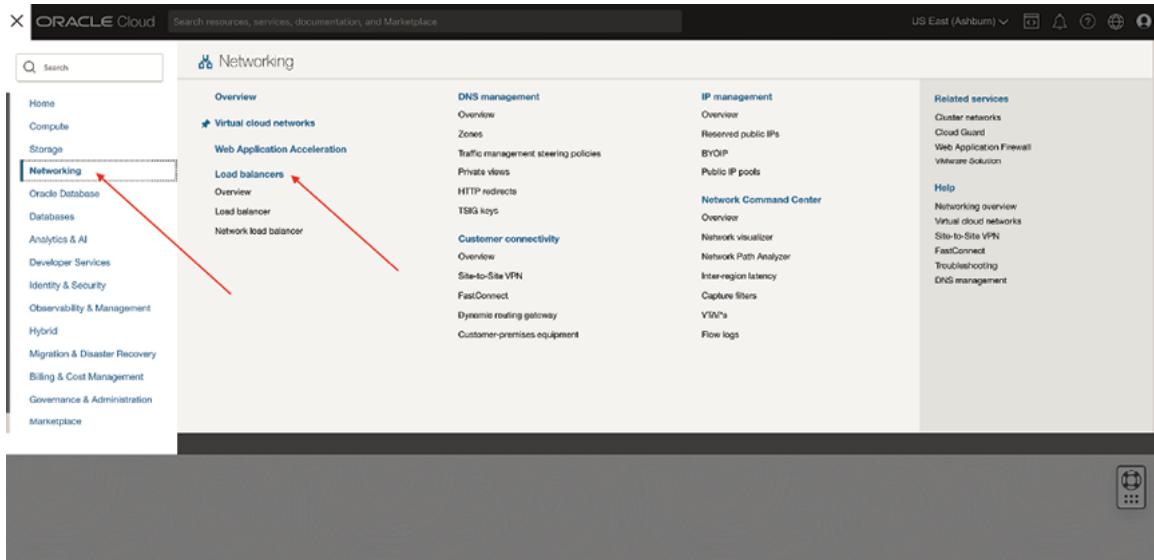


Figure 4.15: First step to navigate the Networking-load balancer

9. Load balancer can be created by clicking **Create load balancer**. We can also create a network load balancer, as shown in [Figure 4.16](#):

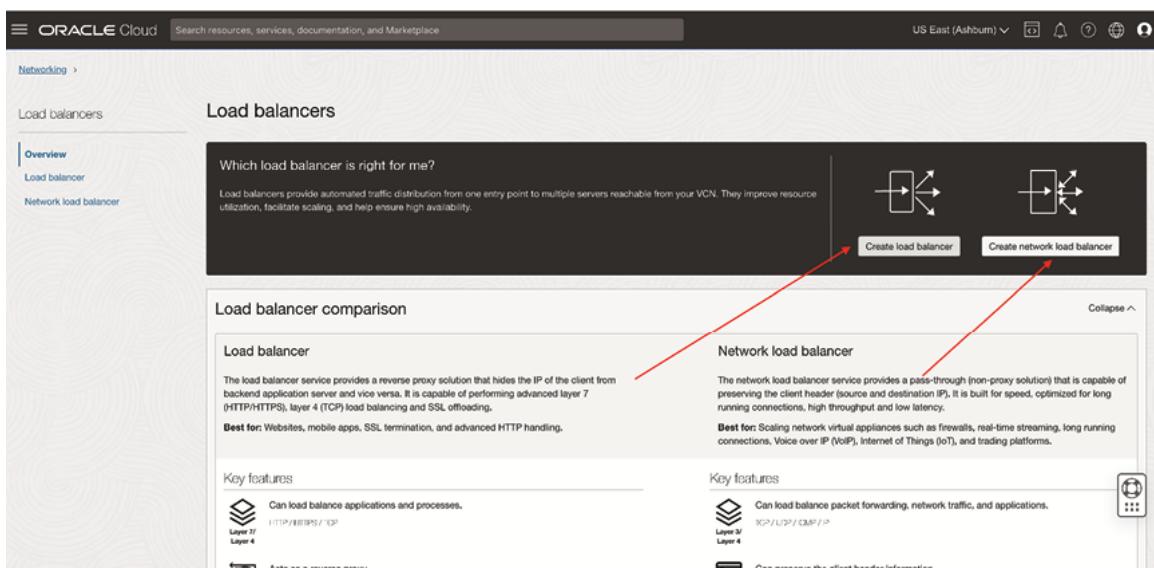


Figure 4.16: Creation of networking-load balancer from networking page

10. Add the below details as shown for the **Load balancer name**, **Visibility type**, and **Public IP address**:

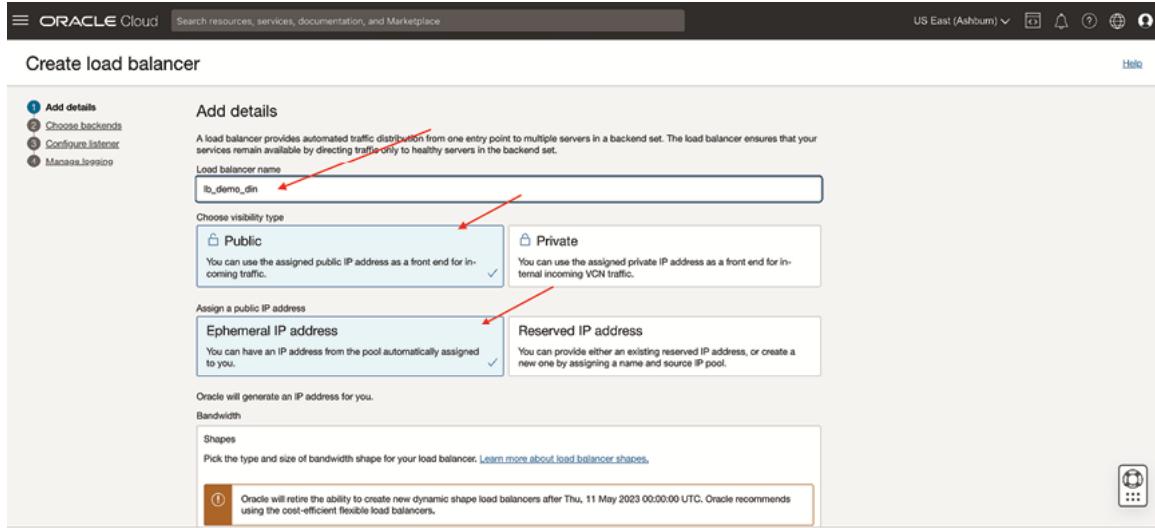


Figure 4.17 (a): Add details-load balancer in load balancer section

11. Select the bandwidth. In the example, we have selected the minimum and maximum bandwidth as 100Mbps:

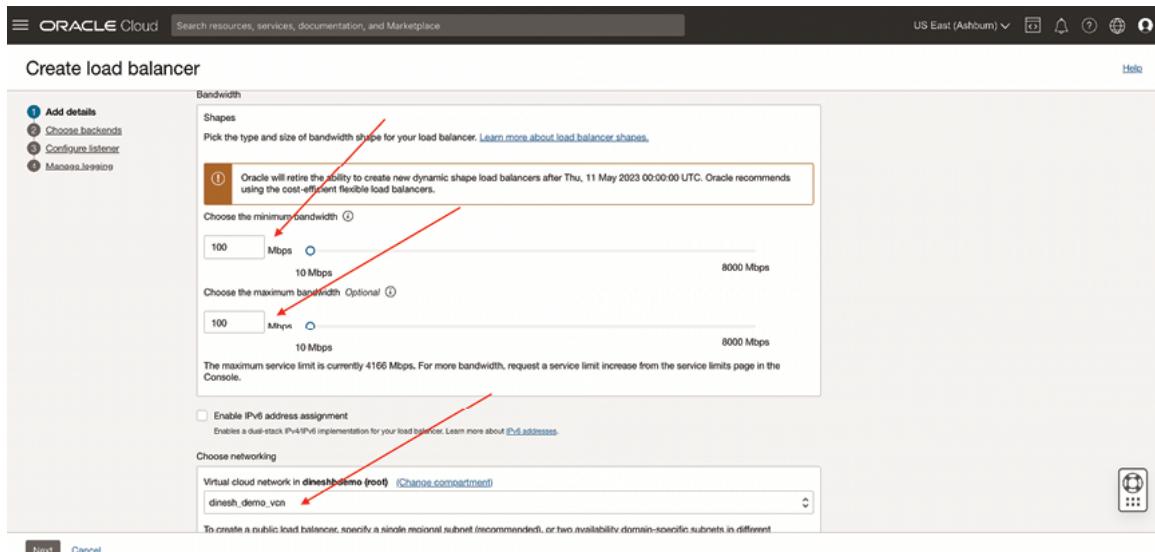


Figure 4.17 (b): Add details-load balancer in load balancer shapes section

12. Choose a VCN in a specific compartment and respective subnets in the **Choose networking** screen. You can enable security by enabling the web application firewall policy as shown below and click next:

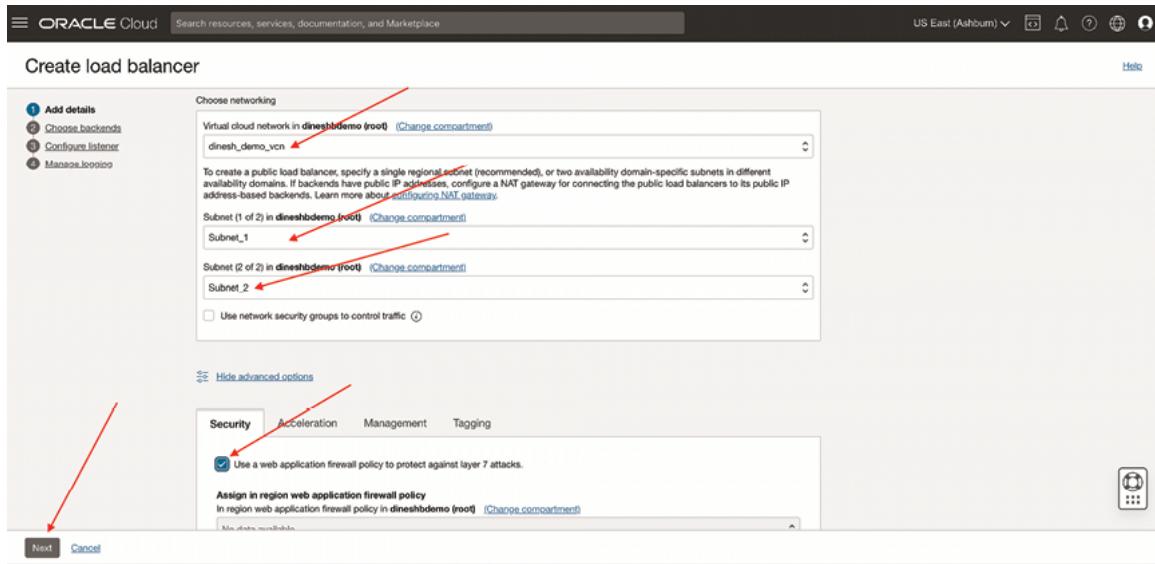


Figure 4.17 (c): Add details-load balancer in security section tab

13. **Choose Backends**, as shown in the next figure. We have **Weighted round robin**, **IP hash** and **Least connections**. In this example, we are considering **Weighted round robin**. Next, click **Add backends**:

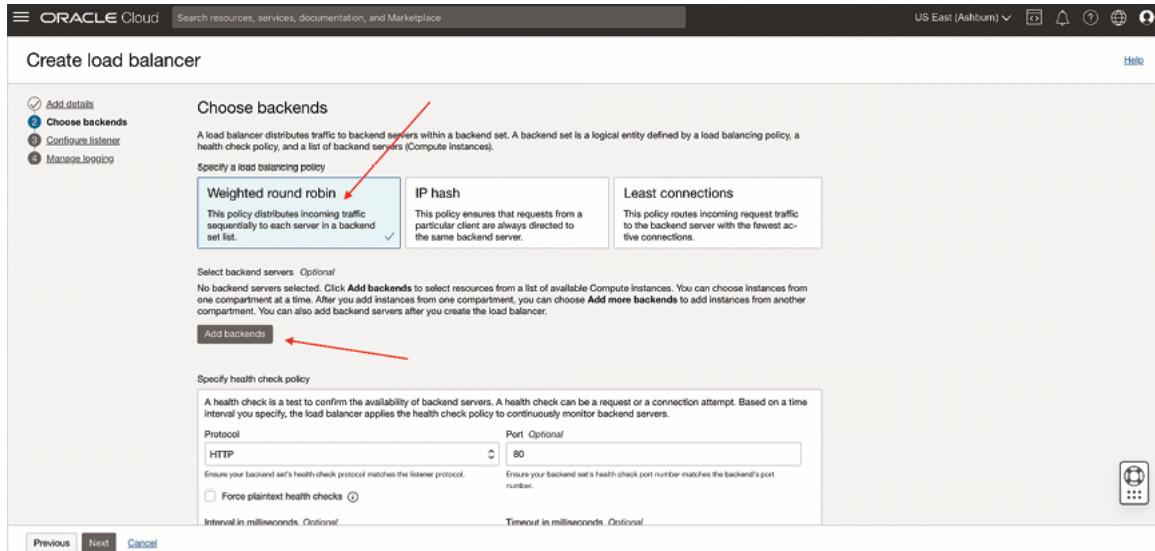


Figure 4.18: Choose backends for create load balancer step

14. Add the backends by clicking the checkbox for respective web servers and click **Add selected backends**. This step will add the backends:

Note: The web servers have already been created in the above steps.

The screenshot shows the Oracle Cloud 'Create load balancer' wizard. On the left, the 'Choose backends' step is active, showing a list of two backend servers: 'webserver_demo_1' and 'webserver_demo_2'. Both servers have checkboxes checked. Red arrows point from the text 'Two backend servers selected' to the checkboxes. On the right, the 'Add backends' step is shown, displaying a table of instances in the compartment 'dineshdemo (root)'. The table has columns for Name, IP address, OCID, and Availability domain. Two rows are listed: 'webserver_demo_1' and 'webserver_demo_2'. The 'Availability domain' column shows 'LanJ.US-ASHBURN-AD-1' and 'LanJ.US-ASHBURN-AD-2' respectively. A message at the bottom says 'Showing 2 items < 1 of 1 >'. At the bottom of the right panel, there is an 'Add selected backends' button.

Figure 4.19: Adding backend for create load balancer step

15. Enter the specific health check policy by entering the protocol, port, and number of retries:

The screenshot shows the 'Specify health check policy' section of the 'Create load balancer' wizard. It includes fields for Protocol (set to 'HTTP'), Port (set to '80'), Interval in milliseconds (set to '10000'), Timeout in milliseconds (set to '3000'), Number of retries (set to '3'), Status code (set to '200'), URL path (set to '/'), and Response body regex. A red arrow points to the 'Protocol' field. Another red arrow points to the 'Port' field. At the bottom, there is a 'Use SSL' checkbox which is checked, and a 'SSL certificate' section with a 'Certificate resource' input field.

Figure 4.20: Adding Backend and specifying health check policy

16. In case we want to use an **SSL certificate**, please enable it as below. **Use SSL** and enter the CA details. In this example, we are disabling. Click **Next:**

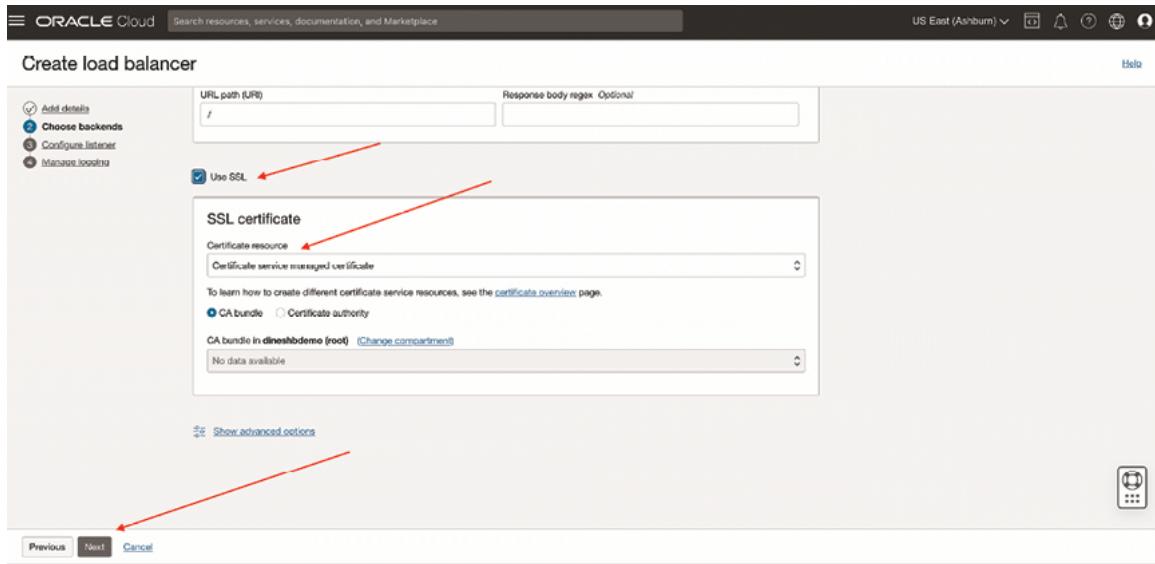


Figure 4.21: Adding SSL in create load balancer screen

17. The next step is to **Configure listener**. In this step, we need to enter a name for **Listener**, and specify the type of traffic. In the figure below, we gave **HTTPS** and port number **443**. For **HTTPS**, we need to provide an **SSL certificate**. For our example, let us consider HTTP and port number as **80** and click **Next** to go to **Manage logging**:

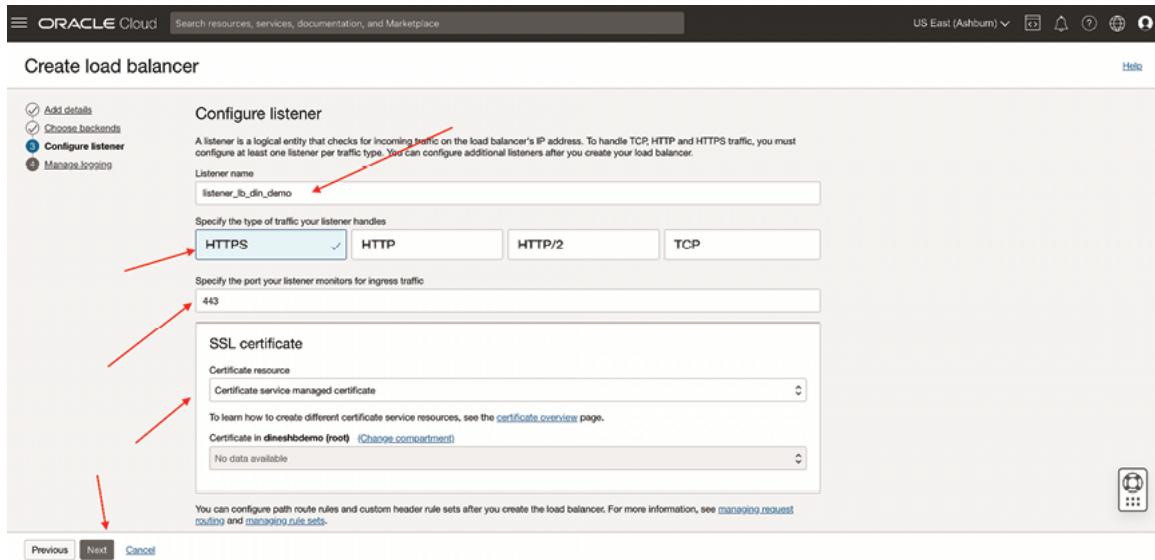


Figure 4.22 (a): Configure listener in create load balancer step for HTTPS

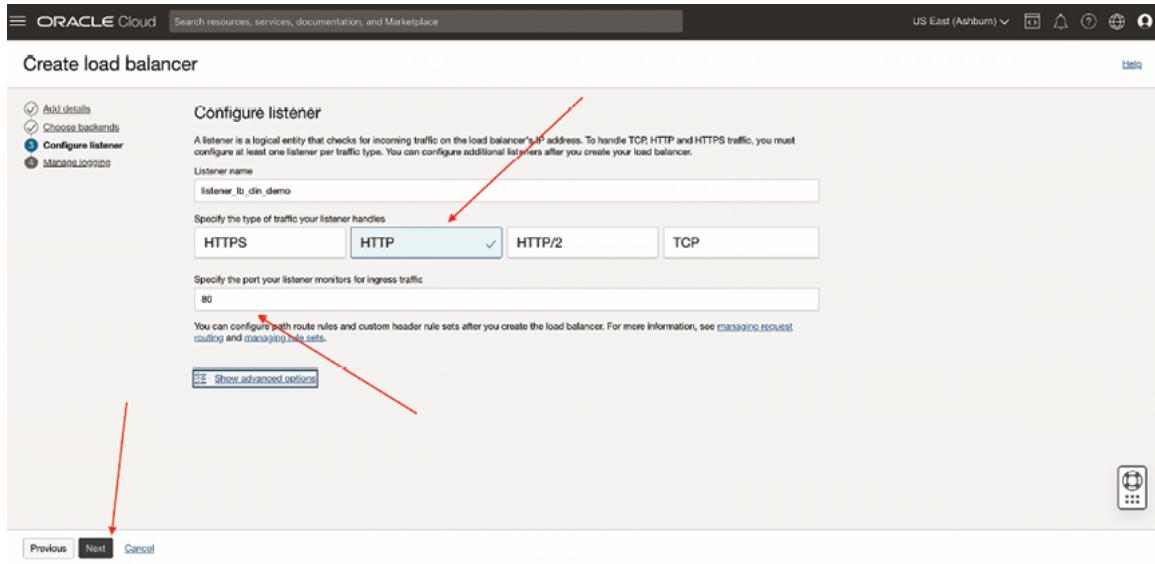


Figure 4.22 (b): Configure Listener in create load balancer screen for HTTP

18. In **Manage logging** enable the **Error logs** and select log group and click **Submit** to create our load balancer:

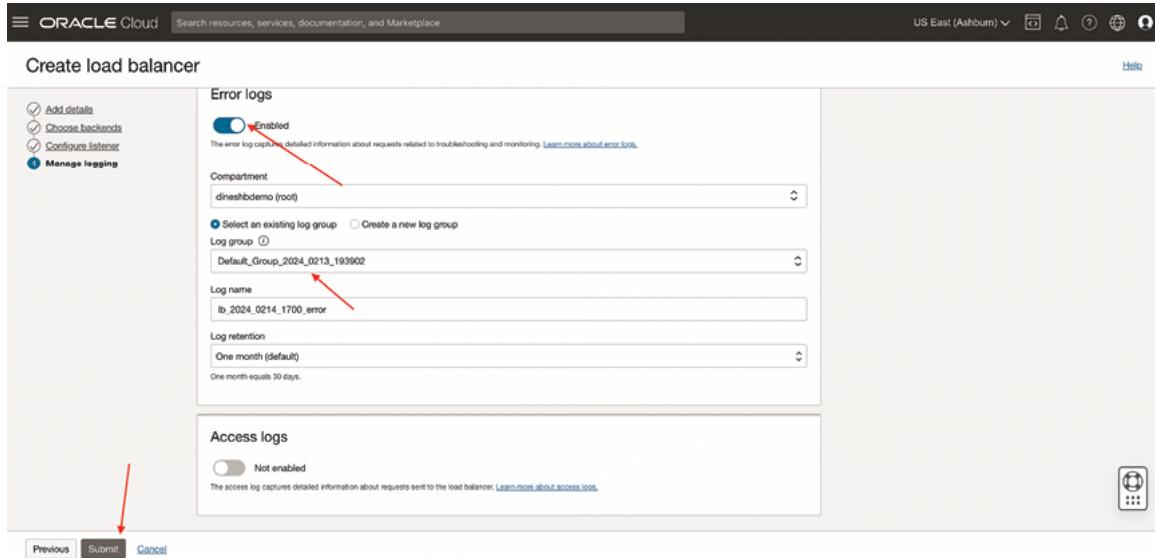


Figure 4.23: Managing logging from error logs tab

19. This will create load balancer with the required specifications, as shown below:

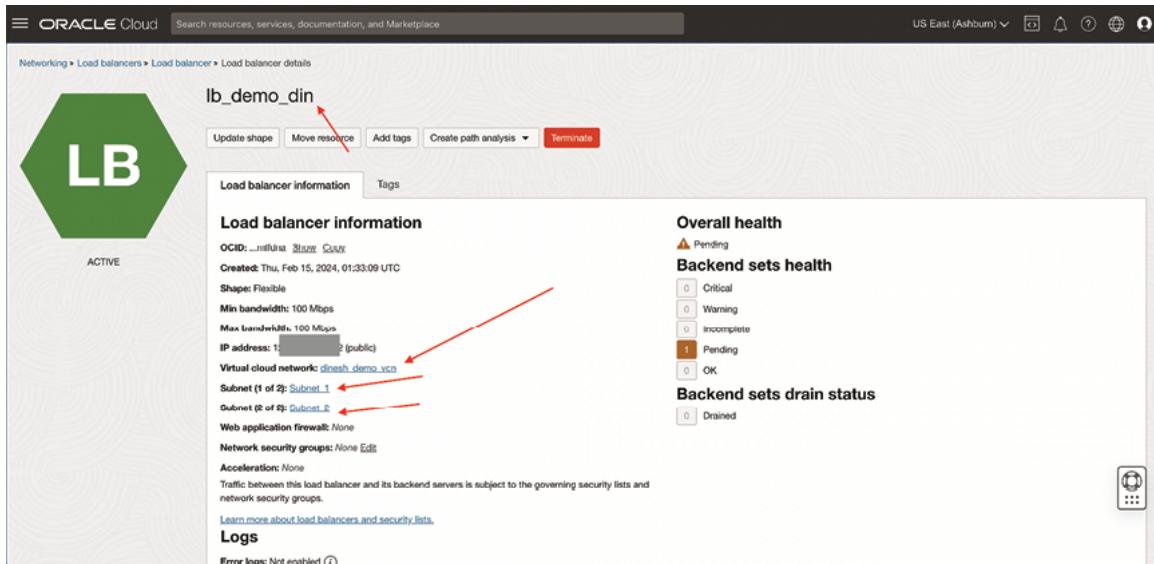


Figure 4.24: Screen representing load balancer created

Securing networks with VCN and subnets

In this section, we will discuss the different ways to secure networks with VCN and Subnets. The Networking service comprises a set of functionalities designed to implement network access control and enhance the security of VCN traffic.

Below are different ways to secure VCN:

- **Security rules:** Security rules establish stateful and stateless firewall capability to regulate network access to your instances. Alternatively, it allows a specific type of traffic in or out of a VNIC. For instance, ingress TCP port 22 SSH traffic from a particular source. Security rules in VCN can be implemented by **network security groups (NSG)** or security lists.

Before we define NSG, let us define a route table.

- **Route table:** VCN uses virtual route tables to facilitate traffic flow out of the VCN (for instance, to the internet, to your on-premises network, or to a peered VCN). These route tables contain route rules that establish the path for traffic originating from subnets via gateways to reach other subnets or destinations outside the VCN. Each rule defines a destination CIDR block and its corresponding target (the next hop) for any traffic matching that CIDR. In a nutshell, route tables basically control traffic routes from your VCN's subnets to destinations outside the VCN. Routing targets can be VCN gateways or a private IP address in the VCN. This is one of the ways to secure VCN.

Upon creating a security rule, you can specify whether it operates in a stateful or stateless manner. The default setting is stateful. However, it is advisable or recommended to opt for stateless rules, particularly in scenarios involving high-volume internet-facing websites, such as those dealing with HTTP/HTTPS traffic. Network access to instances can be restricted by implementing VCNs security rules.

Stateful applications and processes enable users to save, record, and revisit previously established information and procedures via the Internet. Within stateful applications, servers maintain records of individual user sessions, preserving data regarding user interactions and previous requests. Stateful rules store this information in a connection tracking table on each compute instance.

A stateless process or application, on the other hand, does not preserve data regarding the user's past interactions. It does not incorporate the concept of retaining or referencing previous transactions. Each transaction is treated as entirely new and independent. Stateless applications offer singular services or functions and utilize **content delivery networks (CDNs)**, web servers, or print servers to handle these transient requests.

If your subnet has a high volume of traffic, Oracle suggests adopting stateless rules over the stateful rules. Let us consider a scenario where our architecture uses stateful and stateless rules at the same time and there is traffic that meets both a stateful and stateless rule in a specific direction.

For example, let us consider this case as ingress traffic. In this case, stateless rule takes precedence and the connection remains untracked. In this scenario, we require a corresponding rule in the opposite direction, which in this instance is egress, either stateless or stateful, to permit the response traffic.

Security list

A security list is a shared configuration or common set of firewall rules linked (Associated) to a subnet and applicable to all compute instances within that specific subnet. There are two types of traffic allowed in security lists:

- Incoming traffic referred as ingress.
- Outgoing traffic referred as egress. It is important to note that we define firewall rules at the subnet level but not at compute instance level in OCI.

Network security groups

We can also implement security rules by NSGs. NSGs offer a virtual firewall for a group of cloud resources with consistent security configurations. Security lists and NSGs offer distinct methods for applying security rules to a group of **Virtual Network Interface Cards (VNICS)** within the VCN. A VNICS enables an instance to connect to a VCN and specifies how the instance establishes connections with endpoints both within and outside the VCN. The question here arises, when to use security lists and in which scenario to use the NSG? Security lists offer detailed security to applications with security rules applied to every subnet. However, in a situation where various resources require different security configurations within a subnet, and you need to manage traffic at a finer application level, you can establish these detailed regulations and incorporate multiple resources into them using NSGs.

Oracle advises the utilization of NSGs over security lists due to NSGs offering the capability to segregate the subnet architecture of the VCN from your application security needs.

For stateless packet filtering at the subnet level, we use the concept of network ACLs. Unlike security lists, which are stateful, ACLs require you to specify both inbound and outbound rules explicitly.

Gateways

There are five gateways as defined below in OCI networking. Gateways enables resources in a VCN to have communication with destinations outside the VCN:

- **Internet gateway (IG):** It defines the path for network traffic between the Oracle Cloud Infrastructure and the Internet. VCN. By default, compute instance in public subnet will not be able to connect to the Internet without IG. This is basically valid for scenarios which requires internet connectivity (for instance, resources with public IP addresses in public subnets)
- **NAT gateway:** NAT gateway allows resources which do not have public IP addresses to access the internet while preventing incoming traffic from reaching those resources. This enables internet connectivity without exposing the resources to incoming internet connections. For example, for resources in private subnets
- **Service gateway:** Service gateway allows OCI resources to access public OCI services without the need to use the internet or NAT gateway. An example of a service gateway is object storage.

- **Dynamic routing gateway (DRG):** DRG offers a singular point of entry for remote network paths coming into VCN. It establishes a route for VCNs to communicate between regions or connect outside the region to On-premise locations. Each VCN can have a single DRG.
- **Local peering gateway (LPG):** Local peering gateway is utilized to facilitate communication between resources of different VCNs within a region.
- **Gateway endpoints:** Gateway endpoints provide a way for resources in a **Virtual Cloud Network (VCN)** to communicate with Oracle Cloud services without going through the public internet. Gateway endpoints are crucial for maintaining security and reducing latency.
- **Interface endpoints:** Interface Endpoints provide private connectivity to Oracle Cloud services through a network interface within your VCN. They ensure that traffic between your VCN and OCI services remains within the Oracle Cloud network, thereby enhancing security and performance. These endpoints utilize private endpoints and are a feature of the OCI private endpoint service.

IAM policies are another way to secure VCN. IAM policies define the access and actions that IAM groups are authorized to perform on resources within a VCN.

The following figure illustrates a sample architecture showing different gateways:

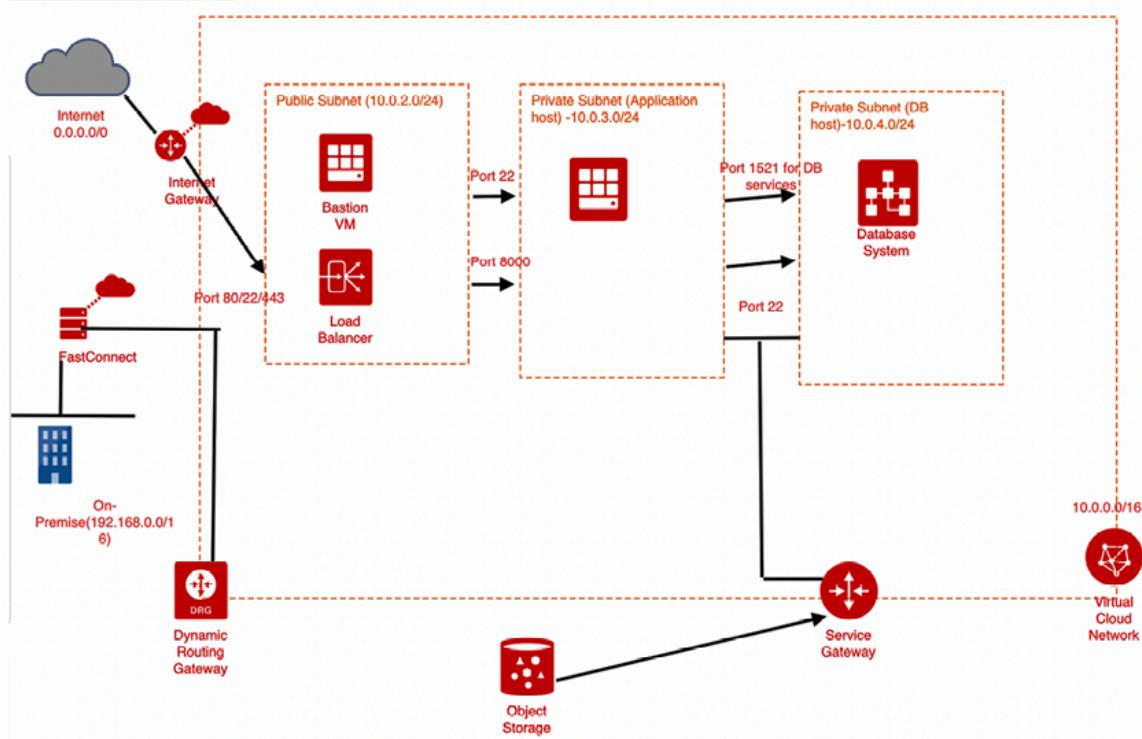


Figure 4.25: Architecture with different gateways

Network firewalls

A network firewall is a scalable and highly available instance which enables you to create in the subnet of your choice. The firewall enforces the business logic outlined in a connected firewall policy onto the network traffic. Routing within the VCN is employed to guide traffic to and from the firewall. The default throughput of the firewall is 4Gbps, which can be extended to 25Gbps network firewall offers a wide range of security features such as **intrusion detection and prevention**, which primarily monitor for malicious activity and thereby block the respective activity by examining the logs, decrypting and inspecting TLS-encrypted traffic, including ESNI support, to identify security vulnerabilities termed as **SSL inspection**, stateful network filtering and restricting ingress and egress traffic to a predefined list of **fully qualified domain names (FQDNs)**, which includes wildcards and custom URLs.

Network firewalls are implemented by network policies. Network policies consist of rules and configurations that control network traffic and oversee the security and accessibility of network resources. These policies are essential for maintaining secure, efficient network communication that meets organizational requirements.

Network firewall provides security features such as Stateful network filtering, Custom URL and FQDN filtering, and **intrusion detection and prevention (IDPS)**. **Stateful network filtering** creates stateful network filtering rules that *allow or deny* network traffic based on source IP (IPv4 and IPv6), destination IP (IPv4 and IPv6), port, and protocol. **Custom URL and FQDN filtering** restrict ingress and egress traffic to a specified list of **fully qualified domain names (FQDNs)**, including wild cards and custom URLs. IDPS monitors networks for malicious activity. Log information, report, or block the activity.

Oracle advises regular monitoring of Oracle Cloud Infrastructure Audit logs to assess alterations made to VCN NSGs, security lists, route table rules, and VCN gateways.

NAT gateway

As previously mentioned, a NAT gateway serves to grant resources which do not have public IP addresses access to the internet without exposing them to incoming internet connections. Let us define a NAT gateway as below:

1. Go to console, click on **Networking**, and select **Virtual Cloud Networks** by clicking on it:

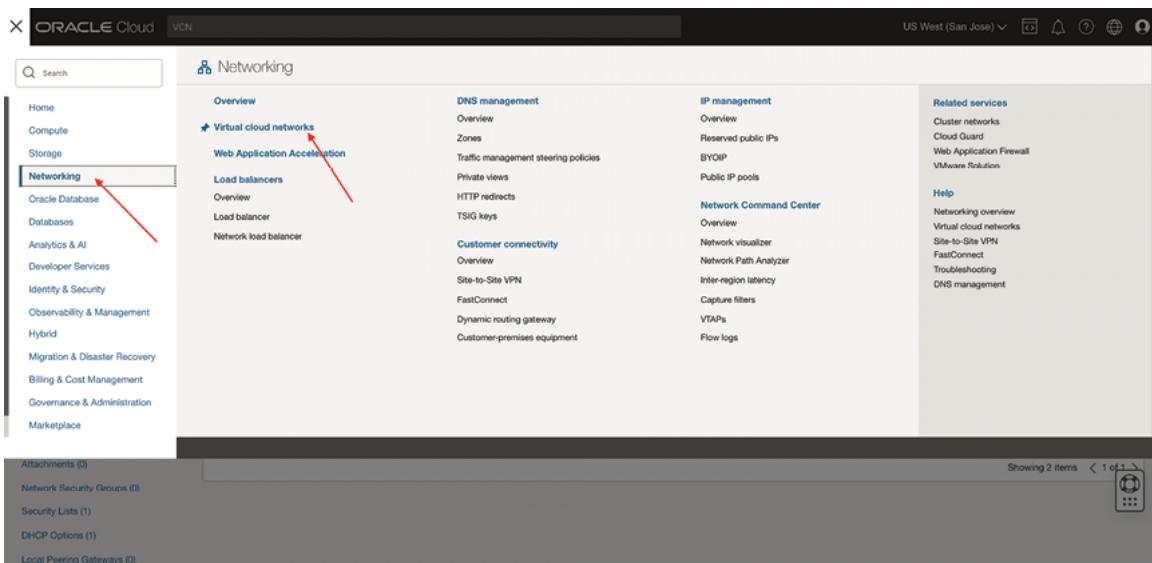


Figure 4.26: Steps to create a VCN from networking tab

2. Choose the VCN for which you wish to create the NAT gateway, then select **NAT gateways**.

Virtual Cloud Networks in dinesh_demo_compartment compartment

Virtual Cloud Networks (VCNs) are private virtual networks you set up in Oracle Cloud Infrastructure. You can attach gateways, route tables, and security lists to specify routing and security rules.

Name	State	IPv4 CIDR Block	IPv6 Prefix	Default Route Table	DNS Domain Name	Created
Dinesh_Demo_VCN_LB	Available	10.0.0.0/16	-	Default Route Table for Dinesh_Demo_VCN_LB	dineshdemovcnlb.oraclevnic.com	Sat, Feb 10, 2024, 17:56:49 UTC
Dinesh_Demo_VCN	Available	10.0.0.0/16	-	Default Route Table for Dinesh_Demo_VCN	dineshdemovcn.oraclevnic.com	Sun, Feb 4, 2024, 19:38:08 UTC

Showing 2 items < 1 of 1 >

Figure 4.27: Figure to select specific VCN created

Dinesh_Demo_VCN

Move resource Add tags Delete

VCN Information Tags

Compartment: dinesh_demo_compartment
Created: Sun, Feb 4, 2024, 19:38:09 UTC
IPv4 CIDR Block: 10.0.0.0/16
IPv6 Prefix: -

OCID: ...t6xxkq Show Copy
DNS Resolver: Dinesh_Demo_VCN
Default Route Table: Default Route Table for Dinesh_Demo_VCN
DNS Domain Name: dineshdemovcn.oraclevnic.com

Resources

Subnets in dinesh_demo_compartment compartment

Create Subnet

Name	State	IPv4 CIDR Block	IPv6 Prefixes	Subnet Access	Created
Private_Subnet	Available	10.0.1.0/24	-	Private (Regional)	Sun, Feb 4, 2024, 20:33:58 UTC
Public_Subnet	Available	10.0.2.0/24	-	Public (Regional)	Sun, Feb 4, 2024, 20:13:31 UTC

Showing 2 items < 1 of 1 >

Subnets (2)
CIDR Blocks/Prefixes (1)
Route Tables (1)
Internet Gateways (0)
Dynamic Routing Gateways Attachments (0)
Network Security Groups (0) ←
Security Lists (1)
DHCP Options (1)
Local Peering Gateways (0)

Figure 4.28: figure representing details of VCN created

The screenshot shows the Oracle Cloud interface for managing a VCN named 'Dinesh_Demo_VCN'. In the 'Resources' sidebar, the 'Network Security Groups (0)' section is highlighted. Below it, the 'Create Network Security Group' button is visible. A red arrow points from this button to the 'Name' input field, which contains the text 'NAT_GW_Din_Demo'.

Figure 4.29: steps to create network security group in VCN screen

3. Enter the name (In this example: **NAT_GW_Din_Demo**) in the specific compartment and click **Next**:

The screenshot shows the 'Create Network Security Group' wizard, Step 1: Basic Info. It includes tabs for 'Basic Info' (selected) and 'Security Rules'. The 'Name' field is populated with 'NAT_GW_Din_Demo'. The 'Create In Compartment' dropdown shows 'dinesh_demo_compartment' selected. At the bottom, there are 'Next' and 'Cancel' buttons, with a red arrow pointing from the 'Next' button to the 'Cancel' button.

Figure 4.30: Selecting name details for creating of Network Security Group

4. Enter the **Security rules** as below figure and click **Create**:

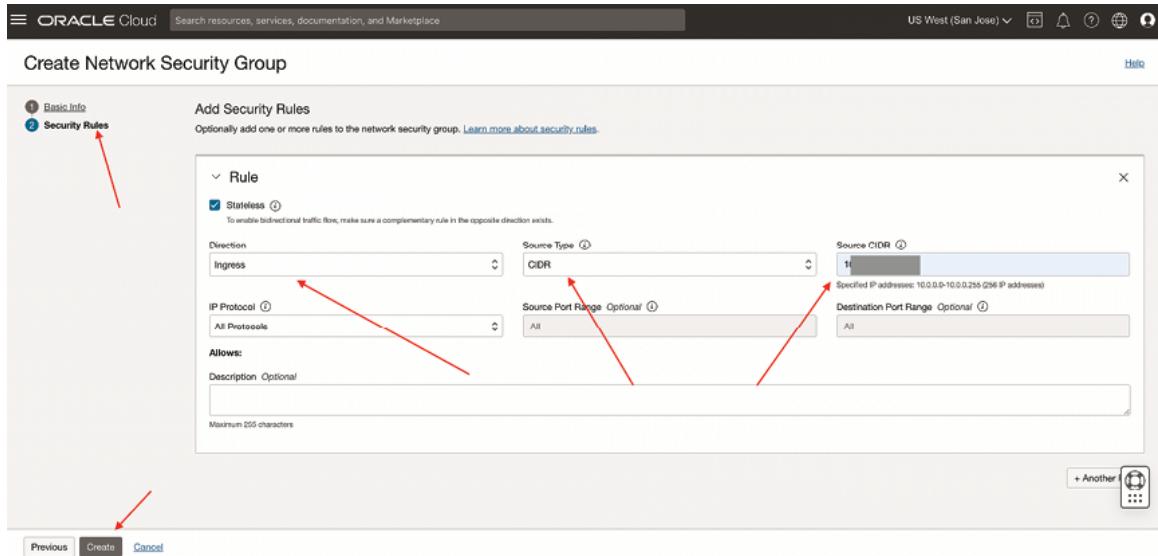


Figure 4.31: Adding security rules for Network Security Group

5. Network security group once created, looks as in the below figure. We can Add any number of rules by adding **Add rule**.

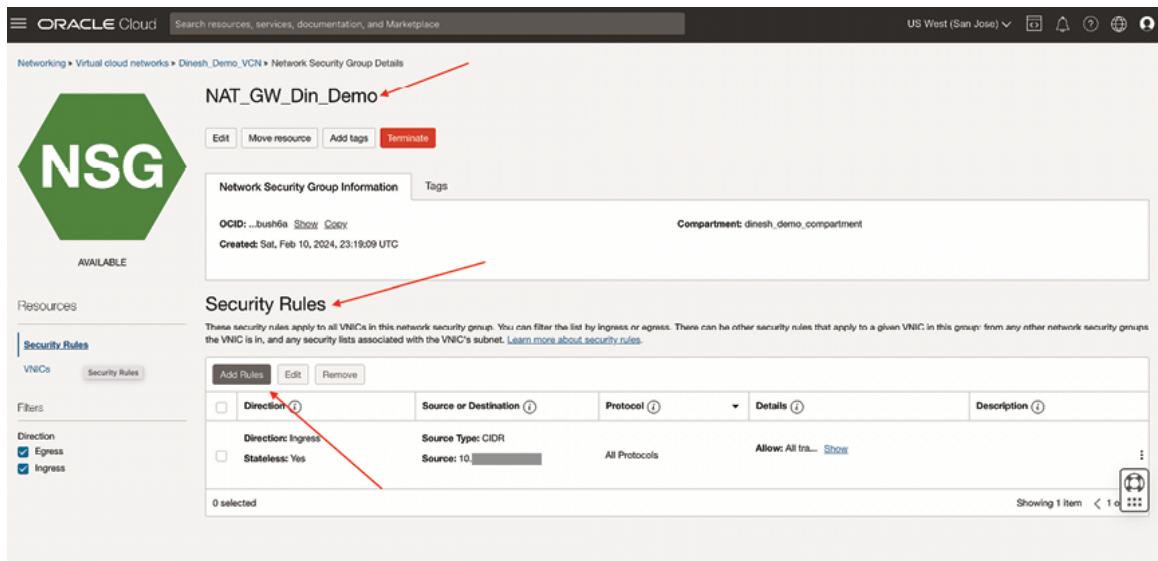


Figure 4.32: Details of Network Security Group

Note: A NAT gateway is incorporated to provide instances in a private subnet with internet access. With the NAT gateway, these instances can establish connections to the internet and receive responses, but they cannot accept any incoming connections initiated from the internet.

Internet gateway

In Oracle Cloud Infrastructure, an internet gateway facilitates internet access for a VCN (for example, a network). It enables both egress connections initiated from

within the VCN and ingress connections initiated from the internet. In the same way as we created the NAT gateway, we can create the internet gateway.

Please find the steps we need to follow in order to create an **Internet Gateway**:

1. Navigate to the console, select the VCN where you wish to establish the internet gateway. Then, click on **Internet Gateways**. We are referring to the same VCN. (**Dinesh_Demo_VCN**):

The screenshot shows the Oracle Cloud interface for a VCN named "Dinesh_Demo_VCN". The main content area displays "VCN Information" with details like compartment, creation date, and subnet information. Below this is a "Subnets" section showing two subnets: "Private_Subnet" and "Public_Subnet". The left sidebar lists resources including Subnets (2), CIDR Blocks/Prefixes (1), Route Tables (1), Internet Gateways (0), Dynamic Routing Gateways Attachments (0), Network Security Groups (1), Security Lists (1), and DHCP Options (1).

Figure 4.33: Steps to configure internet gateway

2. Provide a name, choose the compartment, and proceed by clicking **Create Internet Gateway**:

The screenshot shows the "Create Internet Gateway" dialog box. It requires a "Name" (e.g., "IG_Din_Demo") and a "Create In Compartment" (e.g., "dinesh_demo_compartment"). A note indicates that if a route table is associated, it must always have a route table associated with it. The "Route Table Association" section shows "Default Route Table for Dinesh_Demo_VCN". The "Create Internet Gateway" button is highlighted with a red arrow.

Figure 4.34: Name creation for Internet Gateway

3. Internet gateway looks like as below:

The screenshot shows the Oracle Cloud interface for managing Virtual Cloud Networks (VCNs). The main title is "Dinesh_Demo_VCN". On the left, there's a green hexagonal icon labeled "VCN" with "AVAILABLE" status. Below it is a sidebar with "Resources" sections: Subnets (2), CIDR Blocks/Prefixes (1), Route Tables (1), Internet Gateways (1) (which is highlighted in blue), Dynamic Routing Gateways (Attachments (0)), Network Security Groups (1), Security Lists (1), and DHCP Options (1). The main content area shows "Internet Gateways in dinesh_demo_compartment compartment". A table lists one item: "Name: ig_Din_Demo, State: Available, Route Table: Default Route Table for Dinesh_Demo_VCN, Created: Sat, Feb 10, 2024, 23:40:57 UTC". A red arrow points to the "Name" column of the table. At the top of the main content area, there are buttons for "Move resource", "Add tags", and "Delete". To the right, there are links for "OCID", "Show", "Copy", "DNS Resolver", "Default Router Table", "Default Route Table for Dinesh_Demo_VCN", and "DNS Domain Name: dineshdemovcn.oraclecloud.com".

Figure 4.35: Config details of Internet Gateway

Below are important points to be noted for **Internet Gateway**:

- To establish a connection to the internet, resources must reside in a public subnet and possess an IP address which is public.
- Each public subnet that needs to utilize the Internet gateway must have a **Route table rule** which specifies the Internet gateway as their target. Specify **Security rules** which we discussed in the above sections to manage the types of traffic allowed in and out of resources in that subnet
- Only one internet gateway can be attached to a VCN at any given time

Overview of DNS services and DNS management

In this section, we will provide an overview of the OCI DNS service. We will discuss private views, private zones, hybrid DNS, and conditional forwarding.

What is DNS and what is the purpose of DNS? The **Domain Name System (DNS)** converts human-readable domain names into machine-readable IP addresses. A DNS name server holds the DNS records for a zone and provides responses to queries made against its database. The DNS service assists in establishing and overseeing your DNS zones.

In OCI, DNS service offers public DNS, private DNS, secondary DNS, and reverse DNS:

- **Public DNS** enables the creation of zones with domain names that are publicly accessible and which are reachable on the Internet. This can be accomplished by registering with a DNS registrar (delegation).
- **Private DNS** delivers DNS resolution for custom DNS domains within your VCN. These domains may reside within OCI, span across VCNs, and extend between VCNs and on-premises or other private networks. Additionally, private DNS offers DNS resolution across networks, such as between VCNs within the same region, across regions, or external networks.
- **Private DNS zones** have records for private or custom domains and domains and can be reached from within a VCN using a private IP address. A private DNS zone resolves queries which come from clients that can reach it through a VCN.
- **The private DNS view** comprises private zones, with each zone exclusively associated with a single view, accessible through that view. A view enables sharing of private DNS data with a DNS resolver, which in turn processes DNS queries and provides responses. Multiple resolvers can utilize a single view.
- **The private DNS resolver** responds to DNS queries for a VCN according to the configuration you establish. When you create a VCN and opt for the **use DNS hostnames in this VCN** setting, it generates a dedicated private DNS resolver along with a default private view containing system-managed zones.
- **Secondary DNS** provides backup for primary DNS servers.
- **Reverse DNS** matches an IP address with a **hostname**.

Before explaining the concept of each of the DNS, let us define the below components in DNS:

- **Domain:** Domain names designate a particular location or a collection of locations on the Internet as a whole.
- **Zone:** A zone is an element within the DNS namespace. Usually, it is **Start of Authority (SOA)** record. A zone contains all labels (defined in the next section) below its position in the tree unless otherwise specified.

- **Label:** Labels are added before the zone name, with periods as separators, to create the name of a subdomain.
- **Child zone:** Child zones are autonomous subdomains containing their own start of authority and **name server (NS)** records.
- **Resource records:** A record within a zone encapsulates domain-specific details, with each record type containing information referred to as **record data (RDATA)**. For instance, the RDATA of an A or AAAA record comprises an IP address linked to a domain name, whereas MX records hold details pertaining to the mail server associated with a domain. OCI standardizes all resource RDATA into the most machine-readable format. It is important to note that the displayed presentation of your RDATA may vary from its initial input.
- **Delegation:** By delegating a domain with a registrar, the OCI hosted zone becomes accessible via the Internet.
- In Oracle Cloud Infrastructure, customers can utilize DNS management to establish private zones, ensuring their DNS resolution remains isolated within their dedicated **virtual cloud networks (VCNs)** or extends across various VCNs through peering arrangements. Through managing DNS within private zones, customers can guarantee that their DNS queries and responses are isolated, preventing them from traversing public networks. This approach significantly boosts both privacy and security measures. This concept is referred as *Customer Isolation*.
- OCI provides data encryption capabilities for DNS queries and responses transmitted over the network. Supported mechanisms include **DNS over HTTPS (DoH)** and **DNS over TLS (DoT)** to secure DNS traffic.
- OCI provides security controls such as **access control lists (ACLs)**, security lists, and **network security groups (NSGs)** that can be configured to control access to DNS resources and prevent unauthorized access. All the security controls are discussed in detail in earlier sections. OCI also provides a verifiably secure infrastructure with built-in security controls, compliance certifications, and transparent operational practices.
- OCI's DNS ensures high availability by employing redundancy across multiple **availability domains (ADs)** within a region. Additionally, it utilizes DNS Anycast to direct DNS queries to the nearest available DNS server.

- OCI enables secure hybrid cloud integration by providing customers the capability to connect their on-premises networks with OCI **Virtual Cloud Networks** (VCNs) through VPNs or dedicated connections.

The **Manage DNS Services** offers comprehensive insights into the configuration of DNS-related functionalities, particularly focusing on zones and traffic management steering policies. Within this section, you can access detailed information and options to establish and customize essential components such as zones and **Traffic management steering policies**. **Traffic management steering policies** assists you to guide the traffic to endpoints based on various conditions, which include the endpoint health and the geographic origins of DNS requests.

Let us demonstrate one example of how we can create a private zone in the console of Oracle Cloud:

Private DNS enables the management of private assets within OCI and facilitates DNS resolution between VCNs, as well as between VCNs and on-premise networks.

1. In the console, click **Networking** and select **DNS management**:

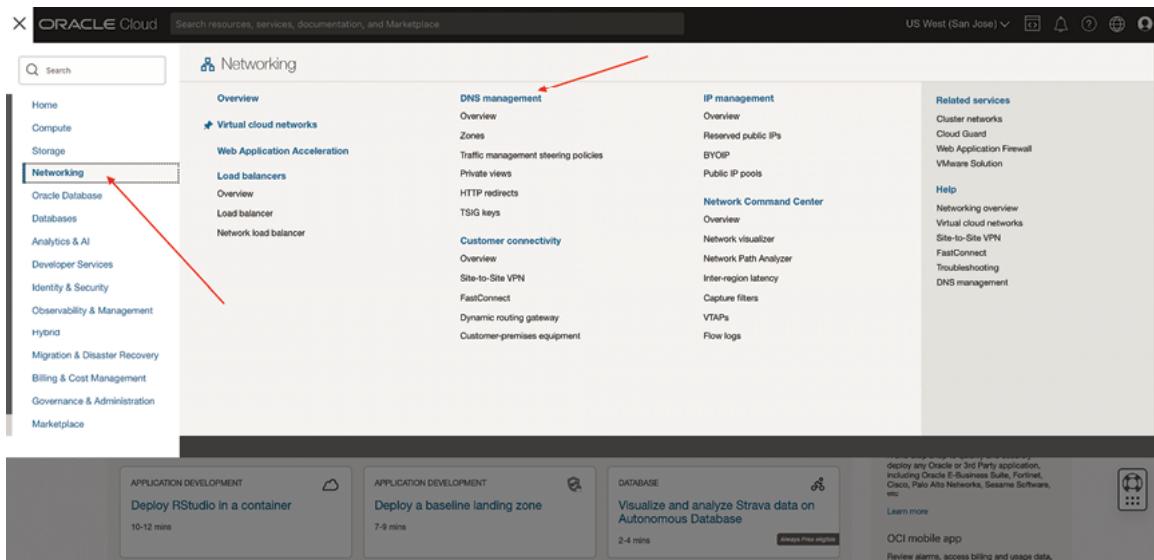


Figure 4.36: Creation of DNS management

2. As shown in figure, click **Zones**. Next, select the **Private zones** tab and proceed to click on **Create zone**:

The screenshot shows the Oracle Cloud DNS management interface. On the left, there's a sidebar with 'Networking > DNS management > Zones'. Under 'DNS management', 'Zones' is selected. In the main content area, the title is 'Zones in dinesh_demo_compartment Compartiment'. It says 'A DNS zone holds the trusted DNS records that will reside on Oracle Cloud Infrastructure's nameservers.' Below this, there are two tabs: 'Public zones' and 'Private zones'. The 'Private zones' tab is selected. A red arrow points from the 'Zones' link in the sidebar to the 'Private zones' tab. Another red arrow points from the 'Create zone' button in the sidebar to the 'Create zone' button in the main content area. The main content area shows a table of existing private zones:

Zone name	Zone type	Protected	Private view	Created
lbsubnet1.dineshdemovcn1.oraclevcn.com	Primary	Yes	Dinesh_Demo_VCN_1B	Sat, Feb 10, 2024, 18:00:02 UTC
0.10.in-addr.arpa	Primary	Yes	Dinesh_Demo_VCN	Sat, Feb 10, 2024, 17:56:51 UTC
privatesubnet.dineshdemovcn.oraclevcn.com	Primary	Yes	Dinesh_Demo_VCN	Sun, Feb 4, 2024, 20:33:59 UTC
publicsubnet.dineshdemovcn.oraclevcn.com	Primary	Yes	Dinesh_Demo_VCN	Sun, Feb 4, 2024, 20:13:32 UTC
0.10.in-addr.arpa	Primary	Yes	Dinesh_Demo_VCN	Sun, Feb 4, 2024, 19:38:09 UTC

Showing 5 items < 1 of 1 >

Figure 4.37: Adding zones for DNS

3. Click **Create zone** under **Private zones** tab and enter the details below:

- Zone name:** Example dineshdemo.com.
- Create in compartment:** Choose the suitable compartment. In this example: **dinesh_demo_compartment**.
- Zone type:** This field is set as read-only.
- DNS private view:** A private zone is initiated within a private view.
- Select existing private DNS view:** Select an existing private view from the drop-down menu.
- Create new private DNS view:** Enter a friendly name for the private view:

The screenshot shows the 'Create private zone' dialog box. At the top, it says 'Create private zone'. Below that, there's a note: 'You can only view or manage a zone when working in the region where it was created. This zone will not be visible when working from another region.' The 'Zone type' is set to 'Read-only'. The 'Zone name' field contains 'dineshdemo.com'. A red arrow points from this field to the 'Zone name' field in the dialog. The 'Creates in compartment' dropdown shows 'dinesh_demo_compartment'. A red arrow points from this dropdown to the 'Creates in compartment' dropdown in the dialog. The 'DNS private view' section has a note: 'A private zone must be attached to a private zone view in order for the resolver to direct traffic to the correct location. When a private zone is attached to a private zone view, the private zone cannot be moved to a new private zone view.' It has two options: 'Selecting existing DNS private view' (selected) and 'Create new DNS private view'. The 'DNS private view in dinesh_demo_compartment' dropdown shows 'Dinesh_Demo_VCN'. A red arrow points from this dropdown to the 'DNS private view' dropdown in the dialog. At the bottom, there are 'Create' and 'Cancel' buttons, with a red arrow pointing to the 'Create' button.

Figure 4.38: Creating private zone

4. As shown in the following figure, the record with domain created looks as below once created. The below figure shows private zone created:

The screenshot shows the Oracle Cloud DNS management interface for a VCN named 'Dinesh_Demo_VCN'. On the left, there's a green hexagonal icon labeled 'PV' with 'ACTIVE' underneath. Below it, under 'Resources', is a link to 'Private zones (4)'. A red arrow points from this link to the table on the right. The table has a header row with columns: Zone name, Zone type, Protected, and Created. There are four items listed:

Zone name	Zone type	Protected	Created
dinehdemo.com	Primary	No	Sun, Feb 11, 2024, 01:05:21 UTC
privatesubnet.dinehdemovcn.oraclecloud.com	Primary	Yes	Sun, Feb 4, 2024, 20:33:59 UTC
publicsubnet.dinehdemovcn.oraclecloud.com	Primary	Yes	Sun, Feb 4, 2024, 20:13:32 UTC
0.10.in-add-area	Primary	Yes	Sun, Feb 4, 2024, 19:38:09 UTC

A second red arrow points from the 'dinehdemo.com' entry in the table back to the 'Zone name' column of the same row.

Figure 4.39: Config details of Private zone

In conclusion, private DNS serves to oversee private assets within OCI and facilitates DNS resolution between VCNs, as well as between VCNs and on-premises networks.

Securing tenancy and services

In [Chapter 2, Mastering Identity and Access Management](#) and [Chapter 3, Navigating Network Security in OCI](#), we have covered the concepts of security services. These include regions, availability domains, compartments, identity and access management, MFA, security zones and various security policies including Cloud Guard. In this section, we will discuss the approach to implement securing tenancy.

In any cloud environment, cloud vendor (Oracle in this case) takes or owns the responsibility of underlying cloud infrastructure such as hardware and software systems, patching/upgrades of OCI Instances, data center facilities etc.). Similarly, customers are accountable for securing the workloads and configuring the security of services. Examples of these include compute, network storage and database). This process we usually term as Shared Responsibility Model.

We have discussed tenancy and steps to create tenancy in [Chapter 2, Mastering Identity and Access Management](#). To recap, In OCI, tenancy denotes the highest

level of organization and isolation, representing an organization's top-level account or subscription used to access and manage its OCI resources. Tenancy offers many benefits, such as isolation and security, granular access controls, a comprehensive view of resource utilization and costs, and resource management and organization, to name a few.

There will be many combination factors we have to take into consideration in order to implement the security of OCI tenancy. To start with we need to take a hierarchical perspective of security configuration where we need to start and focus on addressing foundational security issues followed by addressing the security of specific infrastructure resources in OCI.

Let us discuss at a very high level a road map and **best practices to secure tenancy**. Here are a few to take into consideration:

Establish and define a security framework (referred to as a security model) aligned with the workload needs of your tenancy. Here are the factors we need to consider: The appropriate count of compartments, The number of users possessing administrative privileges, administrative roles and associated permissions.

Security framework allows you to carefully design the compartment structure of your tenancy with proper planning. This will provide isolation of critical workloads and data and hence provide a solid foundation for enforcing least privilege access and separation of duties. The security framework helps achieve logical protection. In addition to creating a security framework, let us dive into a few other best practices, as highlighted below:

- **Implement least privilege access:** This can be achieved by creating and enforcing a process for authenticating and authorizing users to access tenancy resources by providing access in a least-privilege way, such as provisioning users, groups, compartments and policies in the IAM service. This concept is referred to as least privilege access. This is discussed in detail in [Chapter 2, Mastering Identity and Access Management](#).
- **Fault Tolerance:** In OCI Fault Tolerance Infrastructure includes a detailed suite of features and capabilities aimed at ensuring services and applications hosted on OCI maintain high availability and resilience against failures. Fault tolerance can be implemented by securing connectivity and implementing least privilege access.
- **Provisioning security zones:** Custom security zones coupled and integrated with **Cloud Guard** strengthen the security stance or security posture of a customer's OCI tenancy. Custom security zones are free of cost, flexible, simple, and, at the same time, extremely powerful, which ensures the

elimination of any misconfigurations or human errors. These are not only simple and easy to set up but can also be applied to a root or parent compartment, which is the same set of policies for child compartments. Security zones automatically enforce security standards and are considered the best practices for resources in selected compartments. This prevents users from creating or updating a resource in a security zone if the action violates a security zone policy. A security zone is an association of a security zone recipe to a compartment, and a security zone recipe is composed of security policies.

Implement **Vault** to deploy master encryption keys and corresponding secret credentials. A vault includes the encryption keys and the respective secret credentials that we use to protect the data and connect to secured resources. OCI Vault offers a comprehensive lifecycle management service for keys and secrets backed by **hardware security modules (HSM)** for those who prefer to handle their own encryption keys.

Regularly examine and inspect the **audit logs** to verify that user activities align with your initial security setup. This can be achieved by using the Cloud Guard.

- **Network protection:** There is no network access to your tenancy by default. You must implement services to allow for ingress or egress and specify the direction, ports and protocols which are to be allowed. Provisioning and securing the cloud networks by configuring or utilizing the security lists, NSGs, or a combination of both to manage packet-level traffic in and out of the resources in your VCN. This is discussed in detail in the section *Securing Networks with VCN and Subnets*. By separating systems containing sensitive information, including databases, into their own VCNs, you can granularly control access between and within a VCN, achieving the first layer of segmentation.
- **Platform security:** Platform security within OCI constitutes a set of extensive measures and practices aimed at safeguarding the cloud platform and its services against potential threats and vulnerabilities. This includes protecting all elements of OCI's infrastructure, hardware, software, physical network Isolated network virtualization and networking components.

The above are the best practices which can be considered to secure the tenancy.

The configuration of **network firewall service** will provide traffic filtering and monitoring between your tenancy networks and the Internet, your own internal

network and between and within VCNs and subnets. Network firewall service further strengthens the segmentation of your network and reduces the ability for an attacker to access and move laterally through your overall cloud network environment.

Establishing a robust defense against unauthorized access is very critical for safeguarding your tenancy, and this involves stringent access controls both in the management of cloud resources and within the network layer. This proactive approach serves as a fundamental component of an effective ransomware mitigation strategy. Strengthening this protective foundation, infrastructure and application protection capabilities are integrated to fortify your tenancy against potential compromises. In summary, protecting against unauthorized access, implementing access controls, and utilizing OCI's security services create a resilient foundation for ransomware mitigation. The inherent security features can significantly reduce the risk of compromise, but a proactive and adaptive security approach remains imperative in the dynamic landscape of evolving cyber threats.

Best recommendations and considerations

In this section, we will discuss some of the best practices and guide you with recommendations, advice or suggestions to help you design, architect, and build network infrastructure in OCI:

- Ensure that you allocate sufficient time and resources at the outset of your project plan to execute a thorough OCI network design. Make sure your OCI network design incorporates the layout and topology, has proper sizing of the VCNs and subnets, has Domain Name Service and any external network connectivity to on-premises. In summary, it is always advisable and recommended as a best practice to perform your proper OCI network design at an early stage. Properly sizing the VCNs and subnets appropriately during your design will not only assist you in accommodating the needs for future growth and expansion, but it will also streamline your IP allocation by utilizing connected and condensable IP addressing space.
- Incorporate DNS into your initial network design and engage with your DNS administrators from the outset.
- For the majority of OCI deployments, Oracle recommends adhering to best practices by implementing a **multi—VCN design** within a **hub-and-spoke topology**, utilizing the DRG for connectivity. This has benefits such as Isolation and Segmentation of different environments.

- Using the default options such as OCI provided default route table and a security list when provisioning subnets is ideal for a basic deployment or to get you started but definitely not an advisable approach for designing production codes that include various subnets. Maintaining dedicated VCN route tables and security lists for each subnet enables precise control over routing and security settings for individual subnets, avoiding the need for shared resources.
- Prior to the creation of VCN, assess the necessary number and size of CIDR blocks based on the anticipated deployment of resources and subnets within the VCN.
- Consistently applying patches is essential to address vulnerabilities and safeguard your infrastructure and applications from known threats.
- While planning your subnets, take into account or consider your traffic patterns and security needs. As discussed, always assign all resources belonging to allocate a particular tier or role to the same subnet.
- After creating each subnet, enable **VCN flow logs** and consider establishing a distinct log group specifically for VCN flow logs. Ensure that VCN flow logs are integrated as an important component within the broader architecture and design of your **Oracle Cloud Infrastructure (OCI)** logging strategy.
- Oracle recommends using NSG and gives precedence to it over **security lists** for implementing any kind of enhancements needed in the future and also suggests adopting NSGs for components that all have an identical security posture.
- This can be achieved by creating NSG for specific groups of resources that share similar and identical traffic flow requirements, such as NSG for each tier of an application.
- Adopt a whitelist strategy for both security list and NSG rules, permitting only the necessary protocols, sources and ports required by application or workload. Implement ingress and Egress rules. Ingress rules specify the allowed inbound traffic to a network resource. Egress rules specify the allowed outbound traffic from a network resource. It is recommended to use OCI Bastion Service rather than configuring the bastion host in a public subnet.

- Implement DDoS protection. OCI DDoS protection services enable companies to establish a highly available and scalable architecture using a defense-in-depth security model. This approach leverages OCI's cloud-native components, including **Web Application Firewalls (WAF)**, **Network Load Balancers (NLB)**, **Flexible Load Balancers (FLB)**, third-party **Next Generation Firewalls (NGFWs)** with DDoS protection, and TLS/SSL certificates, along with their respective benefits and design considerations.
- Establish policies to restrict access to specific individual network resources by enforcing IAM policies. Detailed IAM policies are discussed in [*Chapter 2, Mastering Identity and Access Management*](#).
- Implement the **Hub-and-Spoke VCN Design**, placing the firewall(s) within a hub VCN and leveraging the DRG to direct traffic through the firewalls. A hub-and-spoke network, usually referred to as a star network has a centralized component that is connected to multiple different networks around it. Setting up this kind of topology in the traditional on-premises data center is very expensive but can be easily implemented in the cloud with minimal or no extra expenses. The **DRG**, on the other hand, is a virtual router which provides a route for private network traffic between a VCN and a network outside the region, including a VCN in another Oracle Cloud Infrastructure region, an on-premises network, or a network from another cloud provider.
- Secure the load balancers by enabling end-to-end TLS connections between a client's applications and a customer's VCN by using load balancers. Define IAM policies to restrict load balancer management permissions to a minimal subset of users and groups.
- Leverage the Maximum Security Zones service, which helps you minimize the risk of inappropriately low-security policies and secure DNS zones and records by defining the IAM policies to restrict the users authorized to make changes to DNS zones and records.
- **High availability** enhances the availability of applications on Oracle Cloud Infrastructure by incorporating redundant compute nodes across various availability domains. This ensures failover capability and optimally utilizes fault domains. This is one of the best recommendations to achieve system resilience and hence High Availability. It is also recommended to have all **virtual machine (VM)** instances in the indicated compartment to be

clustered in a single fault domain. This will improve the availability of your VMs across all fault domains. This approach is also referred to as *Fault Tolerance*.

- Enabling **object versioning** is one of the recommendations, as it provides protection of data against accidental or malicious object updating, overwriting, or deletion. This needs to be enabled at the bucket level.
- Similar to object versioning, it is advisable to enable object replication. This will provide protection from regional outages help in disaster recovery efforts and addresses compliance requirements. In this mechanism of object versioning, we usually maintain multiple copies of data in regional locations closer to user access. This will also reduce latency.

Conclusion

In conclusion, this chapter has provided a comprehensive and detailed exploration of advanced network infrastructure within Oracle Cloud Infrastructure. We begin on a journey from foundational principles to sophisticated strategies, aiming to empower readers with a deep understanding of the intricacies involved in securing their network environments.

We discussed advanced securing network and services methodologies, various access control mechanisms, and cutting-edge network design principles. The knowledge gained throughout this chapter is instrumental in elevating the security posture of your OCI network infrastructure to a more advanced and resilient state. As technology evolves, so do the threats to network security. By understanding the advanced concepts covered in this chapter, readers are well-equipped to implement robust defenses against emerging threats, ensuring the continued integrity and availability of their network resources in the dynamic landscape of OCI.

Moving forward, it is crucial to stay ahead of updates in network security practices and leverage OCI's evolving features. Regularly revisit and reassess your network security strategy to adapt to the ever-changing cybersecurity landscape. This chapter explained in detail the concepts of Infrastructure security. In next chapters we deep dive into database security and application security concepts.

Multiple choice questions

1. You are in the process of setting up a High Availability Realtor registration website on OCI. You use an LB and add a DB service on

OCI. You launch two compute instances, each in a different subnet and add them to the backend set of a public load balancer. The LB is configured correctly and working. You then deploy the Realtor registration app on these two compute instances. The app can interact with the layer in the DB service. However, when you enter the URL of this realtor, no web page is loading. What could be the cause?

- a. DRG
 - b. The security lists of the subnets not having allow rules for port 80 and 443
 - c. Public subnet
 - d. Private subnet
- 2. You have an Oracle Cloud Infrastructure load balancer distributing traffic via an evenly-weighted round robin policy to your back-end web servers. You notice that one of your web servers is receiving more traffic than other web servers. How can you resolve this to make sure traffic is evenly distributed?**
- a. Disable cookie-based session persistence on your backend set
 - b. Disable keep-alive setting between the load balancers
 - c. Enable SSL configuration
 - d. Set up separate listeners
- 3. Name the 2 components that cannot be deleted in your Oracle Cloud Infrastructure VCN?**
- a. Default route table
 - b. Routing gateway
 - c. Default security list
 - d. Service gateway
 - e. Default subnet

Answers

1. b

2. a

3. a and c

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CHAPTER 5

Database Fortification in Oracle Cloud Infrastructure

Introduction

In the rapidly evolving landscape of cloud computing, securing sensitive data has become paramount for organizations worldwide. As businesses increasingly migrate their operations to the cloud, the need to fortify databases hosted in platforms like OCI has never been more critical. This chapter discusses the intricacies of database fortification within OCI, unraveling the fundamental principles and advanced techniques essential for safeguarding valuable data assets.

With cyber threats on the rise and regulations becoming more stringent, the importance of database security cannot be overstated. This chapter serves as a comprehensive guide for IT professionals, security experts, and database administrators seeking to bolster the protection of their databases in OCI. At the heart of any robust database security strategy lies cryptography. Understanding cryptographic principles is key to implementing effective data protection mechanisms. From symmetric and asymmetric algorithms to digital signatures and message security, this chapter elucidates the core concepts of cryptography and its role in safeguarding data integrity and confidentiality.

In the realm of cloud computing, data is constantly in motion, traversing networks and residing in various storage mediums. Securing data both in transit and at rest is imperative to mitigate the risks of unauthorized access and data breaches. This chapter explores encryption techniques tailored for OCI, encompassing encryption of block volumes, block storage, file storage, and more.

Key management services (KMS) play a pivotal role in managing cryptographic keys and secrets. Within OCI, KMS offers a suite of services designed to simplify key management tasks while ensuring robust security controls. Readers will gain insights into configuring OCI KMS, understanding its capabilities, and leveraging OCI HSM for enhanced key security.

OCI HSM, or hardware security module, provides an added layer of security by safeguarding cryptographic keys in tamper-resistant hardware. This chapter elucidates the significance of OCI HSM and provides practical guidance on getting started with OCI HSM keys, managing encryption methods, and implementing **Transparent Data Encryption (TDE)**.

Furthermore, this chapter explores database security tools available within OCI, including the Oracle Database Security Assessment tool and Oracle **Audit Vault and Database Firewall (AVDF)**. These tools offer comprehensive solutions for assessing security posture, monitoring database activity, and detecting anomalous behavior.

This chapter equips readers with the knowledge and tools necessary to fortify their databases in OCI. By understanding the fundamentals of cryptography, harnessing the capabilities of KMS, and leveraging advanced encryption techniques, organizations can bolster their data security posture and navigate the complexities of cloud security with confidence.

Structure

The chapter covers the following topics:

- Overview of database security
- Technical requirements
- Fundamental concepts of securing data
- Key management services vault
- OCI hardware security module
- Overview of encryption methods
- Backing up and restoring vaults and keys
- DB security tools

Objectives

The objective of the chapter outlines important aspects of securing data within OCI. It predominantly focuses on core principles best practices and recommendations for achieving effective database security, addressing the unique challenges of safeguarding data in a cloud environment through various layers of security controls.

The role of cryptography is discussed in depth, underscoring its importance in ensuring data confidentiality, integrity, and authenticity, with a focus on symmetric and asymmetric encryption techniques for data protection. OCI KMS are explained, detailing features such as key generation, rotation, and access control policies that enhance encryption key security. The chapter also focuses on encryption techniques for data at rest and in transit, including the use of SSL/TLS protocols and network traffic encryption. Additionally, it explores the significance of OCI **hardware security module (HSM)** in securing cryptographic operations and protecting encryption keys from unauthorized access, thereby strengthening the overall security posture of databases within OCI.

Overview of database security

In the rapidly evolving landscape of cloud computing, OCI stands out as a robust platform for managing enterprise databases. Fortifying databases in OCI involves a multi-faceted approach that ensures security, availability, performance, and compliance. At the heart of this fortification process is the architecture and design phase, where critical decisions about database types and configurations are made. OCI offers a range of database services, including Oracle Autonomous Database, Oracle Database on bare metal, virtual machines, and Exadata, each tailored to meet specific business needs. Designing for high availability is paramount, as well as leveraging Oracle Data Guard, Autonomous Data Guard, or **Real Application Clusters (RAC)** to ensure continuous operation and resilience against failures. Scalability is equally important, with Autonomous Database scaling and RAC providing seamless capacity adjustments to handle varying workloads.

Network configuration plays a crucial role in fortifying OCI databases. **Virtual Cloud Networks (VCNs)** are meticulously configured with subnets, security lists, and **Network Security Groups (NSGs)** to segment and protect resources. Subnet segmentation ensures that databases are isolated in private subnets, shielded from direct internet exposure, while load balancing solutions distribute traffic efficiently, enhancing the reliability of web applications interfacing with the database.

Security, a cornerstone of database fortification, is addressed through comprehensive **identity and access management (IAM)**. IAM policies are

defined to enforce least privilege access, ensuring that users and applications have only the permissions they need. **Multi-factor authentication (MFA)** is mandated for critical operations, adding an extra layer of security. Data protection mechanisms are robust, with TDE safeguarding data at rest and Oracle Data Safe ensuring data in transit is secure. Oracle Database Vault adds another layer of security by enforcing strict access controls within the database, while data masking capabilities in Oracle Data Safe protect sensitive information in non-production environments.

Network security is bolstered through the configuration of firewalls and security lists that restrict access based on predefined rules. NSGs provide granular control over instance-level traffic, and the use of private endpoints ensures that access to OCI services is secure and restricted to authorized entities.

Monitoring and management are integral to maintaining a fortified database environment. OCI Monitoring tracks performance metrics, offering insights into the health and performance of database instances. Oracle Management Cloud provides deeper analytics, enabling predictive maintenance and performance tuning. Audit logs, enabled through Oracle Cloud Infrastructure Audit, are regularly reviewed to ensure compliance with regulatory standards such as GDPR and HIPAA. Oracle Data Safe and Compliance Reporting tools help maintain adherence to these standards, providing peace of mind that the database environment is secure and compliant.

Backup and recovery strategies are meticulously planned. Automated backups ensure that data is regularly saved and can be quickly restored in case of failure. **Oracle Recovery Manager (RMAN)** offers custom backup solutions, and cross-region backups ensure disaster recovery capabilities by storing data in multiple geographic locations.

Performance optimization is an ongoing effort, with database tuning focusing on query optimization and index management. Partitioning strategies are employed to enhance both performance and manageability, ensuring that the database remains responsive and efficient. Resource management is tailored to workload requirements, with appropriate instance shapes selected to balance cost and performance. Autoscaling capabilities of Autonomous Databases automatically adjust resources to meet workload demands, ensuring consistent performance.

Maintenance and operations are streamlined through regular patching and updates. Security patches are applied promptly to protect against vulnerabilities, and maintenance windows are scheduled to minimize impact on operations. Incident response plans are established, detailing steps to be taken in the event of a security

breach or system failure. Alerting systems are configured to notify administrators of critical events, enabling swift action to mitigate issues.

Documentation and training are vital components of the fortification strategy. Detailed architecture diagrams are maintained, providing a clear overview of the database environment. Runbooks outlining standard operating procedures are created for routine tasks and incident management. Regular training programs ensure that database administrators and users are well-versed in best practices and emerging threats. Security awareness programs educate all stakeholders about their role in maintaining a secure environment, fostering a culture of vigilance and responsibility.

In practice, this comprehensive approach to database fortification in OCI translates into a series of well-defined steps. Initially, the OCI environment is set up, with VCNs and subnets configured according to best practices. Security lists and NSGs are defined to control traffic and protect resources. The database is then deployed, with a focus on high availability and scalability. Security measures are implemented, including encryption, IAM policies, and private endpoints.

Monitoring systems are activated to track performance and compliance, and backup strategies are put in place. Performance is continuously optimized through regular tuning and resource management. Maintenance schedules are established, and incident response plans are ready to be executed if needed. Finally, documentation and training ensure that the entire process is well-documented and that personnel are prepared to maintain and protect the database environment. It is recommended to follow best practices such as enforcing the principle of least privilege, performing regular audits, and adopting cost awareness. The following are the best practices in detail:

- **Principle of least privilege:** Strictly limit access rights to only what is necessary for each role or user.
- **Regular audits:** Conduct frequent reviews of access policies and logs to maintain security.
- **Cost awareness:** Be mindful of the cost implications associated with using KMS and plan accordingly.

Technical requirements

In order to actively participate and understand the contents of the chapter *Database Fortification in OCI*, readers should be equipped with an understanding of computer systems, concepts in networking, and basic knowledge in information technology.

In addition to the above technical requirements, readers are advised to understand the below specification for technical needs:

- **Internet access:** To utilize online resources, references, and examples related to cloud computing, readers need a stable internet connection.
- **Computing device:** Additionally, computing devices such as a desktop computer and laptop equipped with a modern web browser are essential for reading the chapter content and accessing any online materials.
- **Web browser:** It is recommended to have the latest version of web browsers which ensures compatibility and optimal and best viewing experience of web-based resources and interactive content. Here are a few web browsers recommended: *Google Chrome, Mozilla Firefox, Microsoft Edge, or Safari*.
- **Familiarity with basic security and cloud services:** Having knowledge of any cloud services and their basic functionalities will enhance the understanding of the chapter.

Fundamental concepts of securing data

The following are the fundamental concepts of securing data:

- **Fundamentals of cryptography:** Cryptography forms the backbone of data security, providing techniques to protect data from unauthorized access and manipulation. It involves the use of mathematical algorithms to encrypt and decrypt data, ensuring confidentiality, integrity, and authenticity. Understanding the fundamentals of cryptography is essential for implementing robust security measures in OCI.
- **Symmetric and asymmetric algorithms:** Symmetric algorithms use a single key for both encryption and decryption, making them efficient for encrypting large volumes of data. Examples include **Advanced Encryption Standard (AES)** and **Data Encryption Standard (DES)**. Asymmetric algorithms, on the other hand, use a pair of public and private keys for encryption and decryption, offering stronger security but requiring more computational resources. Examples include RSA and **Elliptic Curve Cryptography (ECC)**.
- **Digital signature and message security:** Digital signatures are cryptographic mechanisms used to verify the authenticity and integrity of digital messages or documents. They provide assurance that the sender of a

message is who they claim to be and that the message has not been tampered with during transmission. Message security involves encrypting messages to protect their confidentiality and integrity while in transit.

- **Security of data in motion and at rest:** Protecting data both in motion (during transmission) and at rest (stored in databases or storage systems) is crucial for maintaining data security in OCI.
- **Protect data at rest:** OCI provides various storage options, including block, object, and file storage. *Data at rest* is termed as data that is currently stored, usually on a computer's or server's hard drive. For these services, data is encrypted both at rest and in transit. Implement the following mechanisms discussed in below sections *Data at rest* refers to data that is currently stored, usually on a computer's or server's hard drive. to apply further best practices and ensure your data's security in the cloud.
- **Restrict permissions for deleting storage resources:** Implement strict access controls and permissions to prevent unauthorized deletion of storage resources, ensuring data integrity and availability.
- **Ensure secure access to file storage:** Utilize secure access controls, such as IAM policies, to restrict access to file storage systems, mitigating the risk of unauthorized data access.
- **Ensure secure access to object storage:** Implement encryption and access controls to secure object storage buckets, preventing unauthorized access to stored data.
- **Encrypt data in block volumes:** Utilize encryption mechanisms provided by OCI to encrypt data stored in block volumes, protecting sensitive data from unauthorized access in storage.
- **Encrypt data in block storage:** Implement encryption for block storage volumes to ensure data confidentiality and integrity, mitigating the risk of data breaches or unauthorized access.
- **Encrypt data in file storage:** Utilize encryption mechanisms to encrypt data stored in file storage systems, ensuring confidentiality and integrity of stored files.
- **Maintain application secrets in Oracle cloud infrastructure vault:** Store sensitive application secrets, such as API keys and passwords, securely in OCI Vault, leveraging its encryption and access control features to protect against unauthorized access.

Understanding and implementing these fundamental concepts of securing data in OCI is essential for safeguarding sensitive information and maintaining compliance with regulatory requirements. By leveraging cryptography, access controls, and encryption mechanisms provided by OCI, organizations can enhance the security posture of their databases and storage systems in the cloud.

Key management services vault

Key management is a critical aspect of data security, particularly in cloud environments where sensitive information is stored and transmitted across distributed systems. OCI offers robust KMS through OCI Vault, providing organizations with centralized control over cryptographic keys and secrets.

OCI Vault serves as a secure and centralized repository for managing encryption keys, digital certificates, and other sensitive credentials. It offers a range of features and capabilities designed to simplify key management tasks and enhance the security of data encryption in OCI.

Key features of OCI Vault

The following are the key features of OCI Vault:

- **Centralized key management:** OCI Vault provides a centralized location for storing and managing cryptographic keys used for encrypting data across OCI services. This centralized approach streamlines key management tasks and ensures consistent security controls across the organization's cloud infrastructure. Additionally, KMS facilitates key rotation to periodically update encryption keys, ensuring continued data protection and compliance with security best practices.
- **Secure key storage:** OCI Vault leverages hardware-backed security modules to securely store cryptographic keys, protecting them against unauthorized access and tampering. By utilizing **hardware security modules (HSMs)**, OCI Vault ensures the integrity and confidentiality of stored keys, mitigating the risk of key exposure or compromise.
- **Encryption key lifecycle management:** OCI Vault offers comprehensive key lifecycle management capabilities, including key generation, rotation, and deletion. Organizations can generate encryption keys with specific cryptographic algorithms and key lengths, ensuring compliance with security best practices and regulatory requirements.

- **Access control policies:** OCI Vault enables organizations to define granular access control policies to regulate access to encryption keys and secrets. Administrators can configure IAM policies to specify which users or services have permission to manage and use encryption keys stored in OCI Vault.
- **Integration with OCI services:** OCI Vault seamlessly integrates with other OCI services, allowing organizations to securely encrypt data across various cloud resources. Encryption keys stored in OCI Vault can be used to encrypt data stored in block volumes, object storage buckets, and other OCI resources, ensuring end-to-end data protection.
- **Auditing and monitoring:** OCI KMS provides comprehensive audit trails and logging capabilities, allowing organizations to track key usage, access attempts, and administrative actions. OCI Vault provides comprehensive auditing and monitoring capabilities, allowing organizations to track key management activities and monitor access to encryption keys in real-time. Audit logs capture detailed information about key operations, providing visibility into key usage and compliance with security policies.
- **High availability and durability:** The KMS Vault is designed for high availability and durability, ensuring uninterrupted access to encryption keys and secrets even in the event of hardware failures or data center outages. Encryption keys stored in the vault are replicated across multiple data centers and regions, providing resilience against infrastructure failures and ensuring data availability and accessibility.

The following are the steps to configure KMS in OCI:

1. **Access OCI Console:** Log in to the OCI Console with your credentials.



Figure 5.1: Screenshot OCI Login Console

2. **Navigate to KMS:** From the OCI Console dashboard, navigate to the **Security** section and select **Key Management** under **Identity & Security**.

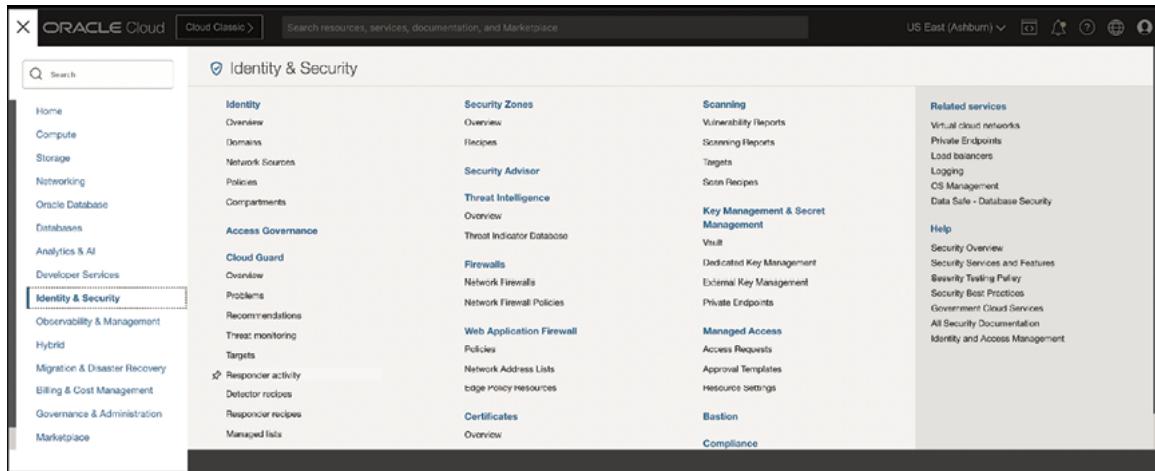


Figure 5.2: Screenshot of OCI Identity and Security Service

3. Create a Vault: Click on the **Vaults** tab and then click on the **Create Vault** button. Provide a name for the vault in the vault section of key management and secret management as shown in *Figure 5.3*, select the compartment where you want to create the vault and configure additional settings such as the replication region and retention period.

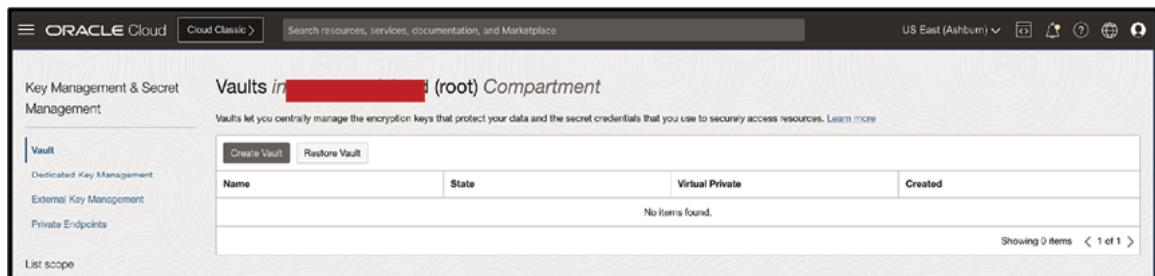


Figure 5.3: Screenshot of KMS Vault

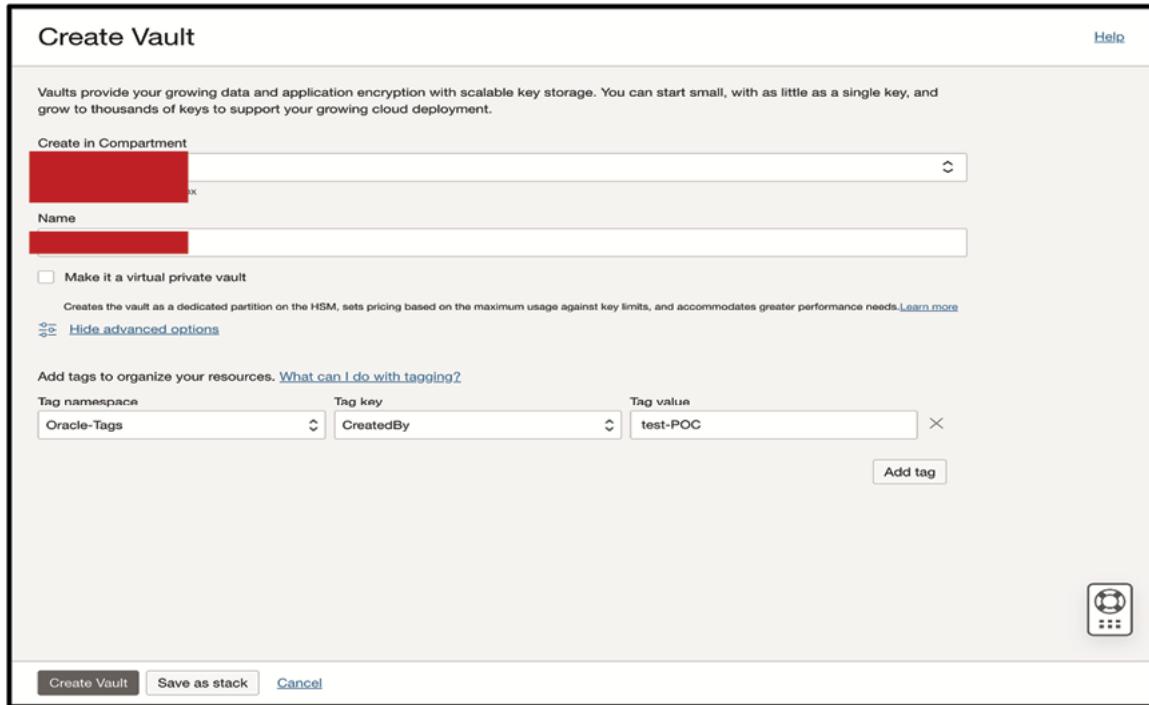


Figure 5.4: Screenshot of KMS create vault console

4. **Define vault access policies:** After creating the vault, define access policies to specify who can access and manage the vault and its contents. Access policies can be configured using OCI's IAM service. Assign appropriate permissions to users, groups, or compartments based on the principle of least privilege. OCI policies can be referred in the section **Identity & Security**, as shown in *Figure 5.5*:



Figure 5.5: Screenshot OCI policies

5. Generate encryption keys: Once the vault is created, generate encryption keys to secure your data and resources. Navigate to the **Keys** tab within the vault and click on the **Create Key** button. Specify the key name, choose the key shape (symmetric or asymmetric), and configure additional settings such as key length and algorithm. *Figure 5.6* represents the general information such as compartment, **Cryptographic Endpoint**, and **Management Endpoint**:

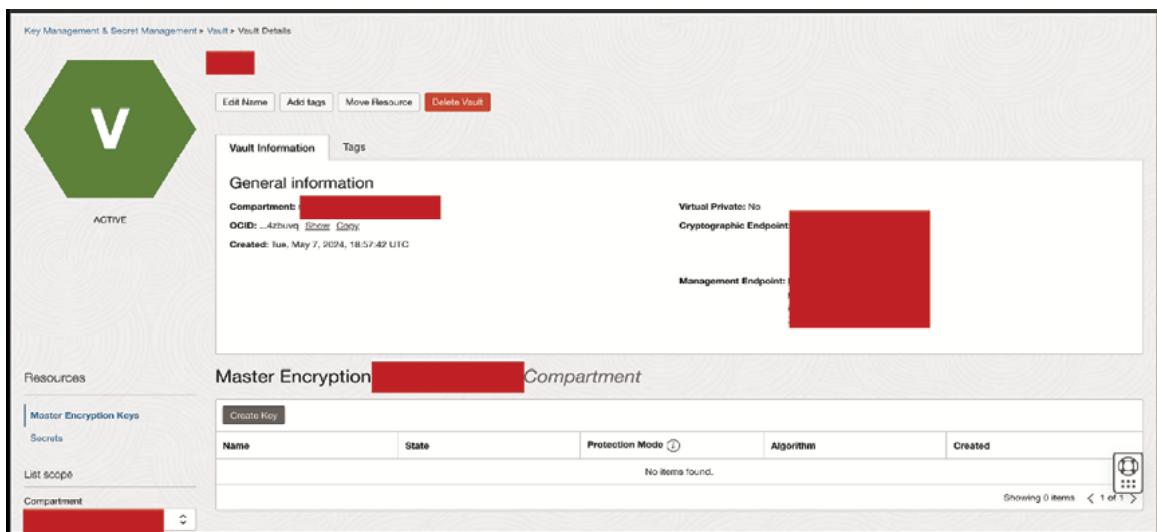


Figure 5.6: Screenshot OCI Key Management Vault

Enter the details such as compartment name, protection mode, and key shape, as shown in *Figure 5.7*:

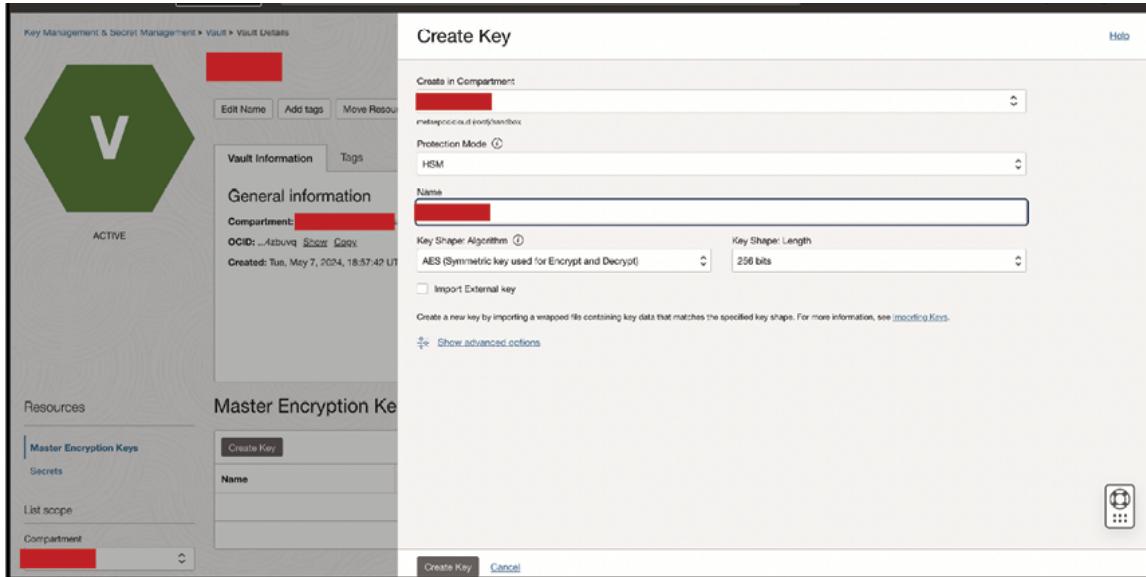


Figure 5.7: Screenshot OCI Key Management Keys Creation

6. Define key management policies: Define key management policies to control the usage and lifecycle of encryption keys. Configure key rotation settings to automatically rotate keys at predefined intervals for enhanced security. Define key activation and deactivation policies to manage key usage and access.

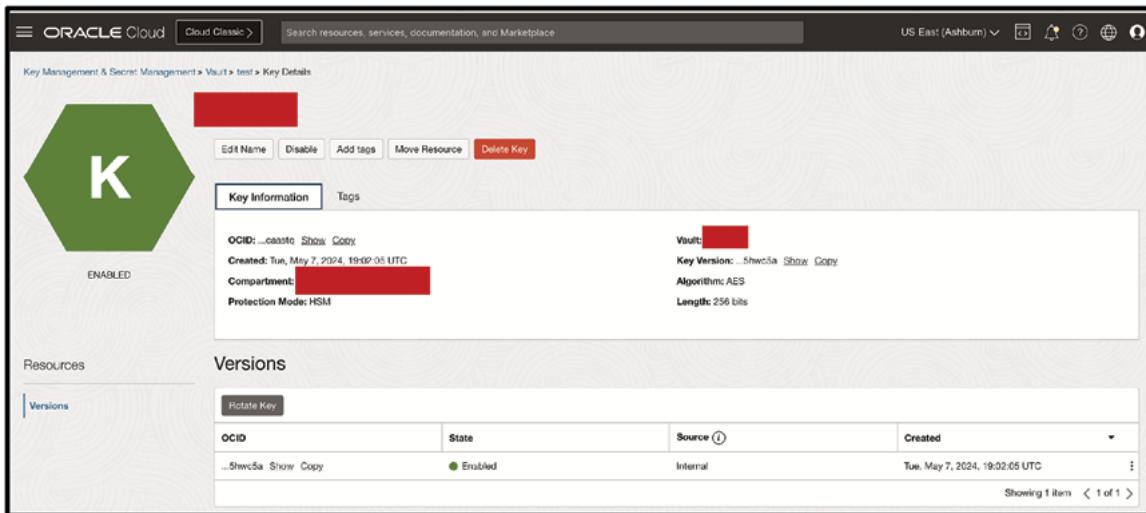


Figure 5.8: Screenshot OCI KMS Key Details

7. Configure key access controls: Configure access controls to regulate who can access and use the encryption keys stored in the vault. Define IAM

policies to grant or restrict access to keys based on user roles, groups, or specific permissions. Implement fine-grained access controls to enforce the least privilege and maintain data security.

8. **Integrate with OCI services:** Integrate the KMS vault with other OCI services and resources to secure data and resources across your cloud infrastructure. Configure encryption key references in OCI services such as databases, storage systems, and applications to use the keys stored in the vault for data encryption and decryption.
9. **Monitor key usage and activity:** Monitor key usage and activity using OCI's logging and monitoring capabilities. Review audit logs and activity reports to track key operations, access attempts, and administrative actions. Monitor key usage patterns and detect any anomalies or unauthorized access attempts.
10. **Review and update security policies:** Regularly review and update security policies and configurations to ensure compliance with security best practices and regulatory requirements. Periodically audit access controls, key management policies, and encryption settings to identify and address any security gaps or vulnerabilities.

The following are the capabilities and features supported by OCI KMS services:

- **Vault:**
 - **Access controls:** Vault access controls allow organizations to define fine-grained policies to regulate who can access and manage keys stored in the vault, enforcing the principle of least privilege.
 - **Key rotation:** OCI KMS supports key rotation to automatically update encryption keys at regular intervals, enhancing security and compliance with industry standards and best practices.
 - **Audit trails:** Comprehensive audit trails and logging capabilities enable organizations to monitor key usage, access attempts, and administrative actions, facilitating compliance auditing and security incident investigation. In addition-KMS provides a secure and centralized vault for storing encryption keys and secrets, ensuring data protection and regulatory compliance. These details are discussed in detail in the section *Key features of OCI Vault*.
- **OCI dedicated KMS:**

- **Dedicated key management:** OCI Dedicated KMS offers dedicated hardware and infrastructure for key management, providing enhanced security and performance for sensitive workloads and high-security environments.
 - **Isolation and compliance:** Dedicated KMS instances provide isolation from other tenants, ensuring data confidentiality and compliance with regulatory requirements such as GDPR, HIPAA, and PCI-DSS.
 - **Customization:** OCI Dedicated KMS allows organizations to customize key management policies and configurations to meet specific security and compliance requirements, providing flexibility and control over key management operations.
- **OCI External KMS:**
 - **Integration with External KMS:** OCI External KMS enables organizations to integrate with external KMS to manage encryption keys stored outside of OCI, such as on-premises or in third-party cloud environments.
 - **Key import and export:** External KMS allows organizations to import existing encryption keys into OCI for use with OCI services and resources, as well as export keys from OCI for use in external systems and applications.
 - **Hybrid cloud security:** OCI External KMS facilitates secure key management in hybrid cloud environments, enabling seamless integration and interoperability between OCI and external cloud platforms or on-premises infrastructure.
 - **Choosing the right OCI KMS envelope encryption:**
 - **Envelope encryption:** OCI KMS supports envelope encryption, a technique used to protect data by encrypting it with a **data encryption key (DEK)**, which is, in turn, encrypted with a **master encryption key (MEK)** managed by OCI KMS.
 - **Enhanced security:** Envelope encryption enhances data security by ensuring that sensitive data is encrypted with unique DEKs, which are rotated regularly and managed securely by OCI KMS.
 - **Performance and scalability:** OCI KMS envelope encryption provides high-performance encryption and decryption operations, enabling

organizations to secure large volumes of data and scale encryption operations to meet growing demand.

By leveraging the capabilities and features of OCI KMS, organizations can strengthen the security of their data and resources in Oracle Cloud Infrastructure, maintain compliance with regulatory requirements, and mitigate the risks associated with unauthorized access and data breaches.

OCI hardware security module

OCI HSM, offers several compelling reasons for its adoption within **Oracle Cloud Infrastructure (OCI)**:

- **Enhanced key security:** OCI HSM provides a hardware-based solution for storing and managing cryptographic keys, offering greater protection against unauthorized access, tampering, and extraction compared to software-based key management solutions. The use of tamper-resistant hardware ensures the integrity and confidentiality of encryption keys, reducing the risk of key compromise and data breaches.
- **Regulatory compliance:** Many industries and regulatory frameworks, such as PCI-DSS, HIPAA, and GDPR, require organizations to implement robust security measures for protecting sensitive data. OCI HSM helps organizations meet compliance requirements by providing a secure and auditable platform for key management, encryption, and cryptographic operations.
- **Key management best practices:** OCI HSM follows industry best practices for key management, including key generation, storage, rotation, and destruction. By leveraging OCI HSM, organizations can implement standardized key management processes and controls, ensuring the security and integrity of cryptographic keys throughout their lifecycle.
- **High performance and scalability:** OCI HSM offers high-performance cryptographic operations, enabling organizations to encrypt and decrypt data efficiently without compromising system performance. Additionally, OCI HSM is designed to scale seamlessly to support growing encryption needs, making it suitable for organizations of all sizes and industries.
- **Trust and assurance:** OCI HSM is built on trusted and proven hardware security technologies, providing organizations with confidence in the security and reliability of their cryptographic infrastructure. Oracle's track

record of providing secure and reliable cloud services further enhances trust and assurance in OCI HSM's capabilities.

- **Multi-tenancy and isolation:** OCI HSM ensures multi-tenancy and isolation by dedicating cryptographic resources to individual tenants, preventing cross-tenant data leakage, and ensuring data confidentiality and integrity. Each OCI HSM instance operates in a secure and isolated environment, minimizing the risk of shared infrastructure vulnerabilities.
- **Seamless integration with OCI services:** OCI HSM seamlessly integrates with other OCI services and resources, enabling organizations to leverage hardware-backed encryption for securing data in databases, storage systems, and applications. Integration with OCI services ensures interoperability and ease of use, allowing organizations to deploy OCI HSM without significant changes to existing workflows and processes.
- **Root of Trust (RoT):** The Root-of-Trust security feature in Oracle Cloud means full access to the physical server for customers to reconfigure/modify the firmware and optimize support for their workloads. When an HSM is deployed with Oracle Key Vault, the RoT remains in the HSM. The HSM RoT provides functionalities such as protecting the wallet password, protecting the Transparent data encryption master key, which in turn protects all the encryption keys, certificates, and other security artifacts managed by the Oracle Key Vault server. It is critical to note that HSM, in this RoT usage scenario, does not store any customer encryption keys. Customer keys are stored and managed directly by the Oracle Key Vault server. HSMs are equipped with tamper-resistant, specialized hardware that is more secure than standard server memory. Oracle Key Vault leverages HSMs to generate and store a RoT, which is critical for protecting the encryption keys used to secure users' keys and credentials. When Oracle Key Vault is integrated with an HSM, access to keys and credentials is contingent upon the availability of the RoT stored within the HSM. Due to the design of HSMs, extracting the RoT is extremely challenging, which greatly reduces the risk of unauthorized access to users' keys and credentials. Furthermore, HSMs can operate in FIPS 140-2 Level 2 or Level 3 modes, assisting in meeting specific compliance requirements. One of the important features of HSM is enabling HSM in your Oracle Key Vault installation will not disrupt existing features. You can continue to work with Oracle Key Vault features like high availability, backup, and restore in HSM mode.

Note: When an HSM is deployed with Oracle Key Vault, the RoT remains in the HSM.

In summary, OCI HSM offers organizations a secure, compliant, and high-performance solution for managing cryptographic keys and protecting sensitive data in Oracle Cloud Infrastructure. By leveraging OCI HSM, organizations can enhance their security posture, meet regulatory requirements, and mitigate the risks associated with key management and data encryption.

Getting started with OCI HSM keys

Getting started with OCI HSM keys involves a few key steps to set up and manage cryptographic keys securely within OCI. Here is a guide to help you begin:

1. **Access OCI Console:** Log in to the OCI Console using your credentials by entering the relevant login information as shown in *Figure 5.9*:



Figure 5.9: Screenshot OCI Login Console

2. **Navigate to key management service (KMS):** From the OCI Console dashboard, navigate to the **Security** section and select **Key Management** under **Identity & Security**:

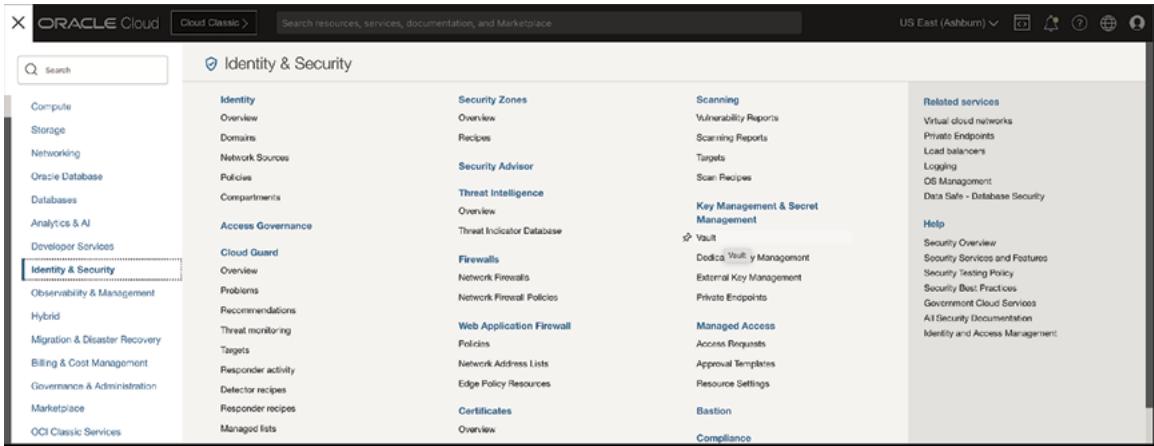


Figure 5.10: Screenshot OCI KMS service

3. **Create a Dedicated HSM compartment:** It is recommended to create a dedicated compartment within OCI to house your OCI HSM resources for organizational clarity and access control:

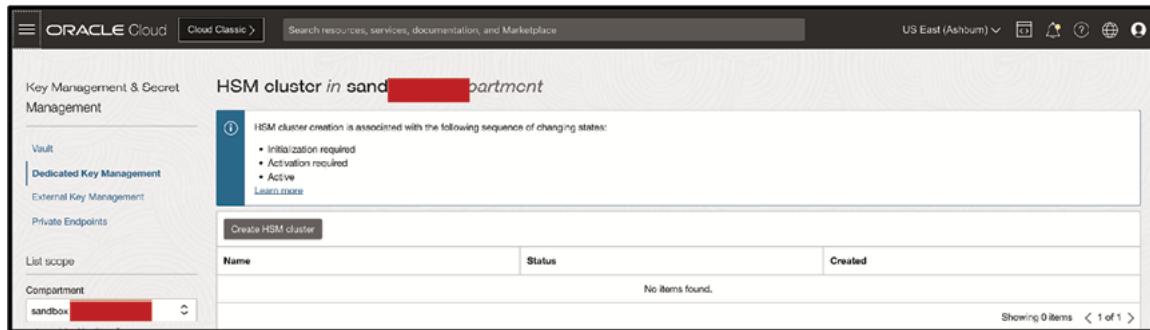


Figure 5.11: Screenshot OCI HSM cluster

4. **Provision OCI HSM instance:** Within the dedicated compartment, provision an OCI HSM instance. Specify the region, availability domain, and configuration details for the HSM instance. This process may involve selecting the desired number of HSM partitions, which determine the cryptographic processing capacity of the HSM. In HSM cluster screen details as shown in *Figure 5.12*:

Create HSM cluster Help

Dedicated key management is a customer-managed, highly available, single-tenant HSM partitions as a service. It enables ownership of the HSM partitions with full control over encrypted keys and users in the partition. [Learn more](#)

Create in Compartment ▼
sand REDACTED

Name ▼
test REDACTED

[Hide advanced options](#)

Add tags to organize your resources. [What can I do with tagging?](#)

Tag namespace	Tag key	Tag value
Oracle-Tags	CreatedBy	<input type="text"/>

[Add tag](#)

CREATE

[Create](#) [Cancel](#)

Figure 5.12: Screenshot OCI HSM cluster create page

5. **Generate HSM key pairs:** Once the OCI HSM instance is provisioned, generate cryptographic key pairs within the HSM. You can create both asymmetric (public-private) and symmetric keys, depending on your specific use cases and encryption requirements. The details related to the key, key algorithm, and key shape should be specified, as shown in **Create Key** screen in *Figure 5.13*:

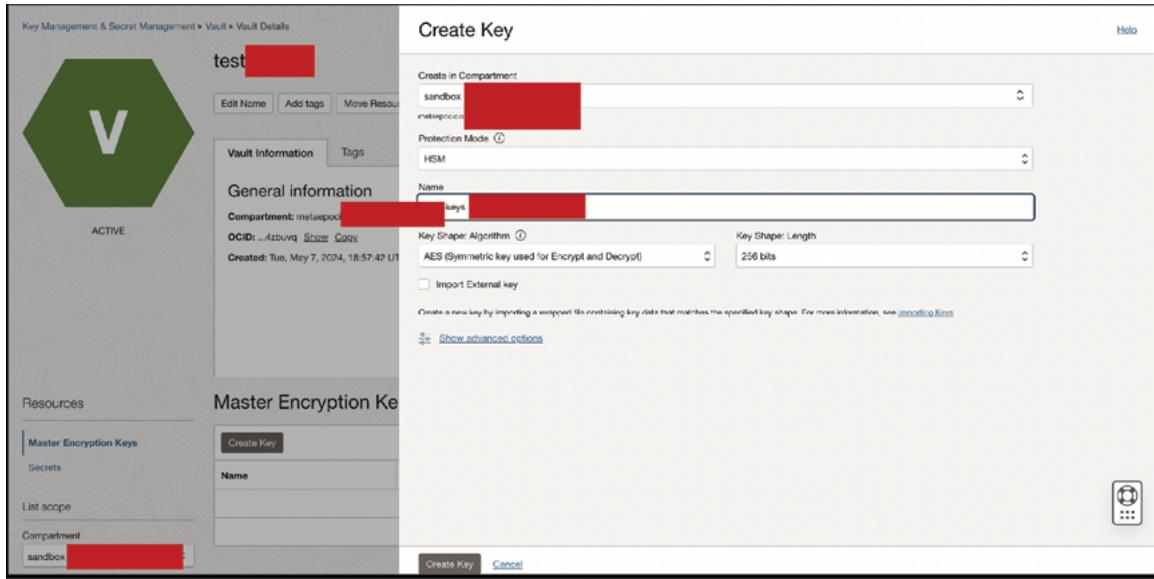


Figure 5.13: Screenshot OCI key creation

6. **Define access policies:** Define access policies to regulate who can manage and access the OCI HSM instance and its cryptographic keys. Utilize OCI's IAM service to create IAM policies that grant appropriate permissions to users, groups, or compartments.

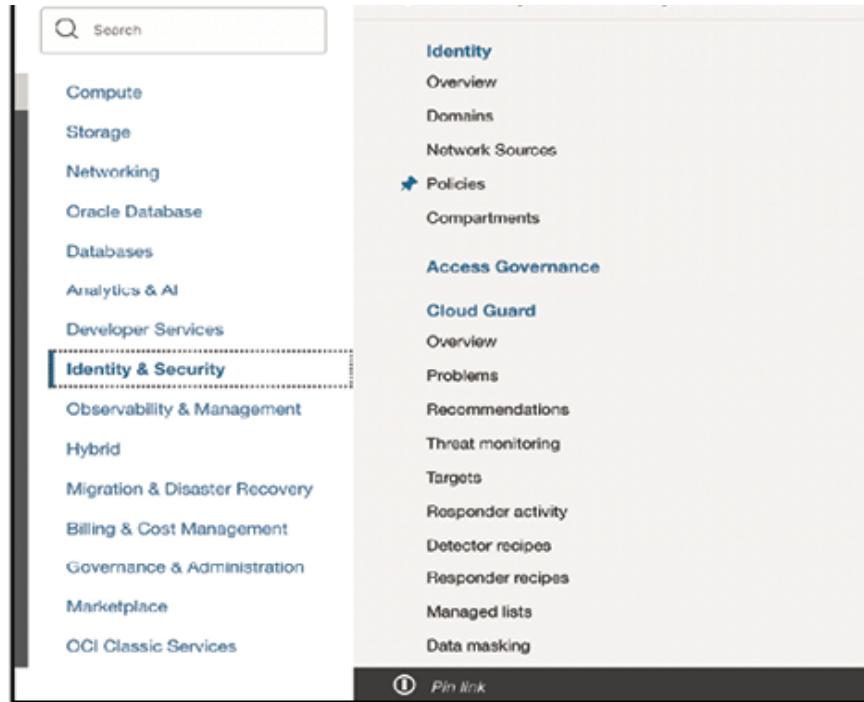


Figure 5.14: Screenshot OCI policies

- **Integrate with OCI services:** Integrate OCI HSM keys with other OCI services and resources, such as databases, storage systems, and applications, to secure data and transactions. Configure encryption and decryption operations to utilize OCI HSM keys for cryptographic operations.
- **Backup and recovery:** Implement backup and recovery procedures for OCI HSM keys to ensure business continuity and data resilience. OCI provides capabilities for backing up HSM keys securely and restoring them in case of accidental deletion or hardware failures.
- **Monitor and audit:** Regularly monitor the usage and activity of OCI HSM keys using OCI's logging and monitoring capabilities. Review audit logs and activity reports to track key operations, access attempts, and administrative actions for security compliance and troubleshooting purposes.
- **Security best practices:** Adhere to security best practices for managing OCI HSM keys, including regular key rotation, enforcing strong access controls, and conducting security assessments and audits. Stay informed about security updates and patches provided by OCI to mitigate potential vulnerabilities and threats.

By following these steps, you can effectively get started with OCI HSM keys and leverage the hardware-based security capabilities of Oracle Cloud Infrastructure to protect sensitive data and transactions with confidence.

Overview of encryption methods

Encryption plays a crucial role in safeguarding data integrity and confidentiality, both in transit and at rest. Here is an overview of common encryption methods and their applications:

- **Encryption in Transit and at Rest:**
 - **Encryption in Transit:** Encrypting data during transmission between client and server endpoints using protocols such as SSL/TLS (Secure Sockets Layer/Transport Layer Security). This ensures that data exchanged over networks is protected from interception and eavesdropping by unauthorized parties.
 - **Encryption at Rest:** Encrypting data stored on disk or in databases to prevent unauthorized access in case of data breaches or physical theft. Encryption algorithms are used to transform plaintext data into ciphertext, which can only be decrypted using the appropriate encryption key.
- **Transparent Data Encryption:**
 - **Encrypted Data at Rest:** TDE is a database-level encryption solution that automatically encrypts data at rest within a database, making it transparent to applications and users accessing the data. TDE encrypts the entire database, including data files, tablespaces, and backups, without requiring changes to application code or queries.
 - **Understanding TDE Architecture:** TDE typically utilizes a **master encryption key (MEK)** to encrypt and decrypt data, which is stored securely within a KMS such as OCI HSM. The MEK is used to encrypt the **database encryption keys (DEKs)**, which in turn encrypt the actual data stored in the database.
 - **Managing keys:** Key management is a critical aspect of TDE implementation. Organizations must securely manage and protect the MEK and DEKs to prevent unauthorized access to encrypted data. Key rotation, backup, and recovery procedures should be established to ensure data availability and resilience.

Managing secrets

OCI Secrets is a comprehensive secret management service designed to help organizations in securely storing, accessing, and distributing sensitive information, including API keys, credentials for cloud services and databases, and other critical secrets. It involves securely storing, managing, and accessing sensitive information such as API keys, passwords, and cryptographic keys used to authenticate and authorize access to resources and services:

- **Best practices:** For managing secrets include encrypting sensitive data at rest, enforcing strong access controls and authentication mechanisms, and implementing key rotation and revocation policies to mitigate the risk of unauthorized access or compromise.
- **Secrets management:** Secrets management solutions such as Oracle Cloud Infrastructure Vault provide a centralized and secure repository for storing and managing secrets, offering features such as encryption, access controls, audit logging, and integration with OCI services.

By understanding and implementing these encryption methods and best practices, organizations can enhance the security of their data and applications, mitigate the risk of data breaches, and comply with regulatory requirements governing data protection and privacy.

Backing up and restoring vaults and keys

In OCI, backing up and restoring vaults and keys is termed the process of securely saving and recovering cryptographic keys and associated metadata stored within OCI Vault services. This mechanism ensures that even if keys are lost, stolen, or compromised, they can be restored at any point in time to maintain data security and integrity. A few mechanisms are discussed below.

- **Vault backup:** Regularly backup the contents of your Oracle Cloud Infrastructure Vault to ensure data resilience and recoverability in case of accidental deletion, corruption, or disaster. Utilize built-in backup features provided by OCI Vault or implement custom backup solutions to securely store vault data in redundant locations.
- **Key backup:** Implement backup procedures for cryptographic keys stored within OCI Vault to prevent data loss and ensure key availability for encryption and decryption operations. Backup key material securely and store it in a separate, isolated location to protect against key loss or corruption.

- **Disaster recovery planning:** Develop and maintain a comprehensive disaster recovery plan for OCI Vault and associated cryptographic keys. Define recovery objectives, backup retention policies, and recovery procedures to minimize downtime and data loss in the event of a disaster or service outage.
- **Key rotation and versioning:** Implement key rotation and versioning strategies to periodically update cryptographic keys and maintain data security. Rotate keys at regular intervals to mitigate the risk of key compromise and ensure compliance with security best practices and regulatory requirements.
- **Secure backup storage:** Store vault backups and key archives in secure, encrypted storage locations to protect sensitive data from unauthorized access and tampering. Leverage OCI's encryption capabilities and access controls to ensure the confidentiality and integrity of backup data.

DB security tools

DB security tools refer to a suite of services and features designed to enhance the security of databases hosted on OCI. This tool includes features such as data masking, database firewall and database activity monitoring. A few of them are discussed as follows:

- **Oracle Database Security Assessment Tool (DBSAT):** The Oracle DBSAT is a comprehensive security assessment tool that evaluates the security posture of Oracle databases. DBSAT scans databases for security vulnerabilities, misconfigurations, and compliance violations, providing actionable recommendations to improve database security and mitigate risks.
- **Oracle Audit Vault and Database Firewall (AVDF):** Oracle AVDF is a unified solution for auditing, monitoring, and protecting Oracle databases from security threats and unauthorized access. AVDF collects and analyzes audit data from databases, detects and alerts on suspicious activities, and enforces access controls and firewall policies to prevent unauthorized access and data breaches.
- **Private endpoints for Autonomous Databases:** Private endpoints provide secure network connectivity between client applications and Autonomous Databases deployed within OCI. Private endpoints utilize private IP addresses and VCNs to establish secure, isolated communication channels,

minimizing exposure to external threats and ensuring data privacy and integrity.

By leveraging these DB security tools and best practices, organizations can enhance the security posture of their Oracle Databases, protect sensitive data from unauthorized access and breaches, and ensure compliance with regulatory requirements governing data protection and privacy.

Conclusion

In conclusion, securing databases within OCI is paramount for organizations aiming to safeguard their valuable data assets and maintain regulatory compliance. Throughout this chapter, we've explored the fundamental principles and advanced techniques essential for fortifying databases in OCI. From understanding the core concepts of cryptography to implementing encryption techniques for data at rest and in transit, we have delved into the intricacies of database security. KMS, including the OCI Vault, Dedicated KMS, and External KMS, provide robust solutions for managing cryptographic keys securely, ensuring data confidentiality and integrity.

We began by delving into the fundamental principles of data security, including cryptography, encryption algorithms, and securing data in motion and at rest. Understanding these concepts forms the basis for implementing robust security measures. The study of data security initiated with an examination of fundamental principles such as cryptography and encryption algorithms, critical for safeguarding data in transit and at rest. Key to this framework is the OCI KMS Vault, which plays a vital role in securely managing encryption keys and implementing resilient security measures. Additionally, the OCI HSM enhances key security and regulatory compliance, providing essential protections for databases hosted on OCI. The chapter also covered encryption methods like TDE architecture and secure management of sensitive information. Furthermore, Oracle's suite of DB security tools, such as the DBSAT, Oracle AVDF, and private endpoints for Autonomous Databases, were highlighted for their capabilities in auditing, monitoring, and safeguarding databases against potential security risks.

By adopting encryption methods, implementing key management best practices, and leveraging security tools, organizations can fortify their databases in OCI, mitigate risks associated with data breaches, and ensure compliance with regulatory requirements. In a rapidly evolving threat landscape, prioritizing database fortification is not just a necessity but a strategic imperative. As organizations continue their journey toward digital transformation, robust

database security measures will play a pivotal role in safeguarding critical assets and sustaining business resilience in an increasingly interconnected world.

In conclusion, database fortification in OCI is of paramount importance in today's cybersecurity landscape. Organizations must prioritize database security and implement robust measures to safeguard their data assets from evolving threats and compliance requirements. By leveraging encryption techniques, key management services, and security tools, organizations can strengthen their database security posture and mitigate the risks associated with unauthorized access and data breaches. It is imperative for organizations to take proactive steps to fortify their databases, implement security best practices, and stay vigilant against emerging threats. By investing in database security measures and fostering a culture of cybersecurity awareness, organizations can protect their data assets and uphold trust and integrity in the digital era.

Multiple choice questions

1. What are the primary goals of database fortification in OCI?

- a. Enhance database performance
- b. Ensure data availability
- c. Protect data integrity and confidentiality
- d. Reduce storage costs

2. Which technical requirement is crucial for securing databases in OCI?

- a. High-speed internet connection
- b. Robust authentication and authorization mechanisms
- c. Large storage capacity
- d. Multiple user accounts

3. What is the primary purpose of data encryption in OCI?

- a. Improve data retrieval speed
- b. Reduce data redundancy
- c. Protect data from unauthorized access

d. Compress data for efficient storage

4. Which of the following is a fundamental concept of securing data in OCI?

- a. Data redundancy
- b. Data encryption
- c. Data compression
- d. Data fragmentation

5. What role does the KMS Vault play in OCI?

- a. Managing user access levels
- b. Storing and managing encryption keys
- c. Optimizing database queries
- d. Monitoring database performance

6. How does KMS Vault enhance data security?

- a. By providing automated backup services
- b. By ensuring encryption keys are securely stored and managed
- c. By increasing data compression rates
- d. By distributing data across multiple regions

7. What is the function of the OCI HSM?

- a. Enhance data retrieval speed
- b. Provide hardware-based encryption and key management
- c. Optimize network traffic
- d. Manage user authentication

8. Which statement about OCI HSM is correct?

- a. It is a software-based encryption tool.
- b. It provides physical security for encryption keys.

- c. It is used for data compression.
 - d. It reduces the cost of database management.
- 9. Which encryption method is commonly used to secure databases in OCI?**
- a. Symmetric encryption
 - b. Asymmetric encryption
 - c. Hash encryption
 - d. Data masking
- 10. What is a key advantage of using asymmetric encryption over symmetric encryption?**
- a. Faster encryption and decryption processes
 - b. Simpler key management
 - c. Better suited for large data sets
 - d. More secure key distribution
- 11. Why is it important to back up and restore vaults and keys in OCI?**
- a. To reduce data storage costs
 - b. To ensure availability and recoverability of encryption keys
 - c. To improve database performance
 - d. To enable faster data queries
- 12. What should be regularly tested to ensure the reliability of backups in OCI?**
- a. Data compression rates
 - b. Backup and restore procedures
 - c. Network speed
 - d. User access logs

13. Which tool in OCI is used for monitoring and auditing database activity?

- a. OCI Monitoring
- b. OCI Logging
- c. Oracle Data Safe
- d. Oracle Data Guard

14. How does Oracle Data Safe enhance database security?

- a. By providing data encryption
- b. By offering comprehensive security assessments, activity auditing, and sensitive data discovery
- c. By reducing storage costs
- d. By optimizing database queries

15. What is a key takeaway from Chapter 5 on database fortification in OCI?

- a. Database fortification primarily focuses on performance optimization.
- b. Secure management of encryption keys is essential for data protection.
- c. Reducing storage costs is the main objective of database fortification.
- d. Data redundancy should be prioritized over data security.

Answers

- 1. c
- 2. b
- 3. c
- 4. b
- 5. b
- 6. b
- 7. b

8. b

9. a

10. d

11. b

12. b

13. c

14. b

15. b

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CHAPTER 6

Applications Security Unleashed

Introduction

In the evolving world of cloud computing, where changes in business environments are constantly changing and industries are going through digital transformations, security remains the foundation of confidence and credibility. In this framework, OCI stands as a guide of security, providing a great range of tools and technologies that can help organizations to improve applications security against various cyber threats.

As organizations work towards migrating their workloads to the cloud, the need for a comprehensive approach to application security becomes essential. This necessitates not only protecting web applications against vulnerabilities and attacks but also ensuring the integrity and confidentiality of data access, protecting API endpoints, and managing user identities with the highest security.

The process of delving into the area of application security within OCI is a complex process which involves a vast number of significant fields and complex technologies. It includes mastering the features of the service mesh architecture, leveraging API Gateway capabilities, managing identity and access management, and addressing new threats.

Fundamentally, this is an expedition that is premised on the principles of confidentiality, integrity, and availability and the need to protect the digital assets of customers and stakeholders. It is a journey of learning, evolving, and innovating, a journey where security is not an end state but a process of constant improvement.

In this chapter, we initiate the journey of exploring the various territories of application security in OCI. We start with the basics to provide context, exploring what a service mesh is and how it fits into the concept of modern microservices-based applications and their security. From there, we move through the complex realm of API security and learn about OCI API Gateway and OpenID Connect to protect web applications from cross-site request forgery and cross-site resource sharing.

However, our journey does not end there. We delve deeper into the realm of data access, unraveling the nuances of securing API endpoints with mutual TLS, client certificates, and custom domains. We then turn our attention to the frontline defenses, exploring the capabilities of **web application firewalls (WAF)** in protecting internet facing and internal applications from a spectrum of attacks. we encounter the realm of identity and access management, where user and identity pools emerge as central pillars of authentication and authorization.

We explore the intricacies of user authentication mechanisms, authorization policies, and access controls, which are critical for the applications' security by enabling organizations to manage user identities with better authentication and access mechanisms. In this chapter, we explore not only the technical aspects of application security but principles of risk management, compliance management, and resilience of the systems. We need to understand security is a shared responsibility, requiring collaboration across teams and disciplines, including cloud provider and customers, and a proactive mindset that anticipates and mitigates threats before they materialize.

Structure

The chapter covers the following topics:

- Application security service mesh
- Web apps security with API Gateway and OpenID Connect
- OCI API Gateway
- Cross-origin resource sharing API security
- mTLS and client certificates for securing API Gateway resources
- Adding CORS support to API deployments
- Customizing trust stores for TLS certificate verification
- Web application firewall
- Protecting public and internal applications from attacks
- Securing applications
- Identity pools

Objectives

In this chapter, we will guide the readers with a set of definite and explicit goals, each of which is aimed at creating among the readers of this chapter a proficiency and confidence in navigating the comprehensive landscape of application security within OCI. By Thoroughly addressing these objectives, we committed in providing a

thorough understanding of key concepts, practical implementations, and best practices, thereby empowering readers to strengthen their applications against evolving cyber threats. The objective of the chapter is to explain the fundamentals of application security, implementation of service mesh, web application security, and best practices for implementing API security. By the end of this chapter, readers should possess the knowledge and insights necessary to implement advanced security measures for securing applications, understand in detail about authorization techniques using user and identity pools and the best recommendations and considerations for securing API's in OCI. The chapter also covers in detail about usage of web application firewall in protecting the applications.

Application security service mesh

Service mesh is an architectural concept that is popular in providing security solutions to microservices-based applications; this is very popular in the **Oracle Cloud Infrastructure (OCI)** Cloud. In this section, we discuss in detail the working with service mesh architecture and its role in improving the security mechanism for modern applications and how it scales and helps in the security of the application in cloud computing. *Figure 6.1* illustrates the interface to access components in the service mesh:

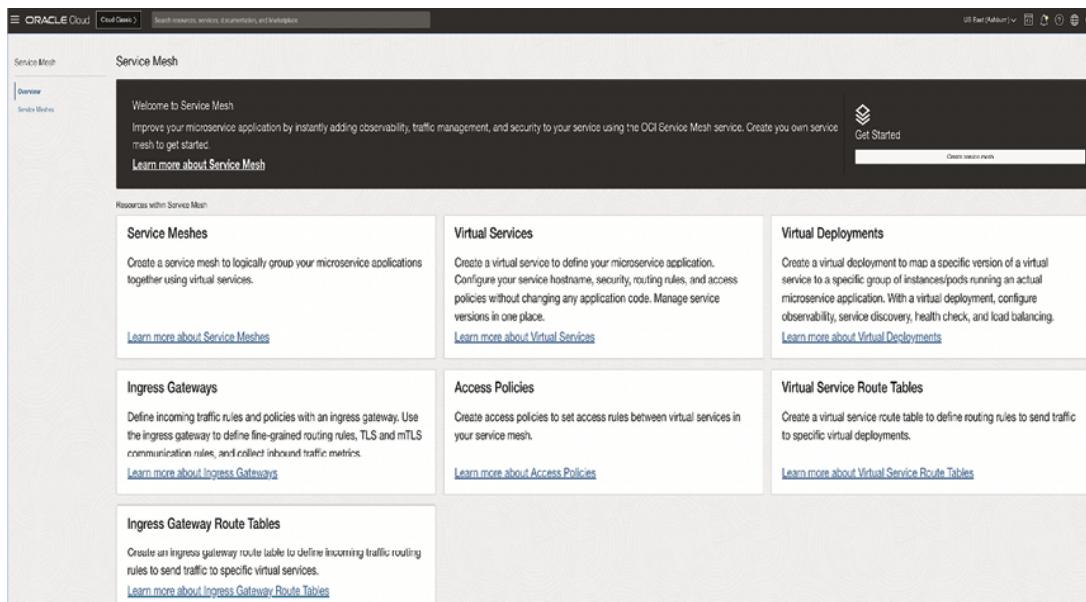


Figure 6.1: Service mesh

Service mesh acts as a dedicated infrastructure layer that facilitates secure communication, observability, and resilience among microservices deployed within a distributed application environment. The way service mesh works is abstracting away the complexities of network communication and providing a centralized control plane;

service mesh helps developers and security personal to effectively manage and secure the communication between microservices in the applications.

The fundamental component of a service mesh deployment within OCI is the creation of ingress gateway route tables. These route tables act as the primary mechanism for routing traffic from external clients (users) to the appropriate microservices within the mesh. The critical component is defining routing rules and policies at the ingress gateway level; companies should ensure that incoming requests are securely directed to the relevant applications services, while enforcing authentication, authorization, and encryption protocols.

The interactions between mesh and virtual service **mutual Transport Layer Security (mTLS)** act as additional layer of security to the communication between microservices. Using mTLS, both the client and server authenticate each other and establish a secure, encrypted channel for data transmission between them. mTLS is popular security concept independent of the service mesh, as it ensures that only trusted users or parties can communicate within the service mesh, minimizing the risk of unauthorized access, data interception or other security attacks.

As most organizations move towards microservices architectures for their agility, scalability, and reliability benefits, the need for greater security mechanisms becomes critical. Service mesh architectures, which focus on secure communication and centralized management, offer a compelling solution to address these security challenges effectively.

The implementation of service mesh within OCI involves a series of configuration steps and best practices. Organizations should design their ingress gateway route tables, defining routing rules based on factors such as request paths, HTTP headers, and source IP addresses. They must configure mutual TLS encryption between mesh and virtual services, using OCI's robust encryption capabilities to protect data in transit.

Organizations should also consider the broader implications of service mesh on their application architecture, including the impact on performance, scalability, and operational standards. Service mesh offers greater security benefits, but it also introduces additional overhead in terms of latency, resource utilization, and management overhead. Thus, organizations must strike a balance between security requirements and operational considerations when deploying service mesh within OCI.

Service mesh architecture represents a greater paradigm shift in the way organizations secure and manage microservices-based applications within OCI. Using the capabilities of ingress gateway route tables and mTLS encryption, organizations can establish a robust security posture that protects against a wide range of threats and vulnerabilities. Please note successful implementation requires careful planning, configuration, and ongoing management to ensure greater performance, scalability, and resilience. By using the best practices, organizations can utilize the full potential of service mesh while protecting their critical assets in cloud computing.

The following are the steps for the creation of a service mesh:

1. Navigate to **Developer Services**. Under **Containers & Artifacts**, click **Service Mesh**.

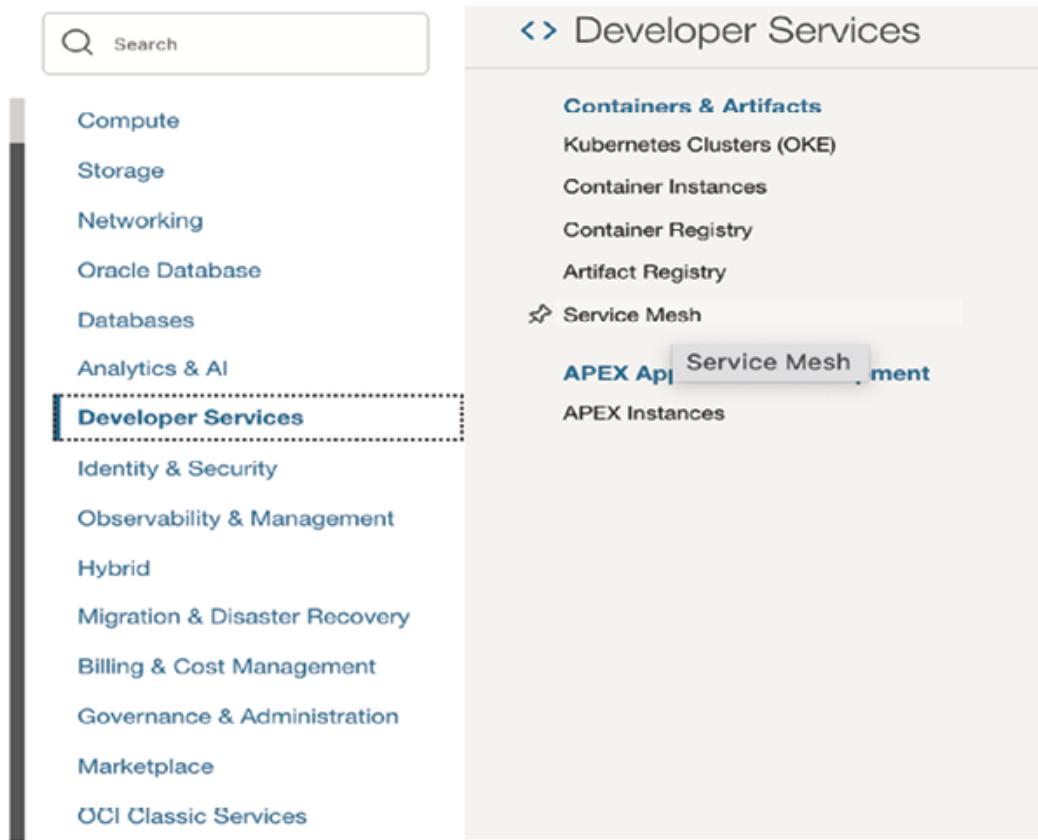


Figure 6.2: Service Mesh navigation

2. Click on **Service Meshes**:

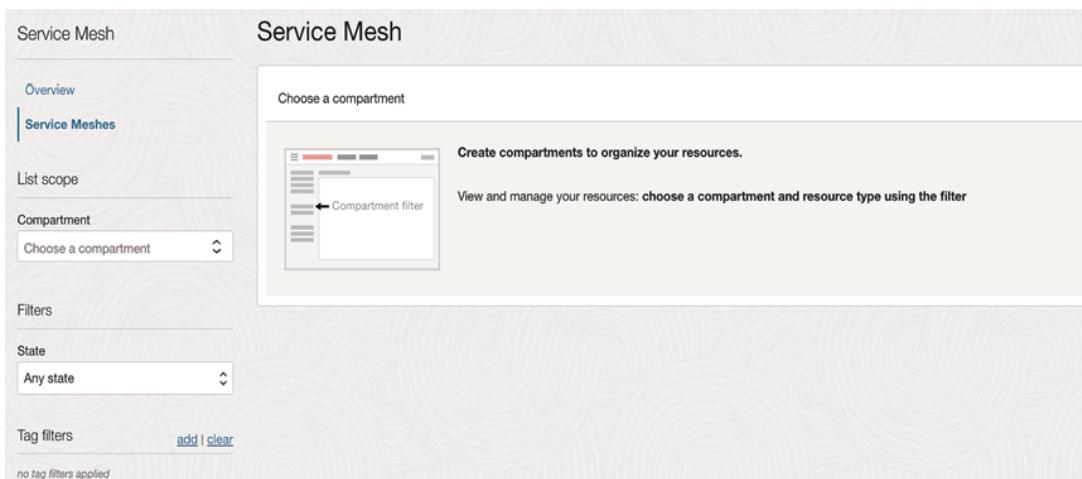


Figure 6.3: Service Meshes

3. Select the **Compartment** and create a new **Service Mesh**.

Creating ingress gateway route table

In the world of OCI, the creation of ingress gateway route tables stands as a basic step towards enabling a secure and efficient communication pathway for microservices based applications. These route tables serve as the cornerstone for routing traffic from external clients to the appropriate microservices within the service mesh architecture.

The process of creating ingress gateway route tables begins with a meticulous analysis of the application's architecture and traffic patterns. Organizations must identify the ingress points where external traffic enters the service mesh and define routing rules to ensure that incoming requests are directed to the appropriate microservices.

Key steps in creation of ingress gateway route tables

In OCI, the creation of ingress gateway route tables involves several key steps:

1. **Ingress points discovery:** We should identify the ingress points within the application architecture where public traffic enters the service mesh. This would include load balancers, API Gateways, or other entry points through which public users access the application.
2. **Routing rules definition:** Once the ingress points are identified, we must define routing rules to enable the flow of traffic within the service mesh for applications. These rules may be based on factors such as request path, HTTP headers, source IP addresses, or other relevant information.
3. **Configuration of route tables:** With routing rules in place, organizations can proceed to configure ingress gateway route tables within OCI. These route tables act as a centralized repository for defining routing policies and forwarding rules, ensuring that incoming traffic is routed efficiently to the appropriate microservices.
4. **Testing:** Deploying the route tables into production, organizations should conduct thorough testing and validation to ensure that routing rules are correctly configured, and traffic flows as expected. This also involves simulation of various traffic scenarios and load testing to assess the performance and scalability of the routing infrastructure.
5. **Monitoring:** The ingress gateway route tables can be deployed into production environments. We should continuously monitor traffic patterns and performance metrics to identify any potential bottlenecks or issues and make necessary adjustments to routing rules as needed.

Understanding service mesh and virtual service mTLS interactions

In OCI Cloud the communication between service mesh **mutual Transport Layer Security (mTLS)** encryption play a critical role in making sure the security and integrity of communication between different microservices based applications.

mTLS is an industry-wide, very popular, and secure protocol that enables both the client and server to authenticate each other and establish a secure channel for data transmission; service mesh architecture requires mTLS encryption secure communication between microservices to ensure user data transmitted over the network is secure.

There are several key components involved in the interactions between mesh and mTLS:

- **Mesh-level configuration:** Within the service mesh architecture, organizations can configure mTLS encryption settings at the mesh level. This involves defining policies and certificates that govern the establishment of secure connections between microservices deployed within the mesh.
- **Virtual service configuration:** At the virtual service level, organizations can specify mTLS encryption requirements for individual microservices. This also includes the client, server authentication, and encryption algorithms used for security during the data transmission.
- **Certificate management:** Organizations should have central automated way of managing the certificates used for mTLS encryption in the service mesh, the key requirement is generating, distributing, and revoking certificates as required to ensure the security of communication between microservices. The certificates are automatically renewed every two thirds of a certificate's validity time. For example, if the maximum validity period is 60 days, the certificate is renewed every $(2/3) * 60 = 40$ days
- **Key exchange and handshake:** Using the mTLS connections, microservices in the service mesh use a key exchange and handshake process to authenticate each other and negotiate encryption parameters during the data transmission. This process helps that only trusted parties can communicate within the service mesh, and the data exchanged over the network remains secure.

Web apps security with API Gateway and OpenID Connect

Securing web applications is very important in cloud computing and, in general, in a high-threat world, where cyber threats are large, and data breaches can have significant consequences. OCI Cloud provides modern tools and technologies to secure web applications with OCI API Gateway and OpenID Connect, which standing helps to prevent the security attacks as first responders.

In this section, we learn on a journey to explore the capabilities of OCI API Gateway and OpenID Connect in protect web applications against security threats. Helping defend against **cross-site request forgery (CSRF)** attacks to help secure communication via mutual TLS, these tools offer a comprehensive suite of features to improve the security posture of web applications deployed within OCI.

Significant improvements in web application security can be achieved by the implementation of CSRF protection, a major protection mechanism against security attacks and actions initiated by malicious actors. OCI API Gateway provides robust CSRF protection capabilities, allowing organizations to mitigate the risk of CSRF attacks by verifying the authenticity of incoming requests preventing access and protecting the resources.

Creation of API Gateway in OCI are:

1. Navigate to **Developer Services** and click on **Gateways** under **API Management**. *Figure 6.4* illustrates interface to access OCI API Management:

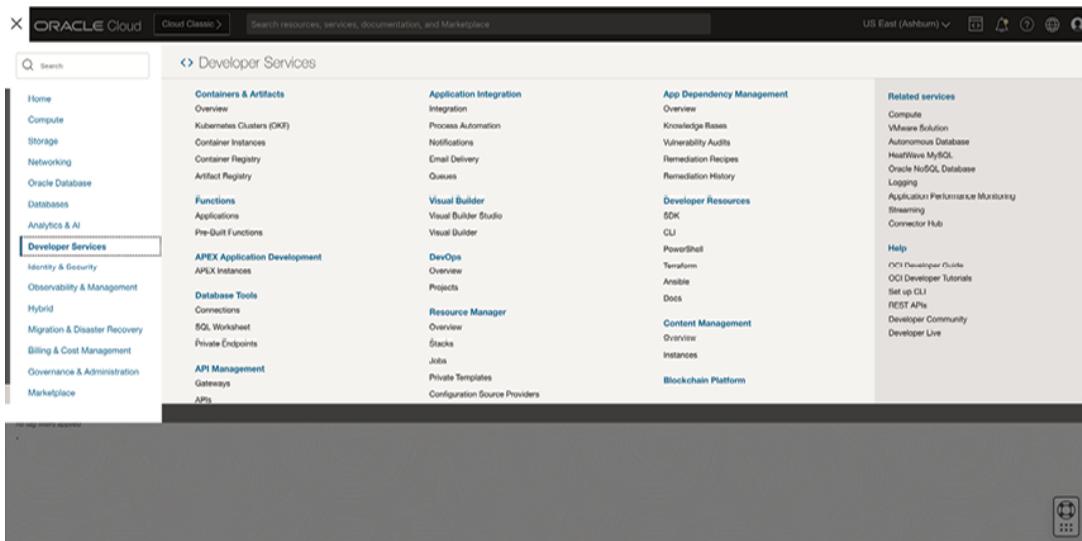


Figure 6.4: Interface for OCI Gateways

2. Click on **Create gateway**:

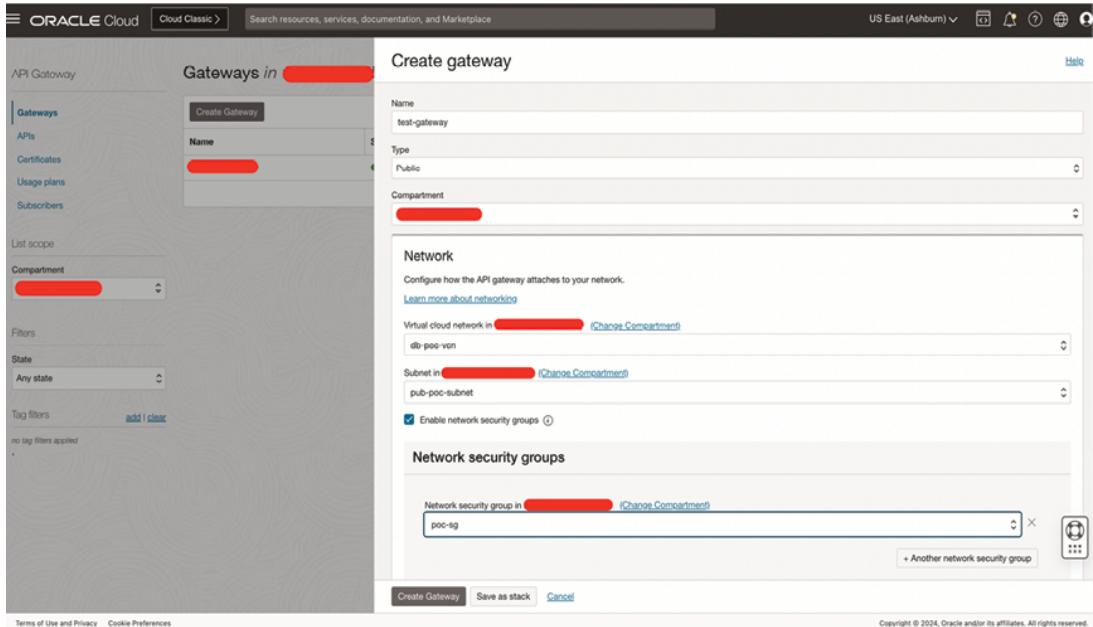


Figure 6.5: Interface to create OCI Gateways

Below figure shows Sample architecture integrating with API Gateway and OpenID:

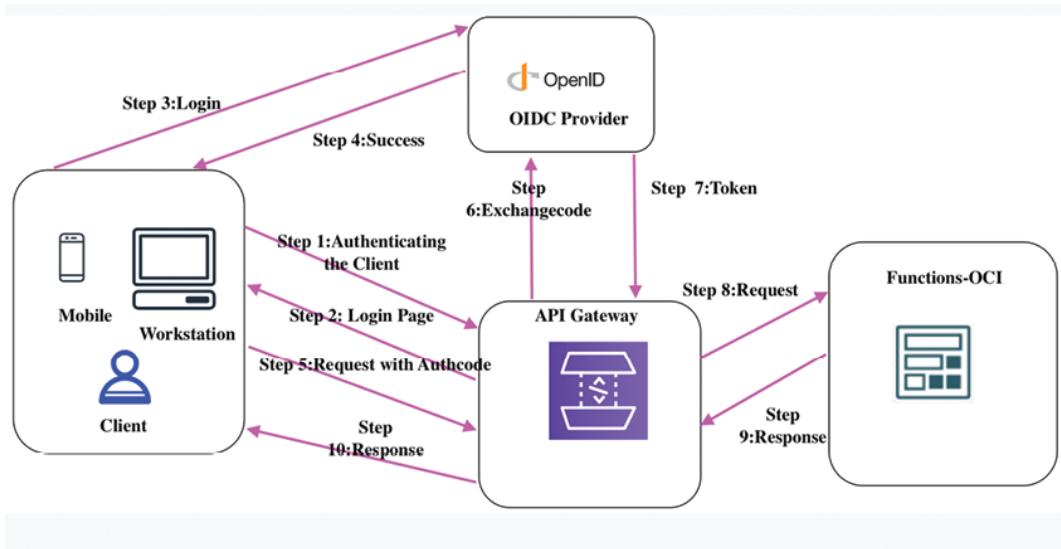


Figure 6.6: Sample architecture integrating with API Gateway and OpenID

Cross-origin resource sharing (CORS) is one of the critical aspects of web application security implementation addressed by OCI API Gateway. Using CORS policies, organizations can control access to web resources from different origins, this helps mitigating the risk of cross origin attacks and help protecting sensitive data from malicious attacks to access data or systems.

Mutual TLS (mTLS) encryption is a robust way of securing communication between web applications and clients, ensuring that data exchanged over the network remains secure and tamper proof throughout the transmissions. OCI API Gateway helps the implementation of mutual TLS by providing seamless integration with client certificates, helping organizations to authenticate clients and establish data transmission over encrypted methods.

OCI API Gateway also offers support for custom domains and TLS certificates, enabling organizations to enhance the security and reliability of their web applications. Using the custom domains and TLS certificates, organizations can establish a strong brand identity, improve user trust, and demonstrate improved security best practices.

OCI API Gateway and OpenID Connect serve as modern and advanced authentication frameworks for web applications deployed within OCI. By integrating with OpenID Connect, organizations can implement secure, standard authentication mechanisms such as OAuth 2.0, helping users to securely log in and access protected resources.

OCI API Gateway and OpenID Connect are great tools for securing web applications deployed within Oracle Cloud Infrastructure. Customers can benefit by using CSRF protection, CORS policies, mutual TLS encryption, custom domains, TLS certificates, and OpenID Connect; this can help improve the security posture that protects against a wide range of threats and vulnerabilities in the applications and other layers.

The following are some recommendations:

- **Custom CSRF protection:** It is very important to develop custom CSRF protection mechanisms in the web application's authentication process when using OpenID Connect option for user authentication and authorizations, including identity management. Using CSRF protection in the authentication process, we can reduce the risk of CSRF attacks from bad actors and protect the user sessions.
- **Validation of OAuth state parameter:** Validation of the OAuth parameters during the OpenID Connect authentication process to avoid CSRF attacks. This OAuth state parameter also helps to make sure the requests are coming from legitimate sources and not been tampered with by bad actors. By validating this parameter, we can improve the security of the authentication process to protect the sessions using the CSRF exploits by bad actors.
- **Security libraries:** For compliance and security, it is best practice to use the security libraries which offer CSRF protection features to ensure compliance with best practices. These libraries provide functionality for generating and validating CSRF tokens to improve security and making it easier to integrate CSRF protection into our web application authentication process. Using these tools, we can reduce development time and effort to ensure the solid CSRF protection.

The following are some considerations:

- **Custom development:** Using and implementing the custom CSRF protection technologies along with OpenID Connect requires additional development efforts and requires the skill set for the developers. This ensures that our development team has the required skills and expertise to implement CSRF protection properly within the authentication process.
- **Maintenance:** We need to regularly update and maintain CSRF protection mechanisms to ensure emerging threats and vulnerabilities addressed properly. To ensure ongoing security compliance. As threats are constantly evolving, new security risks emerge, and we need to implement the best practices of security and update your CSRF protection mechanisms as needed. By prioritizing maintenance and updates, we can effectively mitigate the risk of CSRF attacks and maintain the security of web applications over time.

Data access

Data access in the OCI involves many activities behind the scenes and considerations. Usually this includes from authentication and authorization to encryption and auditing for the security. In this section, we will explore a deep dive into data access within OCI Cloud, focusing on best practices, recommendations, and considerations for ensuring the security and integrity of data stored and processed within the cloud environment.

Authentication and authorization for security

Authentication acts as basic in data access control in the OCI Cloud, ensuring that only authenticated users are granted access to sensitive data and systems. OCI offers different authentication mechanisms from basic to advanced, such as username/password authentication and federated authentication with external **identity providers (IdPs)**, and also allows integration with authentication protocols such as OAuth 2.0 and OpenID Connect.

Authorization in the security world is critical where permissions and privileges granted to authenticated users and systems. Using **role-based access control (RBAC)** and **attribute-based access control (ABAC)** policies, organizations can define granular access controls based on factors such as user roles, group memberships, resource attributes, and contextual information. Using least privilege principles, organizations can minimize the risk of unauthorized access to sensitive data.

Role-based access control

OCI IAM Cloud offers RBAC to manage roles and user access to resources in customer tenancy.

RBAC works in OCI Cloud:

- **Principals:** In OCI Cloud principal refers to a user, group, or dynamic group that can be granted access to your resources. Principals are entities to policies that are attached to define what actions they can perform on specific resources in the cloud.
- **Policies:** Policies are JSON documents that dictate the permissions granted to principals. Permissions specify which actions a principal is allowed or denied on specific resources. Policies are attached to compartments, resources, or the tenancy in the OCI Cloud.
- **Roles:** Roles are nothing but collection of policies which define a set of permissions. Generally, roles allow you to group together common sets of permissions and assign them to principals. Example we might create a database administrator role that grants permissions to manage database resources or a network administrator role for managing networking resources.
- **Permissions:** Permissions define asset of actions that a principal can perform on resources in the OCI Cloud. Most of the actions include read write delete and manage operations on various OCI services and resources.
- **Policy statements:** Policy statements are the individual rules within a policy that grant or deny specific permissions. Each policy statement contains an effect that is allow or deny a list of actions (API operations) and a list of resources.
- **Resource types:** OCI Cloud organizes its services and resources into resource types. For example, compute, network, storage etc. Policies specify permissions for specific resources or resource types or individual resources in the types.

Role based access controls help to create custom roles for the organizational requirements. We design RBAC by assigning the policies to roles and assigning the roles to users, groups or dynamic groups. This way, we can implement the principles of least privilege by granting the required permissions to perform a specific task, which is essential for improving security and minimizing the risk of excessive grants and unauthorized access to sensitive resources.

- **Encryption:** Encryption is a very important aspect of protecting the data at rest and in transit in the OCI Cloud. Any customers can use OCI native encryption capabilities to encrypt data stored in databases, object storage block volumes, or any other persistent data storage. This helps organizations' sensitive information remain protected from bad actors and security attacks, and data breaches. OCI also offers support for encryption in transit (during the transmission) through protocols such as **Transport Layer Security (TLS)**, which enables organizations to encrypt data transmitted by the network between clients (source) and OCI services (target).

- **Auditing and monitoring:** Auditing and monitoring systems are essential for creating visibility and accountability over data/resource access and activity in the OCI Cloud. Organizations can use OCI native auditing and logging features to monitor and analyze access logs, configuration changes, and security events by enabling proactive detection and response to security incidents. Implementing comprehensive auditing and monitoring strategies helps organizations to detect anomalous activity, identify for any security gaps, and ensure meeting the compliance requirements with regulatory authorities and industry standards globally for various countries.
- **Data protection:** Along with authentication, authorization, encryption, auditing, and monitoring, organizations should also implement modern data protection best practices to help protect the systems, data, and systems against data loss, corruption, or unauthorized access. This would include implementing best practices for data backup and recovery, disaster recovery, and maximum availability solutions. Implementing best practices for data lifecycle management policies to ensure the availability and integrity of data in the event of unforeseen disruptions such as disasters or failures.

The following are the best practices and recommendations:

- Implement best practices for multi factored authentication mechanisms to verify the identities of users, systems, and entities accessing OCI Cloud resources.
- Enforce least privilege policies by enabling granular access controls based on users, user roles, group memberships, and resource attributes keeping business functions in the center.
- Ensure data encryption policies are in place for sensitive data at rest and in transit using OCI native encryption capabilities to protect against bad actors, unauthorized access and data/security breaches.
- Implement best practices for auditing and monitoring mechanisms to monitor and analyze access logs, configuration settings changes, and security incidents for proactive **threat detection and response (TDR)**.
- Implement data protection best practices such as data backup and recovery, disaster recovery or **business continuity plan (BCP)**, and data **lifecycle management (LCM)** of data to ensure the availability and integrity of data all the time.

OCI API Gateway

OCI API Gateway is a key feature in the OCI's portfolio of tools for securing APIs and web applications against security attacks. Due to its robust capabilities and advanced

technologies, OCI API Gateway is considered extremely effective for organizations to protect their digital resources against a large scale of cyber security threats, including **cross-site request forgery (CSRF)** attacks.

Built-in CSRF protection

CSRF attacks usually work by exploiting the trust between a client browser and a web application to execute unauthorized actions on the behalf of the user (without user knowledge). CSRF attacks can lead to data manipulation, account takeover, and other security breaches and attacks. Protection against CSRF attacks is very critical for any organizations, OCI API Gateway offers built in features to mitigate this risk effectively against the CSRF attacks.

OCI API Gateway protection against cross-site request forgery

OCI API Gateway uses different techniques to ensure the authenticity of incoming requests maintained and prevent/avoid unauthorized access or modifications to sensitive data and resources:

1. **CSRF token generation:** OCI API Gateway works by generating a unique CSRF tokens for each user session or request coming in, which are embedded in the web pages or API responses. These tokens serve as cryptographic tokens that help to validate the authenticity of subsequent requests coming from the same user. Token generation is the first step in this process and is the most critical aspect. Below interface with *Figure 6.7* shows token generation in OCI. The next step is related to validation of CSRF token:

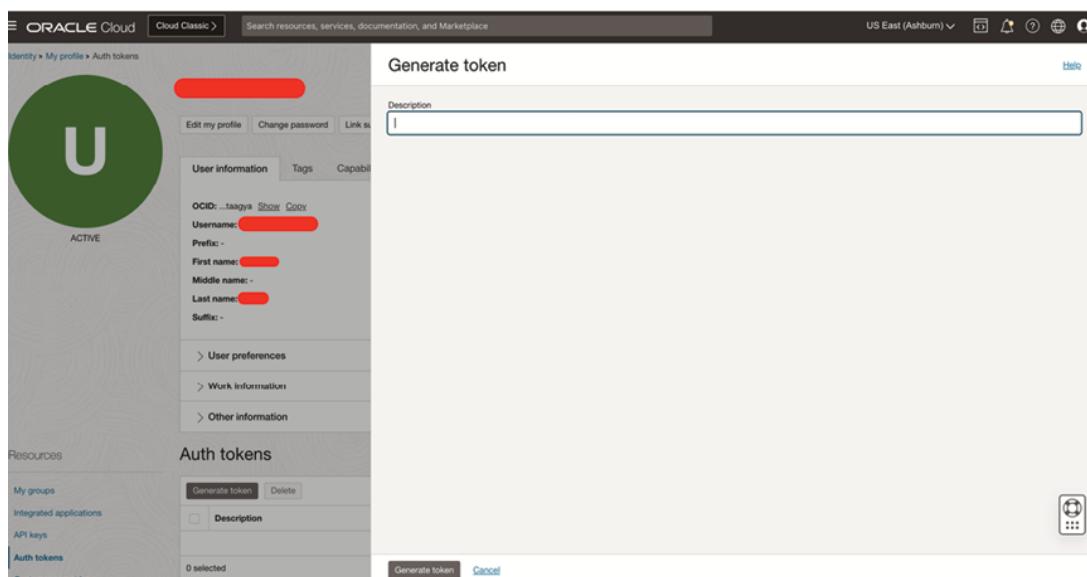


Figure 6.7: Generate token interface

2. **CSRF token validation:** Once we receive the request which has CSRF token, OCI API Gateway validates the CSRF token embedded within the request against the expected token associated with the user session. If the CSRF tokens matches, the request is considered as authentic and processed accordingly. In all other cases, the request is rejected immediately and blocked from further processing, which helps mitigate the risk of CSRF attacks.
3. **Secure token storage:** OCI API Gateway uses secure token storage mechanisms to protect CSRF tokens from manipulation or interception. This is achieved by implementing the encryption and securely managing CSRF tokens; OCI API gateway ensures the integrity and security of the token-based authentication mechanisms.

Benefits of using OCI API Gateway for CSRF protection:

- **Seamless integration:** OCI API Gateway integration with any web application is simple; seamless APIs are deployed within the OCI ecosystem providing out of the box CSRF protection capabilities without requiring any additional configuration, setup or development effort.
- **Scalability and performance:** OCI API Gateway is, by default, designed to scale dynamically to accommodate changes in traffic and demand, ensuring optimal performance and reliability even under peak loads or sudden spikes.
- **Centralized management:** Using OCI API Gateway, organizations can centrally manage CSRF protection policies, configurations, and settings in a single place, which enables easier management and consistent policy implementations across multiple APIs and endpoints and better control.
- **Comprehensive security:** Along with CSRF protection, OCI API Gateway offers another suite of security features or functionalities, such as authentication, authorization, encryption, auditing, and data protection capabilities to provide customers with comprehensive protection for web applications and APIs from different attacks and to improve the security postures.

The following are the recommendations:

- **Enable CSRF protection:** Ensure to enable the OCI API Gateway's built in CSRF protection option to provide a key layer of defense against CSRF attacks for web applications. This feature offers great value to validate the authenticity of all the incoming requests and prevents unauthorized modifications to sensitive data and protection from threats and attacks.
- **Configure CSRF tokens:** Implementing CSRF token generation and validation mechanisms within OCI API Gateway helps to improve the security many folds. This is achieved by generating unique CSRF tokens for each user session or

request and validating them against expected values. This helps organizations to ensure the integrity of all incoming requests and prevent potential CSRF exploits/attacks.

- **Integrate with API endpoints:** Integrate OCI API Gateway natively with your web application endpoints to implement CSRF protection policies for improved protection against attacks. This is enabled by enforcing CSRF protection at the API Gateway level; you can centralize security controls and administration and secure access to sensitive resources across your organization resources.

The following are the considerations:

- **Integration complexity:** We need to consider, like many other integrations, integrating OCI API Gateway with your web applications may involve additional steps and complexity; this is dependent on the web application architecture and existing infrastructure. We need to invest time and resources into configuration and development efforts to ensure seamless integration. This is applicable for any new setup or implementation where we need to consider additional work/setup involved in the integrations.
- **Cost:** We need to consider the implications cost of using OCI API Gateway for CSRF protection; as every service comes with a cost, we need to evaluate the cost vs value, which includes the price plans, usage limits, and potential scalability requirements. It's important to remember CSRF protection is essential for securing your web applications, but we need to aware of the associated additional costs accordingly to optimize your investment in security measures.

Cross-origin resource sharing API security

Cross-origin resource sharing (CORS) is well known security vulnerability. It is very important for API security to enable web applications to access resources from different origins securely. In the context of OCI, implementing advanced CORS policies is critical for avoiding the unauthorized access and protecting sensitive data and resources.

The following are the recommendations:

- **Define CORS policies:** The first step is to define comprehensive CORS policies in the OCI API Gateway to specify which origins are allowed to access which API resources. By defining explicit policies, you can control access to resources and prevent unauthorized cross-origin requests.
- **Validate origin headers:** It is essential to implement validation mechanisms to verify the origin headers of incoming sessions or requests and validate that they comply with the already defined CORS policies. The next step is validating the

origin headers, you can enforce strict access controls and mitigate the risk of unauthorized cross-origin requests by validating the origin requests.

- **Use preflight requests:** Using the option preflight requests, we can negotiate cross origin requests and determine whether the actual request should be allowed based on CORS policies. This preflight request greatly helps to enforce the CORS policies, which ensure that only the authorized origins (known) can access the API resources, which is critical for protecting the resources.

The following are the considerations:

- **Impact on API performance:** We should be implementing additional CORS policies that may introduce overhead to the systems, particularly for handling preflight requests and validating origin headers. Since it requires additional validations, it can cause performance and response time overhead and can impact user experience, so consider the potential impact on API performance and scalability when defining CORS policies in OCI API Gateway. Perform benchmarking and performance tests to understand the overhead and impact to the users and systems.
- **Complexity of CORS configuration:** Implementing and configuring CORS policies can sometimes be complex, which requires additional time and resources, especially for APIs that interact with multiple origins or have dynamic access requirements. Make sure that CORS policies are configured correctly and thoroughly tested for security and performance to avoid misconfigurations and security vulnerabilities.

mTLS and client certificates for securing API gateway resources

Securing resources over data transmissions is one of the key requirements, and having robust data transmission protocols and policies is essential for improved security. mTLS and client certificates are one of the powerful ways for securing API Gateway and API resources in the OCI Cloud. Using mutual TLS authentication, organizations can establish secure connections between clients and API Gateway, enabling the confidentiality, integrity, and authenticity of data transmitted over the public or private network.

The following are the recommendations:

- **Enable mutual TLS:** Implement OCI API Gateway to enforce mutual TLS authentication for incoming requests, which requires both the client and server to present valid certificates to establish a secure connection between them. Mutual TLS protocol help to prevent unauthorized access when data is being transmitted over the network and protects against common attacks such as man in the middle attack.

- **Issue client certificates:** Client certificates are another way to secure communication where client certificates are used to authorize API clients, enabling them to authenticate themselves securely and establish trust when communicating with API Gateway. Using the client certificates used during the communication, organizations can verify the identity of API clients and implement any additional access controls based on client identities.
- **Implement certificate revocation:** As we are using client certificates as a way to secure communication, managing the client certificates is a critical function. Implement policies and processes for revoking a client certificate in case of tampering or unauthorized access. Using a **certificate revocation list (CRL)** or using **online certificate status protocol (OCSP)**, organizations can quickly revoke tampered certificates to avoid unauthorized access. This is a critical step part of the intrusion detection and response.

The following are the considerations:

- **Certificate management:** Managing client certificates and **certificate authorities (CAs)** can be an important security function, but this is challenging, especially at a scale where there are thousands of certificate issues across the organizations. Make sure well-defined processes and tools are in place for certificate issuance, renewal, and revocation to maintain the security and integrity of the certificate infrastructure (PKI). It is essential and very critical to revoke the certificates in the certificate life cycle management to avoid any security incidents.
- **Performance overhead:** As we are already aware, any additional security checks or validations can impact performance, mutual TLS authentication may introduce performance overhead in some cases, particularly for handling certificate validation and encryption/decryption operations. It is suggested to consider the potential impact to performance and perform the performance testing when enabling the mutual TLS authentication for API resources.

The following are the steps for setting up custom domains:

1. **Domain registration:** Domain is your preferred name on the Internet, register a domain name through a domain registrar vendor or your preferred provider. Always choose a domain name that reflects your business and is easy to remember for users.
2. **DNS configuration:** Access your domain provider's DNS management console and configure DNS records to point to your hosting provider or cloud provider where your service is running. Create DNS records such as A (IPv4 address) or AAAA (IPv6 address) and CNAME (canonical name) records to map your

domain to the corresponding IP address(hostname) of your web server or API gateway.

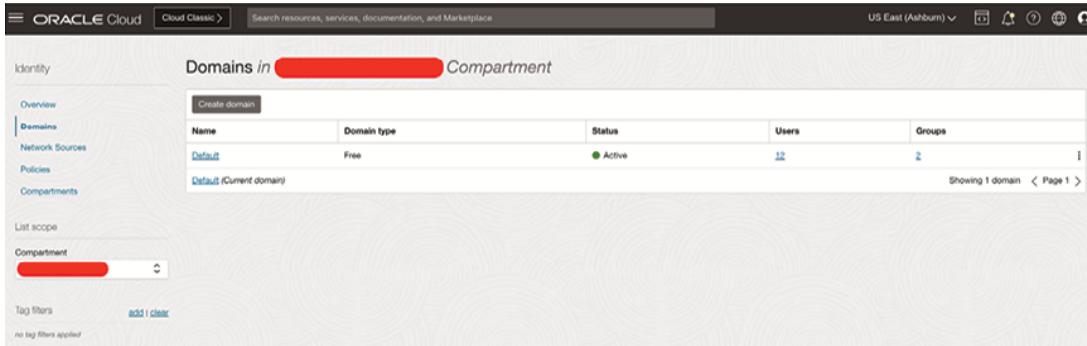


Figure 6.8: Interface to access OCI domains

3. **SSL/TLS certificate:** Use an SSL/TLS certificate for your organization custom domain registered to enable secure connection for data transfer over internet using HTTPS connections. You can get your SSL/TLS certificates from any trusted public/private **certificate authorities (CAs)** you use in the organization.
 - a. **Choose a CA:** There are multiple certificate authority in the market, who you can select a trusted CA from which you will obtain your SSL/TLS certificate. There are options such as DigiCert, and others. When choosing the CA, consider factors such as cost, support, and compatibility with your hosting environment, and public coverage or availability of the CA.
 - b. **Generate a certificate signing request (CSR):** The first step in the process of getting a certificate is to generate a CSR from your web server or hosting provider. CSR usually contains information about your organization and the domain for which you're requesting the certificate, and you can include email, address of the organization.
 - c. **Purchase or obtain the certificate:** Once you create the CSR, you can provide this info to get SSL/TLS certificate from the preferred CA, who will provide you the SSL/TLS certificate. This process usually changes based on the CA you choose, use the instructions shared by the CA to submit your CSR and complete the rest of the certificate generation process.
 - d. **Verify domain ownership:** Depending on the CA used in the organizations and the type of SSL/TLS certificate generated, there would be a need to verify that you own the domain for which you are requesting the certificate. This usually involves confirmation of the ownership through email verification process or adding a specific DNS record to your domain's DNS settings, this process helps to complete the validation of the domain ownership.

- e. **Install the certificate:** Once you receive SSL/TLS certificate from your CA, the next step is to install the certificate on your web server or hosting provider. This process depends on your hosting environment and can be different based on where your service is hosted. Generally, you need to upload the certificate files and any intermediate or root certificate chain to your server and configure your web server software (e.g., Apache, Nginx) to use the certificate for HTTPS (secure) connections. Also, update your web server or API gateway configuration to enable HTTPS connections using the installed SSL/TLS certificates. You can validate the setup by monitoring all the traffic in HTTPS and which is a safe and secure protocol and method for communication over the network.
- f. **Update DNS record:** In some cases, DNS update might be a requirement, this is needed if your website's DNS records are managed separately outside from your hosting provider, in such cases, you may need to update your DNS settings to point to your server's IP address or setup/configure DNS records is required for SSL/TLS certificate validation.
- g. **Test and monitor:** After performing all the steps and successful installation of the SSL/TLS certificates, it is time to test your website to ensure that HTTPS connections are working properly by validating the protocol used during the web traffic to see HTTPS is used as secure protocol. Enable monitoring on the certificate's expiration date and alert when you reach the near the expiration time and renew it before it expires to avoid service disruption and outage.

Adding CORS support to API deployments

Cross-origin resource sharing (CORS) support for API deployments is one of the prerequisite steps for enabling secure connections between web applications hosted on different domains. CORS allows servers to specify which origins are trusted and allowed to access their resources; this helps avoid unauthorized cross-origin requests, which is a must-do step.

Adding CORS to API deployment involves a few steps outlined below:

1. **Configure CORS headers:** In the API deployment configuration, set up CORS headers to define which origins are trusted and allowed to access your API.

The following is the header info:

- **Access-Control-Allow-Origin:** This header option defines the allowed origins for cross-origin requests. This value can be set to specific domains such as example.com or allow all origins (*) setting all origins can be dangerous; exercise caution when setting up all.

- **Access-Control-Allow-Methods:** This header option defines the allowed HTTP actions or methods such as GET, POST, PUT, DELETE allowed for cross origin requests; you can specify only GET or PUT, which allows greater control on the security.
 - **Access-Control-Allow-Headers:** This option specifies what HTTP headers are allowed in cross-origin requests; we can set up the filters on what headers are allowed, which provides greater control on what requests or responses to be allowed.
 - **Access-Control-Allow-Credentials:** This option indicates whether the browser should include sensitive credentials such as cookies authorization headers in cross origin requests. If we choose not to allow any cookies or credentials due to the sensitive nature of the app for better security, this option allows us to block it.
 - **Access-Control-Max-Age:** This option indicates how long the preflight request response can be cached, in seconds, we can specify the duration of the cache.
2. **Handle preflight requests:** For complex cross origin requests, such as requests with custom headers or non-default HTTP methods, browsers send preflight request options to validate if the actual request is allowed. This process ensures the API handles preflight requests and responds with appropriate CORS headers.
 3. **Test CORS configuration:** In order to test your API deployment's CORS configuration or setup to make sure it is working as expected. There are tools available like web browser developer tools, cURL, or postman utilities to send cross-origin requests and validate that the CORS headers are present in the responses, and you can validate the setup.
 4. **Document CORS policy:** Every setup is unique to the organization's requirements. It is important to document your API's CORS policy in your API documentation or developer portals to make users and developers understand the CORS policies, which explains the allowed origins, methods, headers, and other CORS-related configurations, which enable developers to avoid the issues with API development.
 5. **Update CORS configuration as needed:** Security is always changing, so periodic review of the configuration and policies is essential to update your API's CORS configuration based on changing requirements or security considerations. Review and adjust the allowed origins, methods, and headers as necessary to maintain and improve the security posture of your services.

Trust stores customization for TLS certificate verification

Trust stores in SSL/TLS setup contain a collection of trusted **certificate authority (CA)** certificates used to validate the authenticity of SSL/TLS certificates presented by servers during the SSL/TLS handshake process. This process enables trusting CA, which is well known and aware of the certificates they present. If the location of trust store changes or default CA is not present in the trusted store, you might need to customize the trust store to trust and enable the CA provided certificates.

The following steps outline the process of customizing trust stores for TLS certificate verification:

1. **Identify trust store location:** The first step is to determine the location of the trust store on the client system. Trust stores are typically files containing CA certificates in various formats (e.g., PEM, DER) stored in a specific directory or file path; this can be default path based on the servers or custom location.
2. **Add or remove CA certificates:** Default trust stores contain the public CA certificate bundles; you can customize the trust store by adding or removing CA certificates as needed. If we need to add a new CA certificate, you can obtain CA certificates from trusted sources, such as public CA certificate bundles or internal CA authorities.
3. **Update trust store configuration:** Trust store settings or configurations depend upon the client application running and the operating system that is running; it might require modifying the configuration to specify the location of the customized trust store.
4. **Verify certificate chains:** Make sure that the customized trust store contains all necessary public or private CA certificates to validate the certificate chain presented by the server during the SSL/TLS handshake. It is critical to validate that the trust store includes intermediate or root CA certificates if the server's certificate is issued by an intermediate or root CA.
5. **Handle certificate revocation:** It is best practice to include **Certificate Revocation Lists (CRLs)** or **Online Certificate Status Protocol (OCSP)** responders in the trust store to check the validity of SSL/TLS certificates and handle certificate revocation events automatically.
6. **Test trust store configuration:** In order to test the trust store configuration by establishing SSL/TLS connections to servers using client applications. It can be validated with OpenSSL tools for testing and verifying that the client application correctly validates server certificates against the customized trust store and handles the TLS/SSL connections without any errors.
7. **Monitor and update trust store:** Have periodic reviews of the trust store and ensure the contents of the trust store and update it as needed to reflect changes in CA certificates, certificate revocation status, or security policies.

Customization of the trust stores for TLS certificate verification, organizations can improve the security and trustworthy SSL/TLS communication between clients and servers.

Web application firewall

The most advanced and robust security mechanism for web applications is implementing WAF, which is proven to be the most effective defense mechanism against cyber security attacks in public-facing web applications.

OCI Cloud offers a great security solution in the form of the **web application firewall (WAF)**, which is a powerful tool designed to protect web applications from a wide array of attacks such as SQL injection, **cross-site scripting (XSS)**, and **distributed denial-of-service (DDoS)** attacks and a wide variety of the known industry attacks.

In this section on the WAF, we discuss in detail the functionalities and capabilities of the OCI Web Application Firewall, understanding how it can be using the WAF functionalities to protect both internet-facing and internal applications against malicious actors, attacks and potential vulnerabilities.

OCI Web Application Firewall contains a comprehensive set of security rules and policies that help organizations define granular controls over incoming applications traffic. These rules can be customized to specific organization and application requirements, allowing organizations to mitigate commonly known attack vectors while ensuring the seamless flow of actual user traffic. The key feature of the OCI Web Application Firewall is its ability to protect application load balancers from a variety of attacks over the internet. This is achieved using the WAF rules at the load balancer level, organizations can intercept and inspect incoming user requests, identifying and blocking malicious traffic before it reaches the application servers hosting the web services. This proactive method helps prevent potential exploits before reaching the web servers and ensures the availability and integrity of web applications.

OCI Web Application Firewall provides support for TLS termination, TLS termination allows organizations to offload SSL/TLS decryption and encryption functions to the WAF. By terminating TLS connections at the edge, organizations can inspect encrypted traffic for potential threats, ensuring that sensitive data remains protected while maintaining high performance and scalability.

OCI WAF offers a robust protection mechanism for APIs, protecting them against common vulnerabilities such as injection attacks, broken authentication, and improper access controls. Customers can define WAF rules specifically tailored to API endpoints; organizations can enforce stringent security controls and prevent unauthorized access to sensitive data and resources from cyber security attacks.

OCI Web Application Firewall serves as a critical component of the security infrastructure within Oracle Cloud Infrastructure cloud, WAF offering unparalleled

protection for web applications against a wide range of threats across the security world. Using WAF advanced features, organizations can ensure the confidentiality, integrity, and availability of their web applications, reducing the risk of data breaches and attacks on sensitive web applications.

WAF offers huge capabilities, diligent configuration, and use of security best practices, and understanding of the applications and security attack patterns,. Organizations can utilize the full potential of the OCI Web Application Firewall to protect mission-critical business applications from a wide range of security and availability attacks.

Protecting public and internal applications from attacks

Protecting both public facing and internal applications from attacks is important for maintaining the security and integrity of the applications and data. Load balancers play a key role in this security defense strategy by distributing incoming traffic across multiple servers or resources, enhancing performance, reliability, and security.

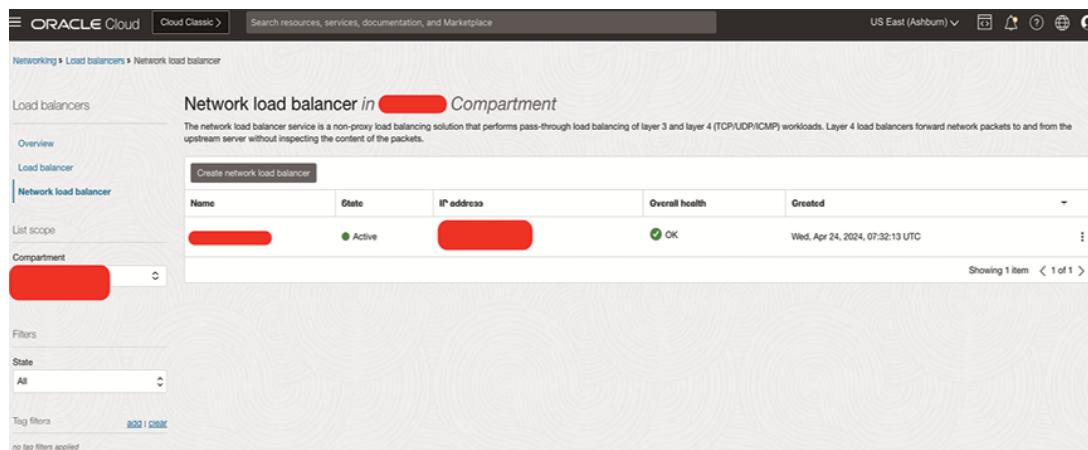


Figure 6.9: OCI load balancer

Below steps outline how load balancers can be used to secure both internet-facing and internal applications:

1. Internet facing (public) applications:

- Distributed denial of service (DDoS) protection:** DDoS are very common attacks that cause outages to services, which create huge financial loss to organizations and inconvenience to users. Using load balancers, we can reduce the DDoS attacks by distributing incoming traffic between multiple servers and setup rate limiting, IP filtering, and other techniques to identify and deny the service to bad traffic or actors.
- Web application firewall (WAF) integration:** Load balancers have the features of WAF where they provide WAF functions such as to inspect and

filter incoming traffic for any malicious attacks from bad actors which are **cross-site scripting (XSS)**, SQL injection or DDoS and other well-known application vulnerabilities.

- c. **SSL/TLS termination:** Load balancers can terminate the SSL/TLS traffic and offload SSL/TLS encryption and decryption at the load balancer level. This feature of load balancers reduces the resource utilization and performance overhead on servers and makes it easier for certificate management and renewals for internet facing applications.
- d. **Access Control Lists (ACLs):** ACLs can be implemented on the load balancers to restrict or control access to specific endpoints or resources based on IP addresses, geographical locations (LBAC), or any other criteria. This is key protection which helps prevent unauthorized access and brute force attacks on the internet facing end points.
- e. **Session persistence:** Enabling session persistence (sticky sessions) is a useful feature available in the load balancers for stateful web applications by configuring the load balancer to route requests from the same client (based on the session) to the same backend server always, maintaining session data integrity, user experience and helps in maintaining the session validity by routing to same servers.

2. Internal (customer network) applications:

- a. **Network segmentation:** Deploy internal load balancers to segment network traffic within private or internal networks such as *High Sec, Low Sec, Mid Sec*. This provides the isolation and compartmentalization of application resources and services.
- b. **Intrusion detection and prevention:** Integrate load balancers with IDPS systems to monitor and analyze internal network traffic patterns for suspicious behavior, malware, or unauthorized access attempts.
- c. **Zero trust architecture:** ZTA is very popular in the security world, implement zero trust principles by authenticating and authorizing all internal network communications through the load balancer, regardless of source or destination, to mitigate lateral movement and insider threats in the internal network.
- d. **Health checks and auto scaling:** Auto scaling is a key feature in the load balancers, configure load balancers to perform health checks on backend servers and automatically scale resources based on demand, ensuring high availability, fault tolerance, and scalability for internal facing applications.

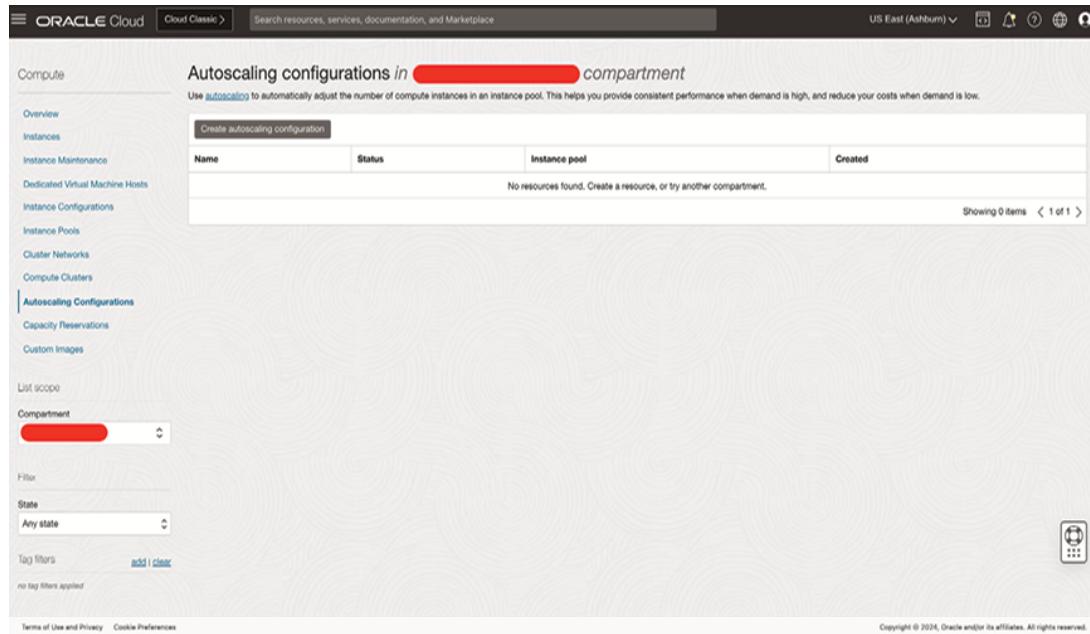


Figure 6.10: Configuration interface for OCI Auto Scaling

- e. **Content-based routing:** This is an intelligent feature in the load balancers where you can route internal application traffic based on content or application-specific parameters (e.g., URL paths, HTTP headers, or other parameters), enabling better control and optimization of application delivery and performance.

Securing applications with load balancer

One of the trends in the industry is to secure applications with a load balancer; this is a critical aspect of modern cybersecurity strategies. Load balancers can serve as a frontline defense mechanism as they are the first point of contact with user requests, and they manage incoming traffic, distributing it across multiple servers. Implementing security measures using load balancer to protect against various attacks is a great way to utilize load balancers for applications security. There are different ways to configure the load balancers. A few of them are discussed below:

1. **SSL/TLS offloading and termination:** Load balancers can offload SSL/TLS encryption and decryption tasks from backend servers; this helps reduce their processing overhead and centralizes certificate management. By terminating SSL/TLS connections at the load balancer, still sensitive data remains encrypted during transmission over the internet from client to load balancer and this does not reduce the security posture of the applications.
2. **Web Application Firewall (WAF) integration:** Modern load balancers come with built-in or integrated WAF capabilities to inspect and filter incoming traffic for common web application attacks such as XSS, SQL injection and file

uploads or other well-known attacks. WAFs usually use a defined set of rules, and customers can have custom rules added; this helps with anomaly detection and identifying and blocking malicious traffic, protecting business-critical applications from external attacks.

3. **Web Application Firewall (WAF) Load Balancer:** WAF rules for **load balancer (ALB)** are essential for deploying a robust security strategy for organizations. WAF rules serve as the first line of defense, inspecting the incoming traffic to web applications hosted behind load balancers. WAF custom rules can inspect and mitigate large sets of threats, which usually follow in the format of SQL injection, XSS, and malicious file uploads and other wide variety of attacks. WAF rules also provide real-time monitoring and logging capabilities, which allow organizations to monitor, detect, and respond to security incidents immediately and take action. Using load balancers native integration with WAF, organizations can easily deploy and manage WAF rules to protect the business-critical web applications against evolving cyber threats.
4. **Elastic Load Balancing (ELB):** ELB provides robust support for **Transport Layer Security (TLS)**, ensuring secure communication between clients and backend servers. TLS encryption is essential for protecting sensitive data transmitted over the internet from eavesdropping and tampering. ELB offers several features to facilitate TLS encryption and certificate management.
5. **Transport Layer Security (TLS):** We have discussed encryption as a fundamental security measure for ensuring the confidentiality and integrity of data transfer between clients and servers over the Internet. TLS enforces the end-to-end encryption of the traffic from client to servers, providing a secure and safe data transmission during the entire transmission process. TLS is a modern and very major, and critical security measure for data transmission in public or private networks. We cannot imagine a critical application not using TLS in the modern world, which emphasizes the need and significance of TLS in securing web applications.

Below outlines how TLS works from client to servers and how encryption works in detail:

- **Client-side encryption:** The TLS handshake begins when a web client, such as a web browser, or mobile app, initiates a connection to a server, such as a web server, or API server endpoints. First the client sends a **ClientHello** message to the server, indicating its support for TLS encryption and specifying its preferred cryptographic algorithms (there are a wide variety of crypto algorithms) and parameters.
- **Server-side encryption:** Once server receives the **ClientHello** message, the server responds with a **ServerHello** message, selecting the appropriate TLS version, cipher suite (from the range of cipher supported),

and other parameters for establishing the encrypted connection. The server also sends its digital certificate, which includes its public key and identity other information, which allows the client to verify the server's authenticity.

- **Key exchange and session establishment:** During the TLS handshake exchange, the client and server perform a key exchange protocol using *Diffie-Hellman* key exchange to securely generate a shared secret key used for symmetric encryption and decryption of data. This shared secret key is ephemeral and unique to each TLS session, providing forward secrecy.
- **Data encryption and transmission:** Using the shared secret key established between source and target now, the client and server can encrypt, and decrypt data exchanged during the TLS session using symmetric encryption algorithms such as AES. All data transmitted between the client and server, including HTTP requests, responses, payloads, and other information in the headers, are encrypted to avoid any unauthorized access and tampering of data over the network.
- **End-to-end protection:** End-to-end protection is possible when all the data from client to server is fully encrypted; TLS ensures that data remains encrypted and secure throughout the entire transmission process from client to all the way to server. This enabled the protection of sensitive information, such as login credentials, personal data, and financial transactions or any other sensitive information that is being transmitted from client to server from interception, eavesdropping, and man-in-the-middle attacks and tampering.
- **Server authentication:** As part of the TLS handshake, the client verifies the authenticity of the server's digital certificate using a chain of trust anchored in trusted CAs such as server, intermediate, and root certificates. This ensures that the client is communicating with the intended server and not an impostor or malicious entity in the middle of the communication.
- **Mutual authentication (Optional):** In some cases, mutual TLS authentication is required based on the business and application requirements. In mutual TLS, both the client and server authenticate each other using digital certificates. This enables an additional layer of assurance of each party's identity and helps prevent unauthorized access to protected resources. This can be used as a client certificate to validate client authenticity.

1. **Access control and authentication:** Load balancers can enforce access control policies based on IP addresses, **geographical locations (LBAC)**, user agents, or any other criteria to restrict access to applications and resources based on some

source rules. Load balancers can also integrate with authentication services such as LDAP, Active Directory, or OAuth/OpenID Connect to authenticate first users before granting access to sensitive applications, ensuring only authorized users can interact with applications, and it is validated before allowing access to the applications.

2. **Rate limiting and bot protection:** Load balancers can implement rate limiting and bot protection mechanisms to mitigate **distributed denial of service (DDoS)** attacks, which are targeted at the availability of the service, brute force attacks, and bot-based attacks, which are automated bots. We can have better control of security by monitoring incoming traffic patterns and applying rate limits to suspicious or abusive clients; load balancers can prevent server overload, maintain application availability against attacks, and protect against a wide range of application layer attacks.
3. **Data protection:** Load balance can help with data protection along with SSL/TLS termination, they also can encrypt traffic between backend servers or services using protocols such as IPsec or TLS mutual authentication. This ensures end-to-end encryption and data integrity from load balance to servers, protecting sensitive information from unauthorized access or tampering, especially in microservices or distributed architectures, which are widely used currently.
4. **Logging and monitoring:** Load balancers generate logs and metrics by default that provide visibility into application traffic, failures, patterns performance, and security events. Using the events and logs and by monitoring and analyzing these logs in real-time, organizations can detect anomalous behavior, security incidents, and potential threats and take required action based on the information from load balancer logs.
5. **Protecting API with WAF:** Protecting APIs with a WAF is an important security measure for organizations to protect against a wide variety of cyber threats targeting API endpoints. WAFs serve as a protection layer between the API and potential attackers. WAF acts as a filtering and monitoring of incoming HTTP traffic to detect and block malicious requests. Using WAF protections for APIs, organizations can mitigate risks such as SQL injection, XSS, API abuse, and other attack patterns. WAF rules can be customized to the specific requirements of API security, including rate limiting, input validation, and protocol enforcement. WAFs also provide real-time visibility into API traffic patterns and security events, enabling proactive threat detection and response.
6. **Private APIs:** Private APIs are API endpoints that are intended for internal use within an organization or restricted access to authorized users or applications. These APIs are typically not exposed to the public internet and are accessed securely within a private network or through VPN connections or allow listing by specific IP ranges. These API are not intended to expose to everyone over the

internet. Private APIs are commonly used for internal communication between microservices, backend systems, and third-party integrations. Implementing private APIs helps organizations have control over sensitive data and limit exposure to external threats by eliminating broader access to the Internet. Access to private APIs can be restricted using secure authentication mechanisms protocols such as API keys, OAuth tokens, or mutual TLS authentication, ensuring that only authorized users or applications can access the protected API resources.

7. **Monitor and control access to web applications:** Monitoring and controlling access to web applications is a critical component for maintaining security and compliance mission-critical applications. Organizations can implement access control mechanisms with various tools such as RBAC, IAM), and MFA to enforce strong mechanisms of security policies and best practices; This can be achieved by implementing least privilege principles to protect and avoid unauthorized access to critical business applications. For effective monitoring practices it's essential to monitor user activities and access patterns and behaviors. Companies can monitor and detect any anomalous behavior or suspicious login attempts by bad actors, and potential security events in real time. Having good logging and auditing mechanisms helps organizations to track and review access to web applications, which helps with compliance with regulatory requirements and security best practices to improve the security posture of the systems.
8. **Threat intelligence:** It is very critical for organizations to know the threat landscape risks in the outside world before they happen; this requires intelligence information about threats an organization or industry faces. Threat intelligence is a process of gathering, analyzing, and using the gathered information about cyber security threats, vulnerabilities, and adversaries to understand and improve security mechanism and incident response functions. Integrating threat intelligence data feed from trusted sources externally, we can proactively identify threats zero-day vulnerabilities, and known attack patterns in the industry, which are targeting web applications and APIs. Threat intelligence provides valuable inputs or context and insights into the pattern's such as **tactics, techniques, and procedures (TTPs)** used by threat actors, enabling organizations to prioritize security efforts and take proactive measures to understand and mitigate the risks. Threat intelligence can also be used to improve security event data and algorithms and improve incident response procedures, ultimately hardening the overall security posture of web applications and APIs.

User pools

OCI user pools serve as a foundational component of identity management in the cloud offering authentication and authorization capabilities for users accessing OCI resources and services.

Below is the overview of the user pools in OCI:

- **Authentication:**

- **Local user authentication:** OCI user pools support authentication through locally managed user accounts such as local accounts, which allows users to authenticate using the username and password credentials stored in the OCI environment.
- **Federated authentication:** User Pools enable federated authentication, which allows users to authenticate with OCI using credentials federated, which means authentication from external identity providers, such as customer corporate directories (AD) or third-party **identity providers (IdP)** supporting standard protocols like SAML (Okta) or OAuth.
- **Identity verification:** User pools help validate user identities during the authentication process, making sure that only authenticated users can access protected data or resources and perform authorized actions that are assigned to the users.
- **Password policies:** User pools provide administrators capabilities to define password policies, including minimum length, password complexity, and password expiration settings, to enforce strong password security policies and practices.

- **Authorization:**

- **Role-based access control (RBAC):** OCI user pools in OCI follow RBAC principles, which enable administrators to define roles for granular sets of permissions and assign them to users in the OCI environment; this helps organizations to use the RBAC effectively in the cloud environment.
- **Policy based authorization:** OCI user pools use IAM policies to implement the access controls, which allows administrators to define policies that define the conditions in which users are granted access to OCI resources and services. Policy based authorization acts as one of the strong foundations for the secure access principles in the cloud.
- **Group based access control:** OCI user pools also support group-based access control, which enables administrators to organize users into different groups and apply access policies at the group level; this simplifies the management of permissions, privileges across multiple users, and standards can be implemented using the using based access controls.

- **Dynamic group memberships:** OCI Cloud uses pools to enable dynamic group memberships; dynamic group memberships are based on user attributes or custom logic. This allows administrators to automatically assign users to groups and apply group-based access control policies.

User pools in OCI provide a secure and scalable solutions for managing user identities effectively and setup secure access to OCI resources. This is achieved by implementing strong authentication and authorization capabilities. User pools help organizations enforce access controls, maintain compliance, and enable the protection of sensitive data and resources in the OCI environments.

Identity pools

OCI identity pools, also called with other name as *identity providers* serve is a centralized solution for handling and managing the identities of users and access control for the users in the OCI Cloud. Identity pools also help manage user identities such as creation, deletion, and any modification of user accounts in the OCI Cloud.

OCI identity pools support authentication mechanisms for users accessing OCI data, applications and resources, this includes the username and password authentication, federated authentication with external identity providers, and integration with **single sign-on (SSO)** solutions.

Identity pools facilitate federated authentication, enabling users to authenticate with OCI using their existing credentials from external identity providers, such as Active Directory, Okta, or other SAML/OAuth providers. OCI identity pools integrate with SSO solutions to provide easy and secure access to OCI resources. This allows users to sign in once and access multiple applications, resources, and services in the OCI environment without the need for additional login every time an application's access is requested. Identity pools in the OCI Cloud support RBAC principles, enabling administrators to setup roles with specific sets of permissions and assign them to users or groups in the OCI Cloud to control access to OCI applications, systems and resources. Identity pools also help companies implement security policies and compliance standards by providing centralized, simple user management and access control options, which ensures that only authorized users can access OCI resources and services for maximum protection.

Authentication

In OCI, authentication in identity pools refers to the process of verifying the identity of users or services accessing cloud resources. OCI IAM supports creation of users who can authenticate using their credentials and allows federated users to authenticate using credentials from external identity providers.

- **IAM users:** OCI IAM console helps allow the creation of users who can authenticate using their basic credentials (username and password) in the OCI environment. The below figure shows the OCI IAM console interface to create users in the default domain:

Figure 6.11: Access UI in identity domain for OCI users

- **Federated users:** OCI IAM supports federated users enabling users to authenticate using credentials from external identity providers, such as Oracle Identity Cloud Service or other identity providers supporting standard protocols like SAML or OAuth.
- **API signing:** OCI IAM supports API signing for programmatic access, where applications and services can authenticate and authorize using cryptographic signatures based on API keys.

Authorization

In OCI, authorization in identity pools refers to the process of determining whether a user or service has the right to access specific resources after their identity has been authenticated. Below are a few important points to discuss about authorization in identity pools:

- **IAM policies:** OCI IAM uses policies to define permissions, allowing administrators to grant access to specific OCI resources and services based on roles, groups, compartments, or individual users.

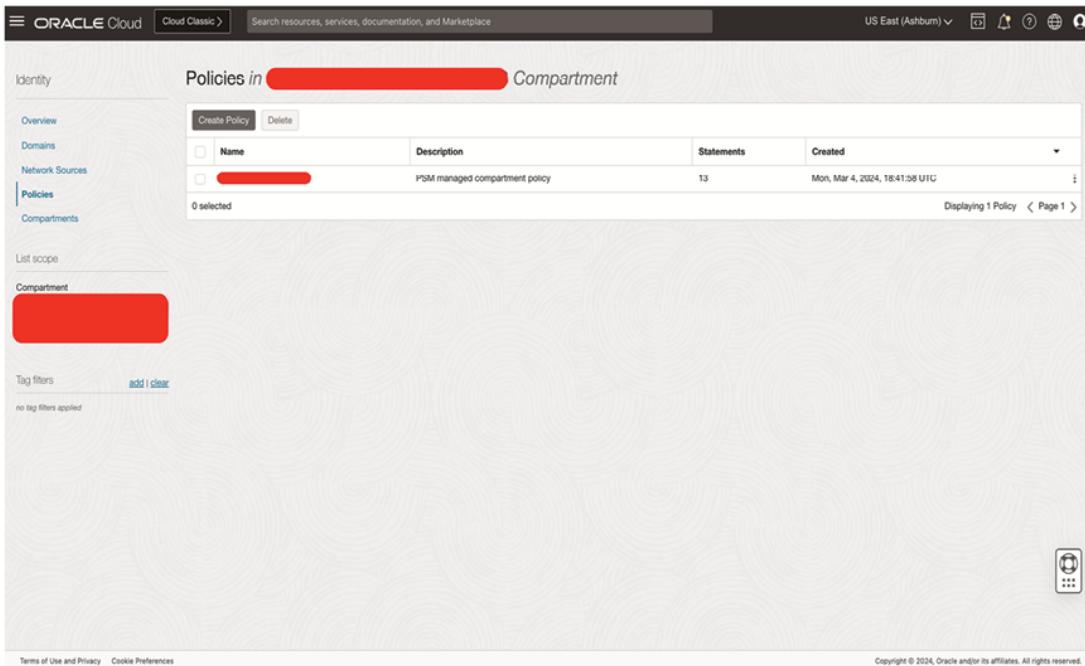


Figure 6.12: OCI policies interface

- **RBAC:** OCI IAM follows RBAC principles, allowing administrators to define roles with specific sets of permissions, which can be assigned to users or groups within the OCI environment.
- **Compartment access:** OCI IAM provides compartmentalization, allowing administrators to organize resources into compartments and define policies to control access to those compartments based on user roles or group memberships.
- **Network security:** OCI IAM integrates with other OCI services, such as **Virtual Cloud Networks (VCNs)** and Security Lists, to control network access to resources based on IAM policies.
- **Service-to-service authentication:** OCI IAM supports service-to-service authentication using instance principals, allowing OCI services to authenticate and authorize requests made between different OCI services without the need for user credentials.

Granular authorization with user and identity pool

Granular authorization with user pools and identity pools in OCI enables organizations to implement fine-tuned access controls for users accessing OCI resources and services. Here is how granular authorization works with user pools and identity pools in OCI:

- **User pool:**
 - **RBAC:**

- User pools in OCI support RBAC principles, allowing administrators to define roles with specific permissions tailored to their organization's needs.
 - Administrators can assign these roles to individual users or groups within the user pool, granting them access to OCI resources based on their assigned role.
- **Policy-based authorization:**
 - OCI IAM policies can be applied to user pools to enforce fine-grained access controls.
 - Administrators can define IAM policies that specify the conditions under which users in the user pool are granted access to specific OCI resources, such as compartments, virtual machines, or storage buckets.
 - **Group-based access control:**
 - User pools support group management, allowing administrators to organize users into logical groups based on their roles, departments, or projects.
 - IAM policies can be applied to these groups to streamline access management and apply consistent access controls to multiple users simultaneously.
- **Identity pool:**
 - **Dynamic group memberships:**
 - Identity pools in OCI support dynamic group memberships based on user attributes or custom logic.
 - Administrators can automatically assign users to groups within the identity pool based on their identity attributes, enabling dynamic and scalable access control policies.
 - **Resource-based policies:**
 - Identity Pools can be associated with IAM policies that define access controls for OCI resources and services.
 - These resource-based policies allow administrators to specify which users or groups within the identity pool are granted access to specific resources and under what conditions.
 - **Attribute-based access control (ABAC):**
 - Identity Pools enable ABAC by allowing administrators to define authorization rules based on user attributes such as department, job title, or

project affiliation.

- IAM policies can incorporate these attributes to enforce context-aware access controls, ensuring that users only have access to the resources they need to perform their roles.

Conclusion

This chapter offers a comprehensive and details explanation of how to secure applications within OCI. OCI provides a variety of tools and technologies such as protecting web applications, secure against potential threats, and improving API security to handle complexities of user and identity pools; this chapter helps engineers with the knowledge and tools necessary to improve their security postures and protect their various resources and assets of the organizations.

This chapter outlines the importance of a multi layered approach to application security, by implementing proactive security measures and plans to reduce the risks and improve the security of mission critical applications. Focusing deep dive into the details of service mesh architecture, organizations gain a deeper understanding of how to secure microservices based applications effectively. The creation of ingress gateway route tables and the detailed interactions between mesh and virtual service mTLS provide detailed insights into building great security frameworks within distributed systems.

This discussion around OCI API Gateway and OpenID Connect elucidates powerful tools and methodologies for securing web applications. From implementing CSRF protection to using mutual TLS and client certificates, organizations are provided with the knowledge to protect their APIs and reduce common vulnerabilities. The integration of custom domains and TLS certificates, alongside the addition of CORS support to API deployments, greatly improves security measures and ensures seamless access control.

WAF is a critical component in the protection against internet facing and internal application threats. Using WAF rules for application load balancers and implementing end to end TLS, organizations can establish great security perimeters and protect against a wide range of attacks. The addition of elastic load balancing and TLS termination improves security measures, ensuring data integrity and security throughout the transmission process.

User and identity pools emerge as essential components of identity management in the OCI, providing authentication and authorization mechanisms that are both secure and scalable. Granular authorization techniques and dynamic group memberships, organizations can implement into fine tuning access controls and implement least privilege principles effectively.

Application Security Unleashed chapter provides detailed application security and guides organizations seeking to improve their application security and protect their

digital assets within Oracle Cloud Infrastructure. Using the principles and best practices discussed in this chapter, engineers can improve the services for great security posture, mitigate risks, and get trust among users and businesses. In the next chapter, we will delve into the critical security elements and expert techniques for optimizing Software as a Service application in the OCI platform. In the next chapter, we will focus on enforcing access restrictions, preserving data integrity, implementing SaaS governance, and integrating DevSecOps methodologies for ultimate security.

Multiple choice questions

- 1. Which type of firewalls are designed to protect against web application attacks, such as SQL injection and cross-site scripting?**
 - a. Stateful inspection firewall
 - b. Web Application Firewall
 - c. Incident firewall
 - d. Packet filtering firewall
- 2. You are using a custom application with third-party APIs to manage application and data hosted in an OCI tenancy. Although your third-party APIs do not support OCI's signature-based authentication, you want them to communicate with OCI resources. Which authentication option must you use to ensure this?**
 - a. OCI username and Password
 - b. API Signing Key
 - c. SSH Key Pair with 2048-bit algorithm
 - d. Auth Token
- 3. Which OCI cloud service lets you centrally manage the encryption keys that protect your data and the secret credentials that you use to securely access resources?**
 - a. Data Safe
 - b. Cloud Guard
 - c. Data Guard
 - d. Vault

Answers

1. b
2. d
3. d

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CHAPTER 7

SaaS Applications Optimization and Security

Introduction

Software as a Service (SaaS) applications have been the most significant underlays of today's business workflow. In a fast-paced cloud computing generation, the **Oracle Cloud Infrastructure (OCI)** has positioned at the center of providing the infrastructure, to allow organizations around the globe to deliver software applications to users worldwide. Thanks to the granularity of resources, flexibility, and cost-saving nature of cloud, software provisioning has become a much more straightforward process. However, this benefit includes the increased responsibility in protecting SaaS applications and data, as well as guaranteeing the efficiency of the applications.

In this chapter, review the important security and optimization factors that are pivotal to the success and security of SaaS solutions. Since applications are being moved to the cloud at a steady pace, it is crucial to know how to apply access control, data control, governance, and DevSecOps. This chapter will also explore the most sophisticated methods and practices to enhance SaaS applications in the OCI environment. From the implementation of solid robust access control right up to the building of security considerations into the coding pipeline, the techniques that let companies surmount the positioning challenges of cloud security are covered. In addition, we will explain the role of SaaS governance frameworks in the compliance of SaaS business with the industry regulation and internal policies. Governing activities include risk management, compliance, and audit trails as part of the overall governance process. We will discuss how OCI can be used to audit and log activities performed by users so that organizations can meet the compliance standards.

Structure

This chapter covers the following topics:

- Advanced performance optimization
- Scaling strategies
- Advanced security measures
- DevSecOps access controls
- DevSecOps access governance
- Oracle Break Glass and OIM
- Integrating Break Glass with OIM
- Best practices for Break Glass procedures in OIM
- Implementation of secure data isolation
- Access control mechanisms
- Data encryption
- Data access auditing and monitoring
- Compliance and regulatory requirements
- Data isolation in SaaS
- Oracle Identity and Cloud Services
- Access controls in OCI
- Data residency and compliance
- Oracle CASB Cloud Service

Objectives

The core objective of this chapter is to provide a comprehensive and detailed understanding of Advanced performance optimization. By discussing sophisticated strategies and best practices, we aim to equip readers with the knowledge and skills needed to elevate security measures related to applications, understand in detail about data access auditing, monitoring, and data encryption to an advanced level. This includes in-depth coverage of advanced concepts such as key concepts in compliance and regulatory considerations, Access controls in OCI, data residency and compliance, oracle Break Glass and Oracle Identity Manager. Our goal is to empower readers to implement advanced security measures effectively, ensuring the resilience and integrity of their security tools in the dynamic and evolving landscape of OCI.

By the end of this chapter, readers will be provided a step-by-step framework on how SaaS applications can be designed, protected, governed, and deployed on Oracle Cloud Infrastructure to meet their sensitive business needs. By incorporating the lessons of access control, data protection, governance, and DevSecOps, organizations can build robust SaaS deployments and showcase their best practices. We hope you enjoy the ride with us on this exploration of how every SaaS application can be deployed securely and efficiently on OCI.

Advanced performance optimization

Fine-tuning the performance of SaaS applications running on OCI can provide the best experience for users and make the most of your investments in cloud services. In this section, we will discuss different ways to implement fine tuning and understand how to improve the performance of applications running on OCI using advanced networking capabilities, compute instance shapes and caching mechanisms.

The fine-tuning of application performance is undertaken as follows:

- **Conduct comprehensive performance profiling:** This is one of the important steps to fine tune application performance. We need to identify at a high level, where the application has performance bottlenecks. This can be identified by conducting a detailed performance profiling using tools like *OCI Monitoring, APM, or third-party solutions*. This will identify the areas for improvement.
- **Optimize code and application architecture:** In a secure software development life cycle, it is recommended to periodically review and optimize application code and architecture. This will minimize resource usage, reduce latency, and improve scalability. Secure software development lifecycle offers various techniques such as code refactoring, database query optimization, and asynchronous processing. These techniques can significantly enhance performance.
- **Implement efficient resource utilization:** OCI provides autoscaling capabilities. These capabilities allow the system to dynamically adjust compute resources, based on demand, ensuring optimal resource utilization and cost efficiency.

The advanced networking features are utilized as follows:

- **Leverage OCI's FastConnect and VPN services:** This is one of the recommended performance optimization techniques. In this approach, dedicated network connections between OCI and on-premises environments will be established, using *FastConnect or encrypted VPN tunnels*. This approach reduces latency and thereby significantly improves network reliability, for

hybrid cloud deployments. *Figure 7.1* illustrates OCI fast connect connections interface:

The screenshot shows a table titled "FastConnect connections in [REDACTED] Compartment". The table has columns for Name, Lifecycle state, IPv4 BGP state, IPv6 BGP state, Connection type, and Created. A message at the bottom says "No items found." and "Showing 0 items < 1 of 1 >".

Name	Lifecycle state	IPv4 BGP state	IPv6 BGP state	Connection type	Created

Figure 7.1: OCI FastConnect connections

Figure 7.2 depicts the site-to-site VPN configuration in OCI:

The screenshot shows a table titled "Site-to-Site VPN in [REDACTED] Compartment". The table has columns for Name, Lifecycle state, Customer-premises equipment, Dynamic routing gateway, and Created. A message at the bottom says "No items found." and "Showing 0 items < 1 of 1 >".

Name	Lifecycle state	Customer-premises equipment	Dynamic routing gateway	Created

Figure 7.2: OCI site-to-site VPN

- **Virtual Cloud Networks (VCN) and subnets:** Subnets and VCN's should be designed to isolate and to optimize network traffic flow. This setup also minimizes the latency and increases network for SaaS applications. Below figure represents the interface in OCI to access virtual cloud networks in a specific compartment.

The screenshot shows a table titled "Virtual Cloud Networks". The table has columns for Name, State, IPv4 CIDR Block, IPv6 Prefix, Default Route Table, DNS Domain Name, and Created. Two rows are listed:

Name	State	IPv4 CIDR Block	IPv6 Prefix	Default Route Table	DNS Domain Name	Created
[REDACTED]	Available	[REDACTED]	—	[REDACTED] Default Route Table for Dinesh_Demo_VCN_LB	[REDACTED]	Sat, Feb 10, 2024, 17:56:49 UTC
[REDACTED]	Available	[REDACTED]	—	[REDACTED] Default Route Table for Dinesh_Demo_VCN	[REDACTED]	Sun, Feb 4, 2024, 19:38:08 UTC

Figure 7.3: OCI Virtual Cloud Networks

Figure 7.4 represents the layout of OCI VCN sandbox:

The screenshot shows the OCI VCN sandbox interface. On the left, there's a large green hexagonal icon with 'VCN' in white. Below it, the word 'AVAILABLE' is displayed. The main area has tabs for 'Details', 'Security', and 'Traffic'. The 'Details' tab is selected, showing 'VCN Information' with fields like Compartment (redacted), Created (Sun, Feb 4, 2024, 19:33:06 UTC), IPv4 CIDR Block (redacted), IPv6 Prefixes (—), OCID (redacted), and DNS Resolver (Redacted). It also lists Default Route Table (Redacted) and DNS Domain Name (dns1.comvcn.oci.dev). Below this, there are sections for 'Resources' (Subnets, CDR, Route Tables, Internet Gateways) and 'Subnets' (a table with two rows: Private Subnet and Public Subnet, both marked as Available).

Figure 7.4: OCI VCN sandbox

- **Traffic steering with traffic management:** OCI's traffic management service helps intelligent routing of traffic based on performance metrics, geographic location, or user defined custom rules, ensuring optimal user experience. [Figure 7.5](#) explains the fields in traffic steering:

The screenshot shows the OCI traffic management steering policies interface. The left sidebar includes options for DNS management, Overview, Zones, Traffic management steering policies (selected), Private views, and HTTP redirects. The main area displays 'Traffic management steering policies in [REDACTED] Compartment'. A sub-header says 'Use traffic management steering policies to serve intelligent responses to DNS queries. Different answers (endpoints) might be served for the query depending on the policy logic.' A 'Create traffic management steering policy' button is at the top right of the table. The table itself has columns for Policy name, Policy type, and Created. A note below the table says 'No policies found.' At the bottom right, it shows 'Showing 0 items < 1 of 1 >'.

Figure 7.5: OCI traffic steering

The compute instance shapes and configurations will be leveraged as follows:

- **Choose appropriate compute instance shapes:** Select OCI compute instance shapes and configurations based on workload requirements, such as CPU, memory, and network performance. Utilize high-performance shapes for compute-intensive tasks and memory-optimized shapes for memory-intensive applications. Below [Figure 7.6](#) shows the interface for instance configurations in OCI:

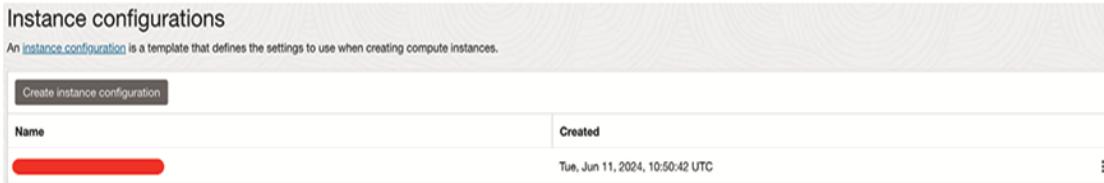


Figure 7.6: OCI instance configurations

- **Optimize storage configurations:** Utilize OCI's block storage, object storage, and file storage services efficiently. Configure storage options such as block volume performance tiers, object storage classes, and file storage protocols to meet performance and scalability needs. *Figure 7.7* represents the fields in interface for Boot Volume Information:

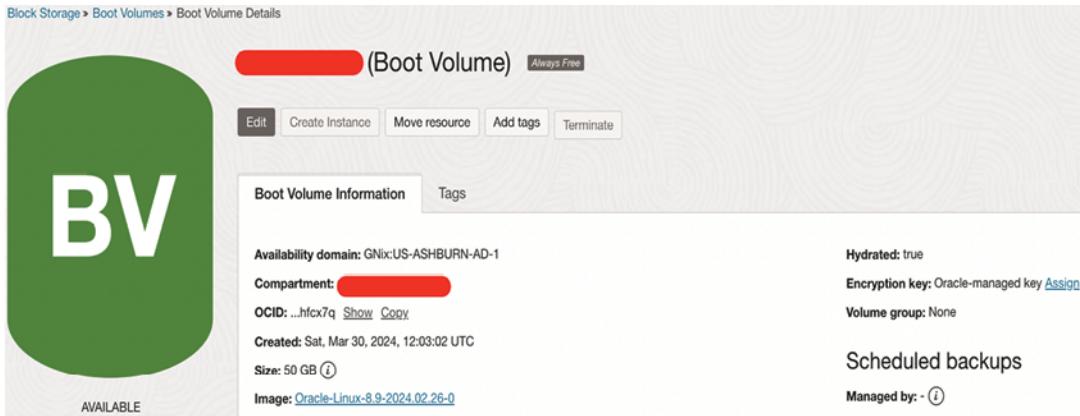


Figure 7.7: OCI test

- **Utilize bare metal instances for performance of critical workloads:** Bare metal instances can be used for use cases, which need sensitive and IO intensive applications for optimum performance. OCI offers bare metal instances that can be configured based on the use case. Bare metal instance are physical servers with high-performance processors and advanced storage and CPU. This does not have virtualization layer for better performance.

The following caching mechanisms and **content delivery networks (CDNs)** are implemented as follows:

- **Deploy caching mechanisms:** For the data which is frequently queried in the memory, caching mechanisms like Oracle Coherence or other third-party caching frameworks should be used to store data. This will avoid putting more load on the database and enhance the response time.
- **Utilize content delivery networks:** CDNs must be used in the use cases where we need to enhance content delivery speed internationally and to minimize the

latency. This can be achieved by incorporating OCI's CDN or other third-party CDNs for caching and delivering static content closer to the end-users.

Scaling strategies

Scaling is a process where a system can adapt to changing workloads, by scaling up or down in its quantity and variety of data, applications, and locations. In the cloud, we have different options for scaling, such as horizontal and vertical scaling, auto-scaling, load balancers, and traffic distribution. Scaling is one of the important concepts for managing SaaS applications. This will address different workloads and achieve the best performance.

In this section, we will discuss the different scaling methods offered by OCI as follows:

- **Horizontal and vertical scaling approaches:**
 - **Horizontal scaling:** This is referred to as scale-out, is a process of increasing the number of instances or resources to spread the load across many servers. In OCI, horizontal scaling can be done by having multiple compute instances which are behind a load balancer so that the incoming traffic is shared.
 - **Vertical scaling:** This is referred as scale up. It is the operation of increasing the capacity of existing instances to handle the increased required workload. OCI provides implementable compute instance shapes with different CPU, memory, and network configurations, enabling organizations to scale their resources vertically according to their demands.
- **Auto-scaling configurations:**
 - **Define scaling policies:** Configure auto-scaling policies in OCI based on predefined metrics such as CPU utilization, memory usage, request rate, or custom application-specific metrics. Define thresholds and scaling actions (scale in or scale out) to trigger automatic adjustments in resource capacity.
 - **Define performance metrics:** Create auto-scaling policies in OCI based on predefined application's metrics (CPU%, memory usage%, request rate) or on custom application-specific metrics, to define the threshold and the scaling action (scale in or scale out) to automatically scale the resource capacity up or down. *Figure 7.8* shows steps to create autoscaling configuration:

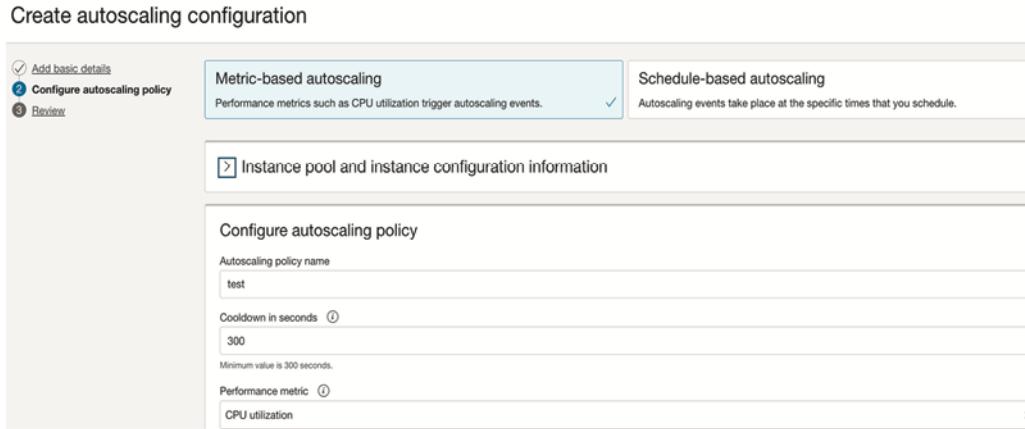


Figure 7.8: OCI auto scaling configurations

- **Utilize OCI auto scaling:** The OCI auto scaling service automatically provisions and removes compute instances according to workload demand. This process offers benefits such as it ensures maximum resource efficiency is achieved at the same time reduces the costs. OCI auto scaling can be achieved by defining the scaling rules and attach them to pools of compute instances to allow auto-scaling.

We will efficiently manage load balancers and traffic distribution as follows:

- **Implement load balancing:** Deploy OCI load balancer service to distribute incoming traffic across multiple backend compute instances or serverless functions. Utilize algorithms such as round-robin, least connections, or IP hash for efficient traffic distribution. *Figure 7.9* shows the interface to create load balancers in respective compartment:

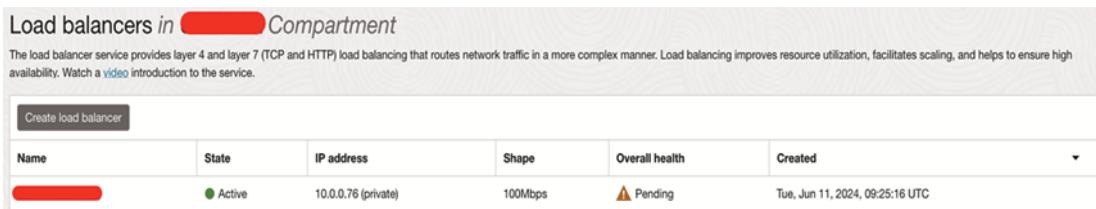


Figure 7.9: OCI load balancer

- **Configure health checks:** Availability and health of backend instances in OCI can be monitored by configuring the health checks.
- This process automatically removes unhealthy instances from the load balancer pool and redirect traffic to healthy instances.

Below *Figure 7.10* directs users to the interface to create and configure listeners:

Create load balancer

The screenshot shows the OCI Create Load Balancer interface. On the left, a sidebar lists four steps: 1. Add details (checked), 2. Choose backends, 3. Configure listener, 4. Manage logging. The main panel is titled "Specify health check policy". It contains several input fields and descriptions:

- Protocol:** HTTP (selected), Port: Optional (80)
- Interval in milliseconds:** Optional (10000)
- Timeout in milliseconds:** Optional (3000)
- Number of retries:** Optional (3)
- Status code:** Optional (200)
- URL path (URI):** /
- Response body regex:** Optional

Figure 7.10: OCI create load balancers

- **Utilize traffic management:** OCI traffic management service enables intelligent routing of traffic based on performance metrics, geographic location, or user-defined rules. Implement traffic steering policies to direct traffic to the nearest or most available backend resources. Below [Figure 7.11](#) explains the policy type for the load balancer created:

Create traffic management steering policy

The screenshot shows the OCI Create Traffic Management Steering Policy interface. It includes the following sections:

- Policy type:**
 - Load balancer: Distributes traffic over several servers to optimize performance.
 - Failover: Automatically redirects traffic to the next highest priority server when primary server is unavailable.
 - Geolocation steering: Dynamically routes traffic requests based on originating geographic conditions (e.g. New Jersey or China).
 - ASN steering: Dynamically routes traffic requests based on originating ASN number (e.g. 6185).
 - IP prefix steering: Dynamically routes traffic requests based on originating IP prefix (e.g. 172.16.1.0/24).
- Policy name:** (empty input field)
- Policy TTL:** (empty input field) eg: 60, (dropdown menu) Seconds

Figure 7.11: OCI traffic management policy

To ensure that SaaS applications hosted on OCI remain responsive, scalable, and resilient to varying workload demands, organizations should implement it as follows:

- horizontal and vertical scaling
- configuring auto-scaling policies
- efficiently managing load balancers and traffic distribution

These strategies enable organizations to dynamically adjust resource capacity to meet the needs of users, while optimizing cost-efficiency and minimizing downtime.

Advanced security measures

SaaS applications hosted in OCI should undergo third party risk assessment and secure development life cycle. Security is considered as an important element whenever we host SaaS application. In this section, we will discuss the security measures we need to consider while deploying the SaaS applications in OCI environment. These security measures are advanced. By adopting these security measures, we can defend the sensitive data in the organizations. This will also shield the infrastructure against any kind of internal and external threats such as unauthorized access. These security measures are important to mitigate the risks.

The robust access controls and authentication mechanisms will be implemented as follows:

- **Role-based access control (RBAC):** RBAC will allow organizations to define granular access policies and assign roles to users, groups, or compartments. Internally RBAC uses least privilege principles. Least privilege principles will restrict access to resources based on least privilege. This will minimize the risk of access to unknown actors and provide the right access, to the right people.
- **Multi-factor authentication (MFA):** Implement MFA for all applications. Enabling MFA is considered as the standard best practice. This will require users to provide multiple forms of verification. Verifications will be in the form of a password, and a one-time code sent to their mobile device, to access OCI resources. This will act as an additional layer of security.
- **Single-sign-on (SSO):** We have many identity providers. One such example is *SAML 2.0. OCI integration*, with identity providers offering various benefits such as, seamless access management across multiple cloud, and on-premises applications. This seamless access management is required for centralized authentication.

The encryption of the data will be done as follows:

- **Transparent Data Encryption (TDE)** enables TDE for Oracle database instances running on OCI to automatically encrypt data at storage layer and protecting against unauthorized access to database files which are stored in the disks. [*Figure 7.12*](#) explains steps to create compute instances.

Create compute instance

Create an instance to deploy and run applications, or save as a reusable Terraform stack for creating an instance with Resource Manager.

Name: test

Create in compartment: [Redacted]

Placement

The availability domain helps determine which shapes are available.

Availability domain:

- AD 1** GNix:US-ASHBURN-AD-1
- AD 2 GNix:US-ASHBURN-AD-2
- AD 3 GNix:US-ASHBURN-AD-3

Show advanced options

Figure 7.12: OCI create compute instance

- **Key management service (KMS):** OCI provides the KMS component. KMS will facilitate to manage encryption keys and securely encrypt data stored in object storage, block storage volumes, and other OCI services. Below *Figure 7.13* represents a sample key management service interface:

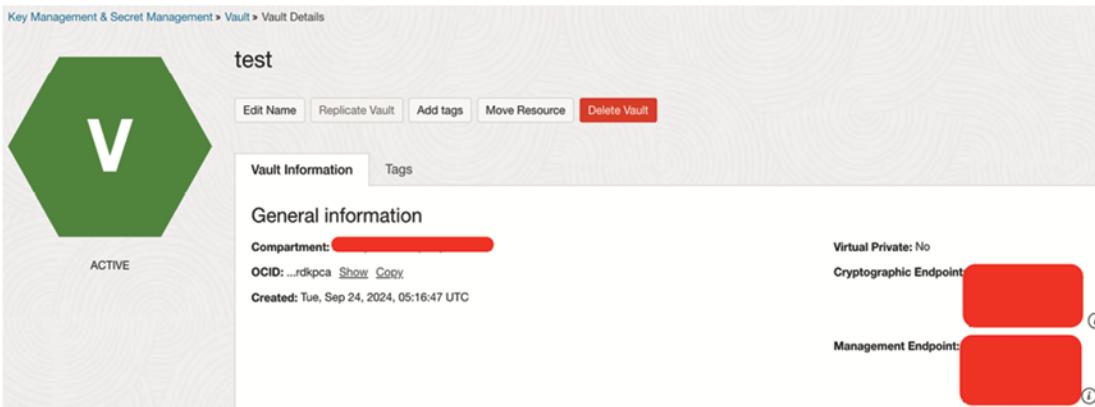


Figure 7.13: OCI key management services

- **SSL/TLS encryption:** SSL/TLS encryption for all in-transit data should be enforced everywhere network data is received and sent so that communications between clients and OCI services (including private and public web applications hosted on compute instances and APIs accessed over HTTPS) are private. Secondly, encryption must be implemented to ensure compliance with **Data Protection Regulatory Frameworks (DPRF)** for outgoing exfiltrated data.
- **Intrusion detection and prevention (IDR):** Introduction detection is key part of the detection infra, where having the controls on the detection and response

based on the set of pre-defined rules which alert and respond to signals of the intrusion.

- **Deploy Network Security Groups (NSGs):** In the process of deploying the Network Security Groups, the first step is to define network security rules. Defining the proper network security rules based on the use cases of the organization will restrict inbound and outbound traffic based on source or destination IP addresses, ports, and protocols. This can be achieved by configuring the NSGs in OCI, to define network security rules. Monitor NSG logs for suspicious activities and potential security breaches.
- **Utilize web application firewall (WAF):** For any Web based security threats we primarily rely on OWASP. As per OWASP, we have top 10 security threats. Few of them are SQL injection, **cross-site scripting (XSS)**, and malicious bot traffic. These threats will be blocked by configuring the WAF. WAF will protect the web applications from common security threats. *Figure 7.14* illustrates network firewalls in OCI:

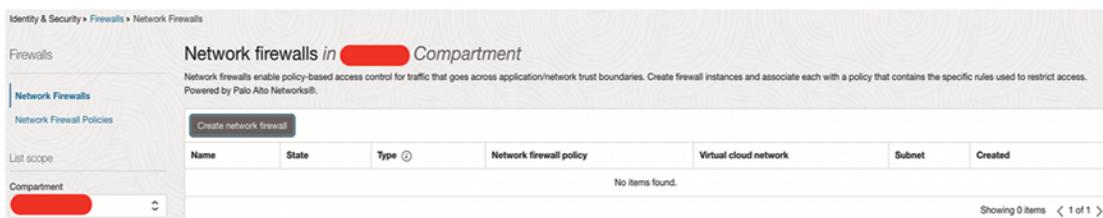


Figure 7.14: OCI network firewalls

The following advanced threat detection and response mechanisms are implemented as follows:

- **Security Information and Event Management (SIEM):** SIEM Tools and OCI tools should be Integrated. This integration provides SIEM solutions to organizations. For instance, few such solutions are having logging mechanism at centralized location, monitoring, and analysis of security events across the cloud environment. Organizations should adopt the SIEM capabilities. This will detect anomalies, identify security events based on relation, and respond proactively to incidents in real-time.
- **Security Orchestration, Automation, and Response (SOAR):** Organizations should mandatorily configure the SOAR. SOAR will automate incident response workflows and help streamline security operations. The other benefit of SOAR is that it orchestrates and manages the responses to security incidents. Integration of OCI with SOAR platforms is considered as one of the best

security practices which also provides seamless incident detection, investigation, and remediation.

The advanced security measures discussed above should be adopted by organizations. This will enhance the application security standards in the SaaS applications on OCI. These security measures will provide various benefits to organizations. Few of the benefits are risks gets mitigated from various sources which also includes third party risk assessments. Other important feature is it will protect the critical sensitive data by adopting various encryption methods and helps achieve the compliance with regulatory requirements.

DevSecOps access controls

Let us define **secure software development life cycle (SSDLC)**. In SSDLC, evaluation is performed in each phase of project or product development considering security as one of attributes in the checklist. DevSecOps highlights the need of combining the security practices in the software development lifecycle process and have security lens during the software development phase.

As we know, the main aim of using DevSecOps practice is to bring development, operations, and security teams together under one umbrella. This will make sure that we treat security as an integral practice which needs to be designed, developed, integrated, and evaluated at runtime. DevSecOps has Access controls which is considered as integral part. Access controls allow least privilege access in implemented and granular level of permissions are managed. Granular level of permissions will reduce the risk of improper access to sensitive resources.

In the next section, we will look at DevSecOps access controls from the perspective of **Oracle Cloud Infrastructure (OCI Cloud)** with an emphasis on **OCI Native Access Controls (OCNA)** and Restricted Bastions.

OCI native access controls

OCI native access control (OCNA) in OCI provides a detailed set of tools and capabilities related to access. This manages the access to OCI resources, establishing, and defining the security policies and establishing the regulatory and compliance requirements as follows:

- **Identity and access management (IAM):** IAM allows organizations to define or controls access control policies at a granular level. IAM will assign roles to users, groups, or compartments. **Role-based access controls (RBAC)** will enable organizations to define and enforce principle known as the least privilege principle. In this principle it will only grant users only the permissions necessary to perform their job responsibilities.

- **Compartmentalization:** Compartmentalization in OCI provides various benefits. They provide logical isolation of resources which allows organizations to segregate workloads, environments, and applications. By organizing resources into compartments, organizations can enforce access controls at the compartment level. This will ensure that users have access only to the resources within their designated compartments.
- **Access policies:** In OCI, IAM will allow organizations to define access policies using a declarative JSON-based language. This declarative JSON-based language is termed as Oracle Cloud Infrastructure Policies. These Access policies specify who can access which resources and what actions they can perform on those resources. Policies can be attached to users, groups, compartments, or resource types, providing granular control over access permissions.
- **Audit logging:** Audit logging provided by OCI is at a granular level. These logs help organization track user activities, monitor changes to your resources, and investigate security issues. The audit logs capture events like authentication events, resource access, and administrative actions with detailed information. Data is stored for enablement of log-based analysis, forensic investigations, and regulatory requirements.

Restricted Bastions

Restricted Bastions are a security best practice to manage the access to OCI compute instances and, other resources from external networks. A Restricted Bastion is a hardened, centrally managed jump host or bastion host, that acts as a gateway for accessing OCI resources securely. The key features of Restricted Bastions are as follows:

- **Secure access:** Restricted Bastions provide a safe, single point of network access into OCI environments that enable authorized users to log into compute instances and other OCI resources using **Secure Shell (SSH)** or **remote desktop protocol (RDP)**. Access through Restricted Bastions can be permitted to only certain users and IP addresses. This kind of restricted access will reduce the risk for unauthorized access, as well as brute-force attacks.
- **Role-based access:** Restricted Bastions provide role-based access controls which limits user's access to only the resources required to do their jobs. Access permissions can be centrally controlled through OCI IAM and aid organization's in enforcing least privilege policies and meeting compliance with their security policies.
- **Monitoring and logging:** Restricted Bastions provide monitoring and logging capabilities to track user activities, record login attempts, and capture audit

trails. Centralized logging enables organizations to monitor access patterns, detect anomalies, and investigate security incidents in real-time.

- **Bastion Host hardening:** According to security best practices Restricted Bastions are hardened by incorporating regular patching, adopting for minimal software installation and configuration hardening. Bastion hosts are usually deployed in a dedicated subnet with restricted network access. The restricted network access reduces the attack surface and mitigate the risk of compromise.

Note:

- A Bastion is not the same thing as a VPN.
- A site-to-site VPN should be used for long-lived and mostly server to server communication.
- A bastion should be used for short duration "a human needs to" use cases.
- It is best to not try to use a VPN when you need a bastion or a bastion when you need a VPN.

We discussed about **OCI native access controls (OCNA)** and Restricted Bastions. These DevSecOps access controls will allow organizations to strengthen the security posture of OCI environments. This will significantly reduce the risk of unauthorized access and hence establish compliance with security policies and regulatory requirements.

DevSecOps access governance

Access governance plays a pivotal role in DevSecOps as it ensures that relevant access controls are in place and always functioning properly and across the entirety of the **software development lifecycle (SDLC)**. Throughout this large and detailed analysis about DevSecOps access governance, we will discuss relating topics, such as access management, identity governance, compliance, easy auditing, and best practices for implementing strong access controls within **Oracle Cloud Infrastructure (OCI Cloud)** environment.

- **Introduction to Access Governance in DevSecOps:** Access governance in DevSecOps involves the definition, management, and enforcement of access controls to secure sensitive resources and data for the duration of the software lifecycle, including IAM, **role-based access controls (RBAC)**, access certifications, audits and compliance management.
- **Foundations of access governance:** By following the simple principle of access governance, you start by defining roles and responsibilities for people within your organization. This includes assigning user roles, defining appropriate access permissions granted to those people within their job roles,

and making sure that you are enforcing the principle of least privilege access allowing access to only what is necessary.

- **Identity and access management:** Identity access management in OCI will allow organizations to functionalities such as creating users, groups, and compartments. IAM will also enable to define respective access policies and enforce role-based access controls. IAM is critical and important component of access governance. This helps organizations to use IAM tools and technologies for managing user identities, authenticating users, and controlling access to systems, data and resources.
- **Role-based access controls:** The second basic principle of access management is known as a RBAC. It helps an organization grant permission to users based on the roles or functions, that the organization assigns to them. In this setup organization's will be able to define roles with specific permissions, and mandate that RBAC will dictate for users to have access only to resources required to do a job function.
- **Access certification:** Access certification is a process where access rights are periodically reviewed and validated to establish compliance with security policies and regulatory requirements. Access certification can be achieved by incorporating various steps. Few of the steps to consider are conducting access reviews, identifying inappropriate access, and taking proactive corrective actions to revoke unnecessary permissions.
- **Compliance management:** We discussed various Industry regulations such as GDPR, HIPAA, PCI DSS. To maintain compliance with this industry's regulations, we need access governance. Maintaining compliance with industry regulations requires Access governance. Organizations should adopt strong access controls, have monitoring tools configured to access activities and regularly conduct compliance audits. With this approach organizations can adhere to regulatory requirements and protect sensitive data.
- **Auditing and monitoring:** Auditing and monitoring tools provide visibility into user activities; access attempts made by different users and finally logs the security events. OCI offers very detailed auditing capabilities, allowing organizations to track changes to IAM policies, monitor resource access, and generate audit logs for compliance purposes.

The following are the best practices for access governance in OCI:

- Based on job responsibilities and business requirements, we need to segregate and define clear access policies and roles.

- Always enforce least privilege by implementing RBAC. This approach will limit access to only necessary resources.
- Regular access reviews and certifications should be conducted in timely manner, to ensure compliance with security policies.
- Need to configure monitoring tools to monitor access activities and audit logs for suspicious behavior and security incidents.
- We need to evaluate and improve access governance processes. This process should be continuously established. This will help governance processes to adapt to evolving threats and regulatory requirements.

There are many challenges and considerations that should be, for example, it is related to managing complex access requirements, trying to ensure consistency across multi-cloud environments, and maintaining balance between security and usability while accessing governance in DevSecOps. It is recommended that organizations consider various factors, such as scalability, automation, and integration, with existing IAM systems when implementing access governance in OCI.

Oracle Break Glass and OIM

In **Oracle Cloud Infrastructure (OCI Cloud)**, *Break Glass* is an emergency access feature that grants administrators temporary, elevated privileges during critical situations, especially when standard access controls fail or need to be bypassed.

This feature is generally employed when there is an urgent need to resolve an issue, and the typical access protocols, such as IAM policies, either lack the necessary permissions or are compromised. Oracle Identity Manager, on the other hand, is an identity management product that automates user provisioning, identity administration, and password management, integrated in a comprehensive workflow engine.

Importance of Break Glass procedures

Break Glass procedures are essential for ensuring business continuity and rapid response during emergencies. They provide a controlled way to grant temporary access to high-privilege accounts while maintaining security and compliance.

The key benefits are as follows:

- **Rapid Response:** Enables quick access to resolve critical incidents.
- **Business continuity:** Ensures essential services remain operational during emergencies.
- **Security:** Implements controlled and auditable access to sensitive resources.

- **Compliance:** Meets regulatory requirements for emergency access procedures.

Note: Break Glass is distinguished from other Privileged Account Management (PAM) use cases by its, ideally, exceedingly rare occurrence. Break Glass is intended to be used only in extremely rare emergency situations, acting as a last resort for immediate access to critical systems when standard procedures are not feasible or not working. Essentially, it should only be activated, when necessary, like breaking glass in an emergency to trigger an alarm.

Overview of Oracle Identity Manager

Oracle Identity Manager (OIM) enterprise edition provides a full identity governance suite covering the overall IAM function for the organization, including automated user provisioning across the user lifecycle and digital access governance; that ensures regulatory requirements on behalf of the corporation. OIM is part of **Oracle Identity Management (IdM)** suite, providing a way to automate access governance, Break Glass processes and granular rules to manage end-to-end IAM.

Integrating Break Glass with OIM

We can integrate Break Glass and OIM as follows:

- **Establishing Break Glass accounts:** Break Glass accounts are highly privileged accounts, that are predefined for emergency use. In OIM, these accounts should be carefully created and managed:
- **Account creation:** Create Break Glass accounts require minimum privileges to perform critical tasks.
- **Isolation:** Isolate Break Glass accounts from regular user accounts, to reduce the risk of misuse.
- **Documentation:** Document the creation, purpose, and privileges of each Break Glass account.
- **Managing Break Glass access:** Managing access to Break Glass accounts in OIM involves several key steps:
 - **Access request workflow:** Implement a robust workflow for requesting and approving Break Glass access. This workflow should require multiple approvals from authorized personnel.
 - **Authentication mechanisms:** Implement strong authentication mechanisms to secure access to Break Glass accounts. For example, **multi-factor authentication (MFA)**.
 - **Time-limited access:** Set access for a predefined period. Here access can be set to be time-limited which will ensure that privileges are revoked automatically

after a predefined period.

- **Auditing and monitoring:** Auditing and monitoring are essential components for maintaining the integrity of Break Glass procedures:
 - **Real time monitoring:** Monitoring as it happens should be implemented to detect and alert on any unauthorized or suspicious activities involving Break Glass accounts.
 - **Audit trails for identity:** Ensure the Break Glass access requests, approvals and activity are tracked. OIM's auditing capabilities can log who accessed what, and when.
 - **Periodic reviews:** Review of Break Glass account usage should be conducted periodically, to ensure compliance with policies and identify any potential security risks.

Best practices for Break Glass procedures in OIM

Implementing effective Break Glass procedures in OIM involves adhering to best practices that enhance security and ensure proper governance as follows:

- **Define clear policies and procedures:**
 - **Policy development:** Develop clear policies that define the circumstances under which Break Glass access is permissible.
 - **Procedure documentation:** Document the detailed procedures for requesting, approving, and using Break Glass access.
- **Train and educate personnel:**
 - **Training programs:** Initiate training programs for the different stakeholders such as IT and security staff, the management and security staff, and the administrators who will implement Break Glass. These training programs will let all stakeholders know the proper procedure and their respective responsibilities.
 - **Awareness campaigns:** Increase awareness of the role and importance of Break Glass procedures and the implications if this is misused.
- **Implement technical controls:**
 - **Role-based access control (RBAC):** Implement RBAC to ensure that only those with permission can submit and authorize Break Glass access.
 - **Access limitation:** Make certain that the access is justified. Reduce the number of individuals who have the authority to grant Break Glass access.

- **Segmentation:** Segregate accounts that can be Break Glass accounts from *regular and normal* user accounts to reduce the likelihood of getting access to Break Glass accounts by mistake.
- **Regular audits and compliance checks:**
 - **Regular internal audits:** Regularly perform internal audits. These actions will provide the review report explaining the effectiveness of Break Glass procedures and policies.
 - **Compliance reporting:** compliance reports should be generated to demonstrate adherence to regulatory requirements and internal policies.
- **Just in time provisioning (JIT) of the Break Glass identity and API key credentials:**

Through this mechanism, a dedicated Break Glass identity is created and added to the administrators group. During the Break Glass process, an OCI API key is generated and configured for this identity. Additionally, the identity is set to accept only API key credentials, ensuring that the corresponding OCI API key is the only valid credential for the Break Glass identity to authenticate to the OCI control plane. Once the Break Glass event concludes, the identity and its associated API key are de-provisioned, thereby removing the Break Glass access.

- **Incident response planning:**
 - **Incident handling:** Develop and document incident response plans that include procedures for handling misuse or abuse of Break Glass access.
 - **Continuous improvement:** Use lessons learned from incidents to continuously improve.

Break Glass procedures and policies

Break Glass procedures are important and integral part of any solid security strategy, as they provide the means for emergency access to critical systems and data. However, when implemented with OIM, Break Glass procedures can also enhance access governance at enterprise scale such as granting emergency access in a controlled manner, monitoring it effectively, and ensuring compliance to any regulatory requirements. Following several best practices can ensure that organization's leverage OIM's capabilities to implement and manage Break Glass procedures in a way that helps their businesses stay up and running while still adhering to a rock-solid security compliance posture. This section in this chapter provides an overview of Break Glass procedures, explains their importance within a solid security strategy, how they should be integrated with OIM, and a list of best practices for their implementation and management. Ensuring that Break Glass access

is controlled, monitored, and audited, guarantees that enterprises do not compromise their posture in any way, even during emergency situations.

Implementation of secure data isolation

Secure data isolation refers to ensuring data protection by keeping data of different users, groups or applications separate and isolated, to prevent data being shared or accessed by applications that it is not intended for, as well as from external users and threats. Multi-tenant environments are a classic example, where customers all share the same infrastructure, backed by a single, ultimately larger contract. At the same time, sensitive data often needs to be isolated from even that larger data set, to protect it from both internal and external threats.

Importance of secure data isolation

Data isolation is a security strategy that involves disconnecting data from the network and creating physical separation from the organization's IT environment, forming a strong barrier against potential threats. In cases where critical data is destroyed or encrypted for ransom, organizations employing data isolation remain resilient, as they maintain a clean copy of the data securely separated from the compromised environment. Below are few methods organizations should adopt to achieve compliance related to data security:

- **Regulatory standards:** Organizations should follow regulatory compliance to meet with the compliance standards like *GDPR*, *HIPAA*, and *PCI DSS* standards which are global and major regulatory regulations. This will mandate stringent data protection measures.
- **Data privacy:** Data privacy is considered as one of process to implement secure data isolation. Implementing the data privacy approach will ensure that only allows access to the people should access to sensitive systems, data or information.
- **Security:** The main intention of secure data isolation is to achieve security where it facilitates the prevention of data breaches and unauthorized access, protecting the organization's reputation and customer trust.
- **Operational integrity:** Operational integrity will guarantee that data used across different applications or departments remains consistent and undisturbed.

Architectural strategies for data isolation

The following are the architectural strategies for data isolation:

- **Physical isolation:**

- **Dedicated hardware:** Allocate separate physical servers, storage devices, and network resources for different tenants or applications. This approach is typically used in highly secure environments where data segregation must be absolute.
- **Network segmentation for security:** Use of firewalls, VLANs, and other network segmentation techniques to isolate data traffic between different parts of the infrastructure for the better security. *Figure 7.15* represents a sample OCI region:

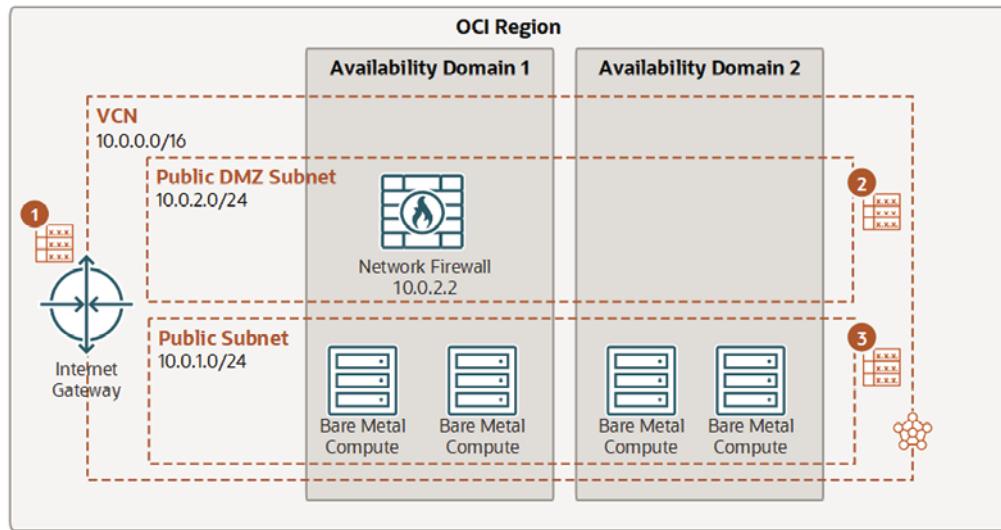


Figure 7.15: OCI Region

- **Virtualization-based isolation:**

- **Virtual machines (VMs):** Run separate VMs for different tenants or applications on the same physical hardware. Each VM operates independently with its own OS and resources.
- **Containers:** Use containerization technologies like Docker that isolates applications and their dependencies. Containers share a common OS kernel and run in isolated user spaces.
- **Hypervisor security:** Ensure secure hypervisor is configured and implemented to manage VM's and guard against VM cross-vulnerability and VM attacks.

- **Logical isolation:**

- **Namespaces:** Namespaces should be used for logical isolation. Namespaces will help logically separate resources within the same environment, such as different databases, directories, or message queues for different tenants.

- **Access control lists (ACLs):** Implement ACLs for all the projects assigned. This will define at granular level who can access specific resources at the network, file system, or application level.

Access control mechanisms

Access control refers to the policies, procedures, and tools that govern access to and use of resources. Examples of resources include a cloud service, physical server, file, application, data in a database, and network device. Key access control mechanisms in OCI include below attributes:

- **Role-based access control (RBAC):**

RBAC is a security feature for controlling user access to tasks that would normally be restricted to superuser. By applying security attributes to processes and to users, RBAC can divide up superuser capabilities among several administrators. Process rights management is implemented through privileges. User rights management is implemented through RBAC. In summary, it defines roles and assigns users to roles. This are explained as below.

- **Define roles:** In this step, based on job functions, roles will be created and appropriate permissions is assigned to each of role created.
- **Assign users to roles:** This step will ensure users are assigned to roles which align with their responsibilities. This will make sure the system designed is adhering and follows the principle of least privilege policy.

- **Attribute-based access control (ABAC):**

Attribute-based access control (ABAC) provides the capability to define fine grained authorization using attributes. Roles need not be created. An ABAC policy specifies one or more *claims* that need to be satisfied before a user is granted access. Let us define the Attributes and policies as below.

- **Attributes definition:** Define attributes for users, resources, and environment conditions (for example, time of access, location).
- **Policies:** Attributes such as users, resources should be evaluated. Based on the evaluation of the attributes, we need to create policies that grant or deny access based.

- **Multi-factor authentication (MFA):**

Multi-factor authentication is a method of authentication that requires the use of more than one factor to verify a user's identity to access an identity domain in

IAM. MFA provides authentication factors and supports integration with all the systems as explained below:

- **Authentication factors:** Multi-factor user authentication adds an extra protection layer. In terms of this mechanism, two or more factors (for example, password and, or biometric and, or one-time code) are utilized to verify user identities before allowing them to access a specific section of a system.
- **Integration:** Security can be enhanced by integration of MFA with all systems. This is very important for system that handle sensitive data.

Data encryption

Data encryption is a security mechanism which protects the data at rest, in transit, and in use by converting it into an unreadable format that can only be decrypted with the appropriate key. OCI provides different encryption services to help secure sensitive data and ensure compliance with data protection regulations. Below are a few key aspects of data encryption in OCI:

- **Encryption at rest:**

Encryption at Rest provides security for data in files that are saved on disk (or at rest) by encrypting that data using Oracle Transparent Data Encryption technology. Below are the few of the mechanism through which we can achieve encryption at rest.

- **Storage-level encryption:** Encrypt data on storage devices using tools like *BitLocker*, *LUKS*, or **Oracle Transparent Data Encryption (TDE)**.
- **Database encryption:** Use database-native encryption features to encrypt data within databases.

- **Encryption in transit:**

In-transit encryption provides a way to secure your data between instances and mounted file systems using transport layer security encryption. Encryption in transit can be achieved by configuring SSL/TLS or by using the VPN's.

- **SSL/TLS:** Encryption in transit can be implemented by configuring the Secure Sockets Layer or Transport Layer Security in the transmission network. This will ensure data is encrypted which is sent over the network.
- **VPNs:** This is another way to achieve data encryption in transit. Deploying **virtual private networks (VPNs)** provides a secure remote access.

- **Key management:**

KMS is an OCI service that stores and manages keys for secure access to resources. The OCI key management service is a cloud-based service that provides centralized management and control of encryption keys for data stored in OCI. Below are core components to understand in key management.

- **Key rotation:** Periodic rotation of encryption keys should be adopted. This will minimize the risk of key compromise.
- **Key management services (KMS):** Managed services like AWS KMS or Azure Key Vault needed to be used based on use cases. This will provide secure key storage and management.

Data access auditing and monitoring

Data access auditing and monitoring involve tracking and reviewing how data within a system is accessed, used, and modified. These processes help ensure data security, compliance with regulatory requirements, and protect against unauthorized access or breaches. Auditing involves keeping detailed logs of who accessed data, when, and what actions were taken, while monitoring actively tracks real-time activity for suspicious behavior. These measures are crucial in detecting insider threats, preventing data leaks, and maintaining accountability in environments that handle sensitive information, such as financial institutions or healthcare systems.

- **Logging:**

The Oracle Cloud Infrastructure Logging service is a fully managed and highly scalable solution that offers a comprehensive view of all logs within your tenancy. It provides access to logs generated by Oracle Cloud Infrastructure resources. OCI supports a comprehensive and centralized logging mechanism, as explained below:

- **Comprehensive logs:** Log and record all data accesses including what user accessed what at what time and from where.
- **Centralized logging:** OCI tools can be integrated with centralized logging tools like Splunk or an ELK. This will allow to stack to aggregate and analyze logs. *Oracle Cloud Infrastructure* has in built logging system referred as log analysis cloud service. This service is used to gather and analyze logs from different sources.

- **Real-time monitoring:**

Monitoring in OCI involves collecting and analyzing performance metrics, resource utilization, and other data to ensure the efficient operation of your OCI environment. OCI offers a range of services and tools for monitoring in real

time that can help you gain insights into your infrastructure's health and performance. OCI provides several security features to protect against network threats, including Intrusion detection systems, SSL inspection and analyzing behavior analytics as discussed below:

- **Intrusion detection systems:** Organizations should introduce tools which can detect and provide alerts on any of suspicious activities. This process can be implemented by adopting to intrusion detection systems which used to detect and provide alerts on suspicious activities. These are configured to capture and detect in real time environments.
- **Behavior analytics:** Organizations should implement a system which can identify unusual access patterns. These unusual access patterns may indicate security threat. Organizations should use this technique as **entity behavior analytics (EBA)** to achieve the behavior analytics. EBA is a cybersecurity approach that focuses on analyzing the behavior patterns of entities within an organization's network, such as users, devices, or applications, to detect anomalies and potential threats.

- **Regular audits:**

Auditing enables users to access events recorded by the Audit service. Users can view these events through the Console, API, or SDKs. The event data can be utilized for diagnostics, resource usage tracking, compliance monitoring, and gathering security-related information. There are different types of Audits in OCI. Few of them are discussed below:

- **Internal audits:** Conduct regular internal audits to ensure compliance with data isolation policies and other security policies are in place.
- **Third party audits:** Engage third party auditors or companies to review and validate the effectiveness of data isolation measures implemented.

Compliance and regulatory requirements

Compliance and regulatory requirements refer to the rules, standards, and laws that organizations must follow to ensure their operations meet legal, industry, and ethical standards. These regulations vary by region and sector, covering areas such as data protection, financial reporting, and security. Compliance ensures that businesses operate responsibly, avoid legal penalties, and maintain trust with customers and partners. Regulatory frameworks like GDPR, HIPAA, and SOX are examples, often designed to protect consumer rights, ensure transparency, and safeguard sensitive information from misuse or breaches. Below are different types of regulations and industry standards to achieve compliance:

- **Data protection regulations:**
 - **General Data Protection Regulation (GDPR) data protection:** For GDPR make sure compliance with the GDPR, which are essential for meeting the compliance requirements by using the strong data isolation and protection measures across the country/region specific regulations specifically in *Europe*.
 - **Health Insurance Portability and Accountability Act (HIPAA) for health:** HIPPA is for healthcare organizations meeting with the HIPAA by securing **protected health information (PHI)** which is a major regulatory requirement in the health care industry.
- **Industry standards:**
 - **ISO/IEC 27001:** ISO/IEC 27001 are general guidelines for the industry quality for information security management systems.
 - **National Institute of Standards and Technology (NIST):** NIST is a standard for data protection and isolation requirements, which upholds standards in the technology sector.

Data isolation in SaaS

Let us explore a scenario with business context, challenges faced and implementation of the solution as below for use case related to data isolation in SaaS.

- **Scenario overview:**
 - **Business context:** A SaaS provider offers a platform used by multiple customers, each requiring data isolation to protect their sensitive information.
 - **Challenges:** Ensuring data isolation while maintaining performance and scalability.
- **Implementation strategy:** The following are the methodologies to be adopted for this implementation.
 - **Architecture design:** Design a multi-tenant architecture with physical and logical isolation using VMs and containers.
 - **Access controls:** Role-based access control and attribute-based access control to provide solid controls on access based on user roles and attributes.
 - **Encryption:** Storage-level and database encryption of data at rest and Secure Socket Layer/Transport Layer Security in transit.

- **Monitoring:** Enable centralized access logging and monitoring, to identify changes and anomalies as they occur in real time.
- **Compliance:** General Data Protection Regulation and ISO/IEC 27001 compliancy should be mandated through scheduled audits and reporting.
- **Outcomes and benefits:**
 - **Improved security:** Enhanced protection of customer data through robust isolation and encryption.
 - **Compliance achieved:** Successful audits confirming compliance with GDPR and industry standards.
 - **Customer trust:** Increased customer confidence in the platform's ability to protect their data.

Secure data isolation is a fundamental aspect of data protection and compliance. It basically means that data is *isolated* from other data, mostly sensitive data is isolated from any other kind of data. This is simply an architectural function of keeping sensitive data separate from less sensitive data. When discussing about secure data isolation we broaden the term isolation, and we discuss protecting highly sensitive data so that it is isolated from unauthorized access. Additionally, we also extend the range of measures we take when talking about secure data isolation versus simple isolation. In essence, we need to have the right data isolation architectural strategies, access mechanisms, data encryption, and we need to continuously audit who sees what and who accesses what. We also need to comply with various regulatory requirements. This complex description separates data isolation into numerous inputs important for keeping sensitive data safe from unauthorized access. We dive deeply into each of them to understand how we can achieve a high level of security and ultimately protect our data and our organizations.

Oracle Identity and Cloud Services

Oracle Identity and Cloud Services offer a complete portfolio of identity, access, and security services for the modern enterprise where cloud services are a foundational platform for conducting business online. Whether it is identity governance across people, processes, and technology to bring businesses into a new era of digital enterprise, securing access to data and applications in the cloud, or addressing compliance in multi-cloud and hybrid cloud infrastructures, solutions from this suite are fundamental.

Overview of Oracle Identity and Cloud Services

Oracle offers a variety of identity and cloud services that cater to different aspects of IAM. These services include Oracle Identity Cloud Service Oracle Identity Manager and other related solutions that help in managing identities, enforcing access policies, and securing cloud resources.

Identity and cloud services offered by Oracle include Oracle **Identity Cloud Service (IDCS)**, **Oracle Identity and Access Manager (OIAM)** and other related solutions used to manage identities, define access policies, and wield actions upon secured cloud resources, among other services.

IDCS, OIM and other complementary solutions harness the power of identity to help organizations achieve their digital transformation goals, securely and efficiently manage identities, and enforce access policies, all in sync with ICS capabilities. Furthermore, they serve to enable such enterprises to make better use of core cloud services across several domains, including IaaS, PaaS and SaaS as follows:

- **Oracle Identity Cloud Service:** Oracle Identity Cloud Service is a cloud native IAM solution that provides detailed identity management and security features. IDCS integrates with on-premises and cloud applications and databases to deliver seamless **single sign-on (SSO)**, two factor or **multi factor authentication (MFA)**, and user lifecycle management across the same or multiple organizations.
- **Oracle identity manager for managing the identities:** OIM is part of Oracle's Identity Governance product suite and is designed to work in complex enterprise environments. OIM is an on-premises identity management solution that automates user creation, manages the identity lifecycle, and ensures compliance with security policies.

Key features of Oracle Identity and Cloud Services

Oracle Identity Cloud Service (IDCS) in Oracle Cloud Infrastructure (OCI) offers a comprehensive suite of features designed to manage user identities, access controls, and compliance. Here are some of the key features:

- **Identity management:** Oracle's Identity Management solutions provide different kinds of features to manage user identities efficiently as follows:
 - **User provisioning and de-provisioning:** In this mechanism, OCI establish a process where managing user accounts across various systems and applications are automated. Some example steps are automated are creation, deletion, and updating of user accounts.
 - **User lifecycle management:** Life of the user management is a process manages users throughout their entire lifecycle, i.e., creation to termination,

it starts from onboarding to offboarding, ensuring end to end oversight of user access.

- **Role management:** Role management involves the process for defining and managing roles for the users that assign users access to specific parts of the system based for the access based on the job nature and function of the user.
- **Access management:** Access management features provided by Oracle help secure access to applications and data which includes the following:
 - **SSO solution:** SSO is industry standard and most used authentication option which allows users to access multiple applications with a single set of login credential.
 - **Multi factor authentication:** MFA originally used to be called as two factor authentication is additional layer of security, which acts as an extra layer of security by challenges users to verify their identity using multiple authentication methods.
 - **Adaptive access controls:** Access controls based on the user risk based on the authentication type and adjust on the fly access requirements based on the context of the access attempt i.e., captcha or any other form authentication when the pattern or source of login changes.
- **Identity governance:** Oracle's identity governance solutions ensure compliance and secure access to the systems and resources as follows:
 - **Access certification:** Access certification helps periodic review and certifies user access to ensure it is appropriate and compliant with policies, this helps to review and certify the access to the user.
 - **Segregation of Duties (SoD):** SoD is critical access management function which prevents conflicts of interest by implementing the policies that restrict certain combinations of roles and access permissions for the user.
 - **Audit and compliance reporting:** Generates reports to demonstrate compliance with regulatory requirements and internal security policies.
- **Cloud security:** Oracle Identity and Cloud Services provide robust security features for cloud environments:
 - **Data encryption:** Data encryption is critical for security the data of the organizations which helps to secure data at rest (storing) and in transit (during the transmission) to protect sensitive data.
 - **API security:** API security helps organizations to secure the APIs in all the layers like authentication, authorization, and monitoring to prevent

unauthorized access.

- **Cloud access security broker (CASB):** CSAB helps organizations to monitors and secures cloud usage and implement security policies across the cloud.

Integration with other Oracle Cloud Services

Advantage of OCI is the capability of Oracle Identity and Cloud Services to be deployed within any of the other services offerings by Oracle Cloud. For example, Oracle autonomous database or some of the Oracle SaaS applications, can facilitate to re-establish traditional IAM experience which OCI offers as follows:

- **Oracle Cloud Infrastructure (OCI Cloud):** OCI offers a secure, high-performance environment for running applications and workloads. Oracle **Identity Cloud Service (IDCS)** integrates with OCI to manage identities and access to OCI resources, providing features like SSO, MFA, and automated user provisioning.
- **Oracle Autonomous Database:** Oracle Autonomous Database uses Oracle's identity and security solutions to protect data. IDCS manages access to the database, ensuring that only authorized users can perform specific actions.
- **Oracle SaaS applications:** Oracle's SaaS applications, such as Oracle ERP Cloud, Oracle HCM Cloud, and Oracle CX Cloud, utilize Oracle Identity Cloud Service to manage user access and enforce security policies. This integration simplifies identity management across Oracle's cloud applications.

Implementing Oracle Identity Cloud Service

Oracle Identity Cloud Service is an **Identity-as-a-Service (IDaaS)** solution offered in Oracle Public Cloud. It aims to enhance enterprise controls by automating the provisioning and deprovisioning of PaaS and SaaS accounts, simplifying user access to cloud applications through seamless integration with enterprise identity stores and authentication services, and supporting compliance efforts by providing clear reporting on cloud application usage. The **Oracle Identity Cloud Service connector** enables you to use Oracle Identity Cloud Service as a managed (target) source of identity data for Oracle Identity Manager. In the account management (target resource) mode of the connector, the data about the users created or modified directly on the target system (Sometimes referred as *Oracle Identity Cloud Service*) can be reconciled into Oracle Identity Manager. This data is used to allocate new resources or update resources already assigned to Oracle Identity Manager users. This will also enable users to use Oracle Identity Manager to provision or update Oracle Identity Cloud Service resources (accounts) assigned to Oracle Identity Manager users. These

provisioning operations performed on Oracle Identity Manager translate into the creation or updates to target system accounts.

IDCS Connector Deployment Models:

The IDCS Connector supports two deployment models for provisioning identity data with IDCS:

- **Single-tenant provisioning:** With single-tenant provisioning you deploy the connector in the typical manner, creating a client application and a user account in the target IDCS tenant for provisioning (e.g., using OAuth 2.0 Resource Owner Password).
- **Multitenant provisioning:** With multi-tenant provisioning you have two options: (a) deploy one connector with multiple IT resource definitions, one for each IDCS tenant, or (b) deploy multiple copies of the connector (clones), each copy having one IT resource definition per IDCS tenant. In either of the cases, you create a client application and a user account for each target tenant. The main difference between the two options, is that with multiples copies of the connector you have a different set of resources and processes per connector that you can customize as needed.

Below is a summary of steps at a high level to implement Identity cloud service in OCI:

- **Setting up IDCS:** Implementing IDCS involves several key steps as follows:
 1. **Provisioning IDCS:** Subscribe to Oracle Identity Cloud Service and configure the initial settings.
 2. **Integrating applications:** Integrate cloud and on-premises applications with IDCS to enable SSO and MFA.
 3. **Configuring identity governance:** Use and setup identity governance in Oracle Cloud using the features such as access management like role management, and SoD policies.
 4. **Defining access control policies:** Create and implement access control policies to establish and control the policies and process to manage and limit who can access specific resources.
- **User and group management:** Managing users and groups in IDCS involves:
 - **User onboarding process:** User onboarding helps to automate the creation of user accounts and assign roles based on user type, access and organizational policies.

- **Group management:** Create and manage groups to simplify access management. Assign roles and access permissions to groups rather than individual users.
- **Lifecycle management:** Automate user lifecycle events such as promotions, department changes, and terminations to ensure access rights are always up to date.
- **Security and compliance:** Ensuring security and compliance in IDCS includes:
 - **MFA configuration:** Enforce MFA for accessing sensitive applications and data.
 - **Access certification:** Periodically review and certify user access to ensure compliance with security policies.
 - **Audit and reporting:** Use IDCS's audit and reporting capabilities to monitor access activities and generate compliance reports.

Best practices for Oracle Identity and Cloud Services

Adopting these best practices for Oracle Identity Cloud Service in OCI will strengthen security, simplify identity management, and help ensure compliance with regulatory standards. By creating a solid identity management framework, organizations can effectively safeguard their sensitive data and enhance user access experiences. Below are few of the approaches which are considered as best practices to be adopted for oracle identity and cloud services:

- **Enforce least privilege:** Users should be provided the minimum level of access required to perform their job functions. Always enforce least privilege by implementing RBAC. This approach will limit access to only necessary resources. In addition, regularly review and adjust access permissions to align with changes in job responsibilities.
- **Implement strong authentication:** Use MFA to add an additional layer of security for accessing critical applications and data. Consider adaptive authentication to adjust security requirements based on the context of the access attempt.
- **Regularly audit access:** Conduct periodically to review the regular access audits to verify that access permissions are appropriate and comply with security policies. Configure automated tools to streamline the auditing process and ensure comprehensive and in detail coverage.
- **Use automated provisioning:** Automating user creation and termination is key to manage the security of the organizations which ensures that access rights are

granted and revoked promptly. This helps to minimize the access risk such as unauthorized access, not having termination access of employees, who leaves organizations.

- **Monitor and respond to security events:** Incoming and outgoing data from and to the systems should be monitored continuously. This data is fed to security information and event management systems to detect, respond, and analyze the security events in real-time.

Secure identity management in a finance

Let us consider a use case where a large financial institution needed to secure access to its cloud and on-premises applications. This should also ensure compliance with stringent regulatory requirements. These can be implemented as explained as follows:

- **Implementation:**
 - **IDCS deployment:** Identity Cloud Service is an Identity-as-a-Service solution available in built in Oracle Public Cloud. This is used for managing of identities and access across its hybrid cloud environment.
 - **SSO and MFA:** Organizations are advised to implement the integration of SSO and MFA. This Integration enhance the security and provide the simplified user access to high priority.
 - **Identity governance:** Implemented access certification, role management, and Segregation of duties policies to enforce compliance with regulatory requirements.
- **Outcomes:**
 - **Enhanced security:** Strengthened security posture with MFA and adaptive authentication.
 - **Compliance achieved:** Successfully met regulatory requirements through robust identity governance.
 - **Improved user experience:** Simplified access to applications with SSO, reducing the need for multiple logins.

Oracle Identity and Cloud Services include a comprehensive suite of services to help manage identities, control access, and maintain compliance in the cloud. Through the implementation of OIGC and Oracle Access Management Cloud, organizations can provide holistic identity governance. In addition, Oracle Cloud Infrastructure access controls enable enforcing access controls and Oracle Cloud Infrastructure compartments provide security and compliance boundaries. With these solutions, customers can secure access and sensitive data throughout their cloud systems and

across unified companies and manage access for users and contractors from a central location. By following best practices and using OICS, we can help build your networking savvy, strengthen your security posture, and increase operational efficiency.

Access controls in OCI

One of the most important steps involved in building a secure place in any cloud computing environment, OCI in this context, is to focus on how access control comes into play. It is a core aspect of security, encompassing three aspects: defining who can do what (in terms of resources), while enforcing those rules. In OCI, this is achieved through a combination of various IAM features, namely users, groups, policies, compartments, and a host of security controls.

Introduction to access controls in OCI

OCI has an access control system that provides *fine-grained control over where, who, and what* can access resources and operate on them. Security, compliance, service governance, cost control, and decentralized self-service all of these are major pillars of the modern cloud.

The following are the key concepts:

- **Users:** Individual identities that can be assigned permissions.
- **Groups:** Collections of users that share the same access permissions.
- **Policies:** Sets of rules that define access permissions for users and groups.
- **Compartments:** Logical containers used to organize and isolate cloud resources.
- **Tags:** Metadata labels that can be applied to resources for better organization and access management.

Identity and access management in OCI

OCI's IAM service is central to its access control framework. It allows you to manage user identities, groups, and their permissions through policies. Here is a detailed look at each component as follows:

- **Users and groups:**
 - **Users:** Individual accounts representing people or systems that need to interact with OCI resources. Using the OCI Console, CLI, SDKs, or API, OCI allows to create, modify, or delete Users. The users authenticate

themselves using a combination of usernames, passwords, and **multi-factor authentication (MFA)**.

- **Groups:** Collections of users that simplify the assignment of permissions. Like users, groups are managed through the OCI Console or other OCI Tools. Users are added to groups, and policies are assigned to groups rather than individual users, streamlining the permission management process. [Figure 7.16](#) represents default domain related to groups:

Name	Description	Created
All Domain Users	A group representing all users.	Mon, Mar 4, 2024, 18:00:42 UTC
Administrators	Administrators	Mon, Mar 4, 2024, 18:00:30 UTC

[Figure 7.16: OCI default domain](#)

- **Policies:** Policies in OCI are used to define what actions users and groups can perform on which resources. They are written in a simple, human-readable language.

The structure of policies is as follows:

- **Statements:** Each policy consists of one or more statements that specify the allowed or denied actions.
- **Syntax:** Policies follow a structure like *Allow group <group-name> to <verb> <resource-type> in compartment <compartment-name>*. [Figure 7.17](#) illustrates interface for policies created.

Name	Description	Statements	Created
CloudGuardPolicies	Cloud Guard Policies for [REDACTED] compartment.	28	Mon, May 20, 2024, 08:25:26 UTC
PSM-root-policy-compartments	PSM managed compartment root policy	7	Mon, Mar 4, 2024, 18:41:58 UTC
Tenant Admin Policy	Tenant Admin Policy	1	Mon, Mar 4, 2024, 18:00:47 UTC

[Figure 7.17: OCI policies](#)

The following are the examples of policies:

- Allow group *Admins* to manage all-resources in compartment *Production*.
- Allow group *Developers* to read objects in compartment *Development*.

- **Compartments:** Compartments are fundamental to organizing and isolating resources in OCI. They enable better access control by allowing policies to be applied at the compartment level. *Figure 7.18* illustrates different components in compartments with their status:

Compartments		
Name	Status	OCID
[REDACTED]	● Active	...nqxjca
database-account	● Active	...eok2rq
ManagedCompartmentForPaaS	● Active	...zel6sa
[REDACTED]	● Active	...igzrmq
[REDACTED]	● Active	...fg2uccq
sandbox	● Active	...5ol5og

Figure 7.18: OCI compartments

The following are the features of compartments:

- **Isolation:** Resources in different compartments are isolated from each other.
- **Hierarchy:** Compartments can have nested structures, allowing for granular access control.
- **Policies:** Policies can be applied at different levels of the compartment hierarchy.
- **Tags:** Tags are metadata labels that can be applied to resources for better organization and management. Tags can also be used in policies to control access based on resource attributes. *Figure 7.19* depicts the sample tag filter:

The screenshot shows the 'Apply tag filter' interface. At the top, there's a 'Tag namespace' dropdown set to 'Oracle-Tags' and a 'Tag key' dropdown set to 'CreatedBy'. Below these are two radio button options: 'Match any value' (selected) and 'Specify matching values'. A text input field is present for the latter option. At the bottom are 'Apply filter' and 'Cancel' buttons.

Figure 7.19: OCI apply tag filter

Advanced access control features in OCI

Beyond basic IAM components, OCI provides advanced features to enhance access control and security as follows:

- **Dynamic groups:** Dynamic groups allow you to define groups whose membership is determined by rules that evaluate resource attributes, such as instance metadata or tags.
- **Use case:** Automatically assign instances to a dynamic group based on their tags, and then apply policies to control the actions those instances can perform.
- **Security zones:** Security zones enforce strict security policies to ensure that resources comply with security best practices. Resources in a security zone must adhere to predefined security policies, providing an extra layer of protection.

The following are the features:

- **Predefined policies:** Enforces policies that prevent common security misconfigurations.
- **Compliance:** Ensures resources comply with regulatory and organizational security standards.
- **Bastion service:** The OCI Bastion service provides secure access to private resources without exposing them to the public internet.

The following are the benefits:

- **Security:** Minimizes the attack surface by providing controlled access pathways.

- **Auditability:** Logs access sessions for audit and compliance purposes.

Best practices for implementing access controls in OCI

Implementing effective access controls in OCI involves adhering to best practices that ensure security and compliance as follows:

- **Principle of least privilege access:** Grant users and groups the minimum level of access necessary to perform their tasks. Regularly review and adjust permissions to align with current needs.
- **Use compartments strategically:** We will be having different projects and different environments like development, QA, production. OCI provides a way to Organize resources into compartments based on project, environment, or department. Using of compartments will simplify access management and apply policies more effectively.
- **Implement two or multi-factor authentication:** It is essential to control the users to log into their accounts using two or multi factor authentication is one of the secure ways to ensure a complete security of cloud applications. Two factor authentication adds an additional layer of security by requiring users to provide a second form of verification.
- **Regularly audit and monitor access:** Regularly audit policies and access logs to ensure compliance and detect any unauthorized access attempts. Use OCI's monitoring and logging services to maintain visibility into access activities.
- **Use dynamic groups and tags:** Leverage dynamic groups and tags to automate and simplify access management, especially in dynamic environments where resources are frequently created and destroyed.

Case study for access control implementation in a large enterprise

A large enterprise needs to manage access to OCI resources for multiple teams, projects, and environments. The organization aims to enforce strict security policies while maintaining operational efficiency.

The following are the steps for implementation:

1. **Define users and groups:** Define the policies of the users and groups i.e. user accounts for employees and group them based on their roles and responsibilities (Example; developers, admins, auditors etc.).
2. **Organize compartments:** Having structure compartments based on business units, projects, and environments is essential for the security of the systems and

applications. For example, create separate compartments for the sales, marketing, and IT departments.

3. **Write policies:** Develop and apply policies to groups and compartments to enforce the principle of least privilege. For instance, grant developers read-only access to production resources but full access to development resources.
4. **Enable MFA:** Require MFA for all user accounts to enhance security.
5. **Implement dynamic groups:** Use dynamic groups to manage instance access based on tags, ensuring instances have the necessary permissions automatically.
6. **Use Bastion service:** Configure the Bastion service to provide secure access to private resources. This will prevent exposing them to the public internet.
7. **Audit and monitor:** Review regularly the access logs and audit policies to ensure they are up-to-date and compliant with security standards.

The following are the outcomes:

- **Enhanced security:** Improved security posture through strict access controls and MFA.
- **Operational efficiency:** Simplified access management by organizing resources into compartments and using dynamic groups.
- **Compliance:** Ensured compliance with internal policies and regulatory requirements through regular audits and monitoring.

Access control in OCI is a critical for protecting cloud resources and achieving compliance with business and regulatory mandates. With OCI's advanced IAM capabilities, which include users, groups, policies, compartments, and dynamic groups, all supported by security zones, organizations can implement fine-grained, flexible and secure access controls. Together with best practices, including the principle of least privilege, **migration access control (MFA)** and regular access audits, access controls in OCI can be run securely and efficiently.

Data residency and compliance

As more and more corporate data is generated, processed, and stored, companies are facing a crisis in data custody. From confirmation of data residency to meeting compliance norms, OCI provides businesses engaged in regulated industries; or operating in a multi-country or multi-jurisdictional environment or having data sites located across geographies, the tools, and services they require to defend their data borders.

Data is being seen as increasingly strategic asset as organization's continuing to leverage advanced technologies. Cloud adoption and the daily ingestion of petabytes of data by businesses from multiple industries results in organization's needing to effectively manage data storage and processing in a new world filled with everchanging regulatory and compliance standards. OCI Cloud is structured to help organization's meet the growing compliance challenges that arise due to the everchanging needs of businesses. With a broad set of tools and services, OCI helps you ensure data residency and compliance.

Understanding data residency and compliance

OCI provides data residency options to its users. Data residency defines a process to organizations as of where organizations can store user's data. If this storage is permitted locally either in the region or country to be compliant with the local data protection laws. This approach reduces the probability of fines and customer loss because of breach of personal data due to non-compliance with laws.

Data residency focusses on the following:

Where the data is to be stored?

How data needs to be processed?

- **Compliance:** Compliance is practice of adhering and complying to laws, regulations, and standards that govern data protection, privacy, and security. Each jurisdiction and industries will follow different regulations based on their use cases. For instance, Payment industry has one set of regulations, Health care industry has other set of regulations. This are explained in *Chapter 9, Compliance, IDR and Vulnerability Management in OCI*. In addition to this we have *California Consumer Privacy Act* which is specifically for providing the privacy rights and consumer protection for residents of *California*.

Key regulations and standards

This is commonly referred as frameworks and compliance requirements which governs data security, privacy, and operational practices within OCI. These regulations help ensure that organizations using OCI maintain legal and industry-standard levels of data protection, privacy, and security. Here are some key regulations and standards in OCI:

- **General data protection regulation:** GDPR majorly applies to any organization, regardless of its location where it operates, which processes the personal data of EU citizens across the globe.

The following are the requirements:

- Data collected must be processed lawfully. Transparency and fairness in the process should be established.
 - While collecting and gathering the personal data, organizations should make sure this are for a specified use case, explicit, and legitimate purposes, and reasons of collecting data should be justified.
 - This is one of the critical requirements where data is expected to be always accurate and, where necessary, kept up to date.
 - Data must be processed in a process that ensures appropriate security and controls are implemented.
- **Health insurance portability and accountability act (HIPAA):** HIPAA is most important regulation which applies healthcare providers, health plans, and healthcare clearinghouses in the U.S as well as their business associates.

One of the important requirements, which organizations should mandate is to ensure the following attributes are protected. Few of the attributes are as follows:

- Confidentiality
 - Integrity
 - Availability of all **electronic protected health information (ePHI)**
 - Protect against reasonably anticipated impermissible uses or disclosures
 - Organizations should focus in designing the systems which are capable to Protect against any kind of anticipated threats to the security or integrity of electronic protected health
- **California Consumer Privacy Act:** The *California Consumer Privacy Act* applies to businesses that collect personal data from California residents and meet specific criteria.
- The following are the requirements:
- California Consumer Privacy Act should be transparent to its users about the way data collection practices are followed.
 - Allow consumers to opt out of data selling.
 - Options such as to access, delete, and obtain data should be provided to its consumers.
- **Payment card industry data security standard:** PCI DSS applies to all organizations that handle credit card and financial information.

The following are the requirements:

- Protect cardholder data through encryption and other security measures.
- Maintain a secure network and systems.
- Implement strong access control measures.
- Regularly monitor and test networks.

Data residency and compliance in OCI

OCI provides data residency options that let you store your data in specific regions or countries to meet regulatory requirements. This ensures you can comply with local data protection laws and reduce the risk of data breaches or unauthorized access due to non-compliance. Few of the key terminologies are to be noted are as below:

- **Global data centers:** OCI cloud has a network of data centers configured around the world. This global presence allows organizations to choose specific regions for data storage and processing. Global presence of data centers ensures organizations to have compliance with local data residency requirements.
- **Data sovereignty:** Data sovereignty is very important for countries which has a strict data localization laws and regulations. OCI enables its customers meeting the Data sovereignty requirements by enforcing organizations to store data in specific geographic locations that meet local regulatory requirements.
- **Security and compliance certifications:** Security and compliance certifications are an important part of establishing trust and confidence in OCI and Oracle Cloud customers and the trade press.

These certifications will ensure that trust and confidence are established by mandating that Oracle cloud infrastructure has implemented effective security controls and are continually compliant with internationally accepted standards and adopt best practices for protecting data and be accountable for the data being stored and transferred by our customers. In the following sections we will understand in detail about some of the key certifications obtained by OCI:

- **ISO/IEC 27001:** ISO or IEC are considered as important international standards for information security management systems. OCI has this certification. This signifies that it successfully demonstrated its capacity to employ in detail and integrated framework for managing and protecting sensitive information right from assessing risks to implementing security controls and ongoing improvement processes. This is one of the certifications which OCI demonstrated. This will build the trust and confidence in the customers.

- **ISO/IEC 27017:** It is considered as best practice for implementation of standards within a cloud service. It covers controls applicable to the provider of cloud services and relevant to the customers of that provider. This certification is intended to focus on providing the security controls which protects the customer data stored in the cloud. OCI having this certification demonstrates OCI's commitment in protecting customer data.
- **ISO/IEC 27018:** ISO/IEC is focused on protecting the **personally identifiable information (PII)** in public cloud environments. It protects privacy and confidentiality of customer data by incorporating security controls and standards in align with industry best practices. This standard includes personally identifiable information.

OCI holds various security certifications that demonstrate its commitment to maintaining a secure environment for its customers. OCI provides compliance tools and services to assist customers achieve and maintain compliance. Some of the critical requirements are SOC1, SOC2 and SOC3 which are required for the organizations.

These certifications depend on principles such as security, availability, processing integrity, confidentiality, and privacy. OCI provides users with different types of compliance tools and services which will help organizations to achieve compliance. These Compliance tools help customers to achieve standard compliance along with security controls, encryption, and audit trails. This approach we usually term as Oracle Cloud Compliance.

PCI DSS security standards are designed to ensure the secure handling of payment card information. Health Insurance Portability and Accountability Act abbreviated as HIPAA is designed for protecting sensitive patient health information. These concepts are discussed in detail in *Chapter 9, Compliance, IDR, and Vulnerability Management in OCI*.

Based on obtaining these certifications and adhering to international standards, OCI delivers a secure and compliant cloud platform for customers, across industries. Besides providing a framework that enables OCI to secure customers' data, these certifications provide customers with the confidence that OCI manages their data with the highest industry standards and regulatory requirements. OCI provides several tools and services to help organizations achieve and maintain regulatory compliance. These compliance tools offer monitoring, reporting, security, and governance features to meet legal and industry-specific requirements. Below are some key compliance tools in OCI:

- **Built-in compliance tools:** OCI offers several tools to help organizations manage compliance as follows:

- **Oracle Cloud Infrastructure audit:** Provides comprehensive logging of all API calls, enabling detailed tracking and auditing of actions within OCI.
- **Oracle Cloud Infrastructure Security Zones:** Helps enforce security best practices and ensures compliance by preventing common misconfigurations.
- **Oracle Data Safe:** Offers features such as security assessments, user assessments, activity auditing, and sensitive data discovery to help manage database security and compliance.
- **Oracle Cloud Guard:** Monitors and enforces security best practices across OCI resources, helping to maintain compliance.

Implementing data residency and compliance in OCI

In this section, we will learn how to implement data residency and compliance in OCI:

- **Choosing data regions:** Selecting appropriate data regions is the first step in ensuring data residency compliance. Organizations should:
 - **Identify regulatory requirements:** Understand the data residency requirements of the countries and regions where they operate.
 - **Select appropriate regions:** Choose OCI data centers in regions that meet these requirements.
 - **Consider latency and performance:** Balance regulatory requirements with performance considerations by selecting regions that provide optimal latency for end-users.
- **Data encryption:** For protecting the sensitive information and meeting compliance requirements, organizations should implement industry standard data encryption methods. As we are aware data will be stored at rest and data will be in transit. For both the ways data needs to be safeguarded as follows:
 - **Encryption at Rest:** OCI uses strong encryption algorithms which automatically encrypts data stored in its services.
 - **Encryption in Transit:** TLS and SSL should be used to encrypt data during transmission. This will protect data from interception and tampering.
- **Access controls:** Implementing strict access controls is crucial for compliance. They are defined as:
 - **Identity and access management:** Use OCI's IAM service to define and enforce who can access what resources. Implement least privilege access principles.

- **Multi-factor authentication (MFA):** MFS helps to increase the security by requiring multiple forms of verification for user access, MFS is common practice in the industry which requires more than one forms authentication for user authentication to allow login to the system.
 - **Compartmentalization:** Organize resources into compartments to isolate and manage access effectively.
- **Auditing and monitoring:** Regular auditing and monitoring help ensure compliance and detect potential security issues:
 - **Audit logs:** Use OCI's Audit service to maintain detailed logs of all actions performed in the cloud environment.
 - **Security monitoring:** Implement continuous monitoring with tools like Oracle Cloud Guard to detect and respond to security threats.
 - **Compliance reporting:** Generate compliance reports to demonstrate adherence to regulatory requirements.
- **Data masking and reduction:** For additional data protection, especially in non-production environments:
 - **Data masking:** Data masking is the process of replacing the sensitive data permanently with fictitious data to protect confidential information. Non-production environments also need to be shielded, hence organizations need to safeguard sensitive data and stay compliant with data privacy regulations. One of the recommended solutions is to mask sensitive data before using it in non-production environments. This technique will minimize the sensitive data you have, and thus, reduce the risk and compliance boundary.
 - **Data redaction:** In data redaction technique, sensitive data is hidden from unauthorized users.

Best practices for data residency and compliance in OCI

OCI provides the guidelines and strategies for ensuring that data is stored, processed, and managed in compliance with relevant legal, regulatory, and organizational requirements based on geographic location. Data residency involves the physical or geographic location of where data is stored, while compliance refers to adhering to applicable data protection laws and industry standards. Below are few best practices which needs to be adopted to achieve data residency and compliance in OCI:

- **Understand legal and regulatory requirements:** Organizations must be stay informed about the data protection laws and regulations applicable to your industry and regions of operation. Legal and regulatory requirements must be

regularly reviewed and updated in align with your compliance strategies. This also should be aligned with changes in legislation.

- **Implement comprehensive data protection measures:** Use a combination of encryption, access controls, and monitoring to protect sensitive data. Ensure that all data, whether at rest or in transit, is adequately secured.
- **Regularly review and update policies:** Regularly review and update your access control policies, encryption standards, and compliance procedures to ensure they remain effective and relevant.
- **Educate and train staff:** Provide regular training and education to staff on data protection practices, compliance requirements, and the use of OCI tools to ensure they understand their roles in maintaining compliance.
- **Leverage OCI compliance tools:** OCI offers built-in compliance and security tools, such as Oracle Cloud Guard, Oracle Data Safe, and OCI Audit. Organizations are recommended to adopt these tools to automate and streamline compliance management.

Data residency and compliance for a global enterprise

A global enterprise with operations in multiple countries needed to ensure compliance with various data residency and protection regulations while leveraging OCI for their cloud infrastructure.

The following are the steps of implementation:

- **Assessment of regulatory requirements:** A through and in detail assessment of data residency and protection regulations specific to each country of operation should be conducted periodically.
- **Selection of OCI data regions:** It is strongly recommended to select OCI data centers in regions which meets the regulatory requirements for data storage and processing.
- **Implementation of encryption:** Configured encryption at rest and in transit for all sensitive data.
- **Access controls:** Set up IAM policies, MFA, and compartmentalization to enforce strict access controls.
- **Auditing and monitoring:** Deployed OCI Audit and Oracle Cloud Guard for continuous monitoring and compliance reporting.
- **Data masking:** Used Oracle Data Safe to mask sensitive data in non-production environments.

The following are the outcomes:

- **Regulatory compliance:** Successfully met the data residency and protection requirements for all regions of operation.
- **Enhanced security:** Implemented comprehensive data protection measures, significantly reducing the risk of data breaches.
- **Operational efficiency:** Streamlined compliance management using OCI's integrated tools, reducing the administrative burden on IT staff.

Oracle CASB Cloud Service

With the increasing demand for connecting enterprise users to various cloud service providers, Cloud Access Security Brokers have emerged as the central gatekeepers to cloud. Oracle CASB Cloud Service is a powerful solution that gives core visibility and control over the use of your and your users' clouds. This enables robust cloud security, ensuring compliance and governance, while helping you to encrypt and protect sensitive data, detect, and respond to threats, and fulfil your compliance requirements. *Figure 7.20* explains the various cloud services in OCI:

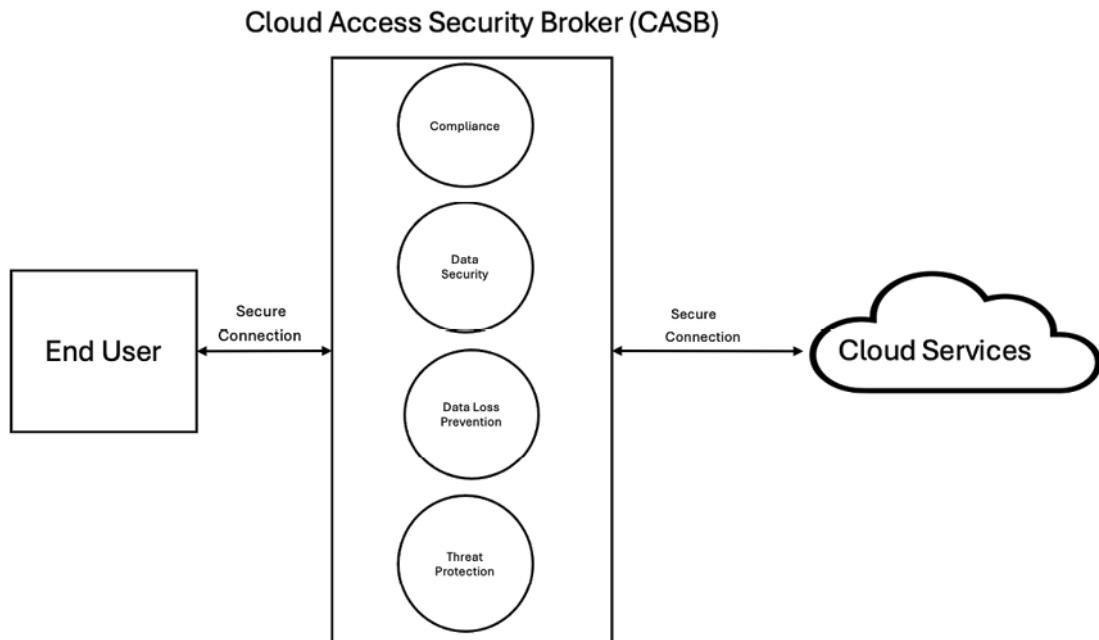


Figure 7.20: OCI Cloud Access Security Broker

The key features of Oracle CASB Cloud Service are as follows:

Comprehensive visibility

Oracle CASB Cloud Service provides deep visibility into cloud applications and services, allowing organizations to monitor and manage their cloud environments effectively.

- **Cloud application discovery**

- **Discovery of shadow IT:** Identify unsanctioned cloud applications being used within the organization.
- **Usage patterns:** Monitor usage patterns to understand how cloud services are being utilized and identify potential risks.

- **Detailed activity monitoring**

- **User activity:** Track user activities across cloud applications to detect unusual or risky behavior.
- **File activity:** Monitor file uploads, downloads, shares, and edits to protect sensitive data.

Advanced threat protection

Organizations should be capable to monitor, detect and mitigate any kind of potential security threats which occurs in real time. This is achieved by configuring the Oracle CASB Cloud Service.

- **Anomaly detection:**

- **Behavioral analytics:** ML algorithms should be used to identify behavioral analytics. ML algorithms captures and analyzes user behavior. This data is fed to different sources like Splunk which can detect anomalies that may indicate security threats.
- **Risk scoring:** Based on detected anomalies, risk scores should be assigned to users prioritizing investigations and responses.

- **Threat intelligence integration:**

- **Threat feeds:** Systems should be Integrated with external threat intelligence feeds. This will allow organizations to have up-to-date information on vulnerabilities and threats.
- **Real-time alerts:** Threats can be detected in real time by configuring the Real time Alerts. This will allow security teams to enable rapid response and mitigation steps.

Policy enforcement

Enforcing security policies across cloud applications is crucial for maintaining control and compliance.

- **Granular policy controls:**

- **Access policies:** Establish and enforce access control policies based on user roles, locations, and devices.
- **Data loss prevention:** Implement DLP strategies to protect sensitive data from unauthorized access.

- **Automated remediation:**

- **Automated actions:** Systems should be configured to perform automated actions once a policy is violated, such as locking accounts, quarantining files, or notifying administrators.
- **Workflow integration:** Workflow and existing security workflows should be embedded. This will allow incident response and remediation be seamless.

Compliance management

Compliance management is achieved by using Oracle CASB Cloud Service. The service helps organizations meet regulatory compliance requirements and adhere to industry standards:

- **Regulatory compliance:**

- **Regulatory templates:** Simplify compliance by using templates for common regulations such as GDPR, HIPAA, PCI, and others.
- **Continuous compliance monitoring:** In the cloud, continuously monitor regulatory requirements and internal policies to ensure compliance.

- **Audit and reporting:**

- **Detailed audits:** User activities and application activities should be recorded for audit. Detailed audits will ensure compliance and identify potential issues.
- **Custom reports:** OCI provides custom reports which generates insights into cloud usage, security incidents, and compliance status.

Integration and extensibility

Oracle CASB Cloud Service integrates seamlessly with other security tools and cloud services, enhancing its capabilities and providing a unified security framework as follows:

- **Cloud service integration:**
 - **Multi cloud support:** CASB provides support for various cloud service providers, including *Oracle Cloud*, *Amazon AWS*, *Microsoft Azure*, *Google Cloud*, and others.
 - **SaaS applications integration:** CASB integrates with SaaS applications like Office 365, Salesforce, and Google Workspace to offer thorough protection.
- **API and SDK:**
 - **API access:** Use APIs to integrate *Oracle CASB Cloud Service* with other security tools, enabling data sharing and automation.
 - **SDK support:** Utilize SDKs to extend the capabilities of *Oracle CASB cloud service* and customize its functionality to meet specific organizational needs.

The following are the use cases for *Oracle CASB cloud service*:

- **Protecting sensitive data:**
 - **Data loss prevention:** Sensitive data can be protected by implementing the Data loss prevention policies. This will prevent sensitive data from being exposed through cloud applications.
 - **Encryption and tokenization:** Encryption and tokenization is data protection techniques to protect sensitive data which is stored and processed in the Oracle Cloud.
- **Detecting and responding to threats:**
 - **Anomaly detection:** Employ behavioral analytics to identify abnormal activities that could indicate insider threats or compromised accounts.
 - **Incident response:** Utilize real-time alerts and automated remediation processes for swift response to detected threats.
- **Ensuring compliance:**
 - **Regulatory standards:** Using pre-defined templates and continuous monitoring to ensure compliance with data protection security regulations such as GDPR and HIPAA.
 - **Audit trails:** Maintain detailed audit trails of all cloud activities to demonstrate compliance during audits and investigations.
- **Managing shadow IT:**

- **Enforcement of policy:** Implement policies to control the use of unapproved applications and mitigate associated risks.

The best practices for using Oracle CASB cloud service are as follows:

- **Establish clear security policies:**
 - **Policy definition:** Ensure clear security policies that align with organizational goals and regulatory requirements are defined.
 - **Regular updates:** Review and update policies to address emerging threats and changes in regulatory landscapes.
- **Monitor continuously:**
 - **Continuous monitoring:** Setup and implement continuous monitoring of cloud activities to detect and respond to security incidents as they happen.
 - **Behavioral baselines:** Create and establish behavioral baselines for normal user activities to improve the accuracy of anomaly detection.
- **Automate remediation:**
 - **Automated actions:** Setup and implement automated remediation actions to respond to policy violations and security incidents promptly.
 - **Integration with SIEM:** Integrate with **security information and event management (SIEM)** systems to improve incident detection and response.
- **Educate and train users:**
 - **User training:** Provide regular training to users on cloud security best practices and the importance of compliance.
 - **Awareness campaigns:** Conduct awareness campaigns to keep users informed about potential security incidents and threats and how to avoid them.
- **Using threat intelligence:**
 - **External threat inputs:** Integrate with external threat intelligence information to stay updated on the latest threats and vulnerabilities.
 - **Proactive defense:** Use threat intelligence to proactively defend against known threats and improve overall security posture.

Oracle CASB Cloud Service is a powerful tool for securing cloud environments. This tool help providing comprehensive and in detailed visibility, threat protection, and robust compliance management. This cloud service offers entities a security advantage through its tools, allowing its use with data that is sensitive by design or by

default, enabling detection of malicious activities, react to internal and external threats, alongside compliance.

By adopting the best practices and including steps such as continuous monitoring, updating of security policies will significantly optimize the effectiveness of *Oracle CASB Cloud Service* and thereby ensures a secure cloud platform.

It is important to follow those best practices and to monitor and update security policies regularly for *Oracle CASB Cloud Service* to be most effective and provide a highly secure cloud environment. In addition, this guarantees compliance with regulatory mandates. Security best practices, continuous monitoring, and updates of security policies of *Oracle CASB Cloud Service* will guarantee a secure cloud platform.

Conclusion

This chapter explains the importance of optimizing and securing applications in the *Oracle Cloud Infrastructure OCI*. Contents in this chapter also focused on general strategy and guidelines on how costs, performance and the secure deployment of your application can be best adopted in the *Oracle Cloud Platform*.

We discussed various strategies, such as rightsizing, shaping, tuning and resizing; cost optimization; daily, weekly or monthly review of costs; and enhancing the performance of SaaS applications on OCI with services such as IAM, encryption, and monitoring tools. Organization's SaaS applications cannot exist without some form or an aspect of security, and you can secure your applications by implementing these practices. Scaling up, shaping usage, rightsizing, resizing, and performance tuning help your organization not only ensure a great user experience, but also protect data, ensure availability of applications, comply with regulations, and achieve long-term operational efficiencies in your cloud deployment. Organizations should set up continuous monitoring and responsive actions to adapt their SaaS applications to changing conditions.

Beyond automated and analytics aided techniques, there are pre-provisioned application performance (and security) best practices that will enable you to run and maintain a SaaS application on OCI to deliver the best business benefits. The future is also evolving at a rapid pace and the organization's that are agile to anticipate SaaS optimization and security trends will not merely stay ahead but build cloud-native applications that will be undefeatable.

Mastering SaaS optimization and security in OCI is not only about quick gains in optimizing utilization and performance for now, but also about creating a future-ready cloud strategy.

Multiple choice questions

- 1. Through which one of the following models, SaaS supports multiple users and offers a shared data model?**
 - a. Multiple instance
 - b. Multi-tenancy
 - c. Single tenancy
 - d. None of the above

- 2. Which of the following is a feature of the SaaS applications?**
 - a. SaaS applications are not reliable
 - b. SaaS applications are customizable
 - c. SaaS applications are reliable
 - d. Non-reliable

- 3. Which one of the following statements is incorrect about SaaS?**
 - a. All users with a little knowledge or know how to operate a computer also know about the SaaS
 - b. SaaS applications are offered in all shapes and sizes
 - c. SaaS software is not customizable
 - d. None of the above

Answers

- 1. b**
- 2. b**
- 3. d**

CHAPTER 8

Monitoring and Logging for Robust Security

Introduction

In the rapidly changing world of Cloud computing, monitoring, and logging are mandatory and essential components for achieving the reliability, performance, and security of the **Oracle Cloud Infrastructure (OCI)** environment. As companies increasingly move their workloads to the Cloud, it is very much essential to exhaustively monitor all activities to achieve operational excellence.

This chapter explains in detail the various monitoring and logging details that are implemented on OCI giving you an understanding of some strong tools and services through which you can easily get real-time visibility into resources. These capabilities are critical in maintaining a robust and productive cloud platform, as they help in keeping track of the infrastructure health status, as well as alerting on potential matters before they arise.

Throughout this chapter, we will cover key core principles, methodologies, and practices for handling OCI's monitoring and logging functionalities effectively. This chapter covers the concepts of security overview for logging and monitoring, logging analytics, custom logs, and Cloud Guard, and presents best practices for logging and monitoring.

If you are an experienced professional with cloud technology or if you have just started exploring it for the first time, these chapters provide insights that help you acquire the necessary knowledge about best practices for logging and monitoring.

Structure

The chapter covers the following topics:

- Technical requirements
- Security overview of logging and monitoring
- Logging and detection control
- Cloud Guard
- Monitoring using Cloud Guard
- Logging analytics
- Custom logs connectors
- Best practices for logging and monitoring
- SSL inspection and its need in OCI

Objectives

The core objective of this chapter is to provide a comprehensive and detailed understanding of logging and monitoring within OCI. By delving into sophisticated strategies and best practices, we aim to equip readers with the knowledge and skills needed to elevate logging, monitoring, and best OCI tools in monitoring and logging services in OCI to an advanced level. This includes in-depth coverage of advanced concepts such as key concepts in monitoring tools, real-time visibility, and tracking. Our goal is to empower readers to implement advanced security measures effectively, ensuring the resilience and integrity of their security tools in the dynamic and evolving landscape of OCI.

By the end of this chapter, readers should possess the knowledge and insights necessary to implement advanced security measures, ensuring robust and fortified logging and monitoring tools in the dynamic environment of OCI and the best recommendations and considerations for securing OCI.

Technical requirements

To fully engage with the content of this chapter on navigating network security in OCI readers should have a basic understanding of computer systems, networking concepts, and information technology.

Additionally, the following technical requirements are recommended:

- **Internet access:** Readers should have a reliable internet connection to access online resources, references, and examples related to cloud

computing.

- **Computing device:** A desktop computer, laptop, tablet, or smartphone with a modern web browser is necessary to read the chapter content and access any online materials.
- **Web browser:** The latest version of a modern web browser such as *Google Chrome*, *Mozilla Firefox*, *Microsoft Edge*, or *Safari* is recommended. This ensures compatibility and optimal viewing experience of web-based resources and interactive content.

OCI supports the following browsers and versions:

Google Chrome 80 or later, Safari 12.1 or later, Firefox 62 or later (private browsing mode is not supported), Edge 104 or later. This is required for accessing or creating security zones etc.

- **Security best practices:** Acquaint yourself with general security best practices and principles applicable to Cloud environments.
- **OCI Identity and Access Management:** Familiarity with OCI **Identity Access Management (IAM)** for managing users, groups, and policies to control access to OCI resources.
- **Logging and monitoring:** Familiarity with OCI logging and monitoring services to capture and analyze network activity and security events. Knowledge of concepts of encryption or decryption
- **Advanced networking concepts:** Gain knowledge of advanced networking concepts such as **Virtual Cloud Network (VCN)** design principles, routing, and subnetting, and knowledge of SSL or TLS concepts.
- **Lab environment:** Set up a lab environment within OCI to practice configuring advanced network security features.

Security overview of logging and monitoring

Security, logging, and monitoring are important components of OCI. These components ensure the confidentiality, integrity, and availability of resources and data.

In the previous chapters, we covered concepts of security such as IAM which manages user access, permits and allows us to define roles, groups, and policies, network security, creation and configuring of VCN, security lists, and network security groups. We also discussed firewall rules and data encryption.

In this section, we will provide an overview of logging and monitoring.

Logging service allows you to collect, search, and analyze logs generated by various OCI services. It helps in identifying security threats, operational issues, and compliance violations.

The OCI logging service stands out as an advanced and scalable solution, thoroughly managed to serve as a unified control center, often referred to as a *single pane of glass*, for overseeing all logs associated with your tenancy. In essence, it functions as a centralized repository for logging-related activities across the entire OCI environment.

The primary purpose of the logging service, as mentioned, is to grant users convenient and easy access to logs generated by various resources within OCI. These resources include but are not limited to a wide array of elements, such as virtual machines, databases, networking components, and more. By consolidating logs in a centralized location, the logging service simplifies the task of monitoring and analyzing critical diagnostic information.

The logs offered by this service provide essential details regarding the performance and access patterns of resources within the OCI environment. This includes valuable insights into how different components are functioning and how they are being interacted with or accessed. In essence, the logging service acts as a comprehensive observability tool, enabling users to gain a deeper understanding of the operational aspects of their OCI resources. This level of insight is instrumental in troubleshooting, performance optimization, and maintaining the overall health and security of the Cloud environment.

Similarly, we have the concept of *monitoring* in OCI. This service helps monitor the performance and health of your resources. Metrics, alarms, and notifications can be configured to detect and respond to anomalies or issues. We have an *OCI monitoring agent* that can be used for on-premises resources or non-OCI environments to collect and send metrics to the Oracle Cloud monitoring service. OCI provides APIs and integrations with third-party monitoring tools, allowing you to use your preferred monitoring and management solutions. This is one of the benefits OCI offers which provides seamless integration with third-party tools. In addition to logging and monitoring, OCI provides tools and procedures for incident response, including access to audit logs, detailed activity tracking, and integration with Oracle Cloud Guard for automated threat detection and response. In summary, OCI offers a comprehensive suite of security, logging, and monitoring tools to help you build and operate a secure and well-managed Cloud environment. It is crucial to configure and utilize these services effectively to protect your assets and maintain the desired level of operational visibility.

In the next sections, we will discuss logging implementation, monitoring, and observability concepts in detail.

Logging and detection control

As discussed previously, *logging* is used to enable, manage, and search logs. In OCI, we primarily have three types of logs. In this section, we will define these logs and understand them step by step to create our custom logs.

Audit logs

These are logs about events emitted by the OCI. The audit service captures a record of activities and changes within your OCI environment. These logs can be accessed through the logging audit page, providing a dedicated space for auditing-related logs. Additionally, they are searchable on the main search page, allowing for convenient exploration and analysis alongside other logs from various sources within your infrastructure. This integration of audit logs into the broader logging framework facilitates efficient monitoring, analysis, and management of security-related activities across your Oracle Cloud tenancy.

The following are the steps to navigate and filter audit logs in OCI:

1. Navigate to OCI and under **Observability & Management**, click **Audit**:

The screenshot shows the Oracle Cloud interface with the 'Observability & Management' section highlighted. The main menu on the left includes links for Home, Compute, Storage, Networking, Oracle Database, Databases, Analytics & AI, Developer Services, Identity & Security, and Observability & Management. The 'Observability & Management' link is enclosed in a dashed blue box. The main content area is titled 'Observability & Management' and contains several sections: Application Performance Monitoring, Logging Analytics, Events Service, Database Management, and Ops Insights. Each section has its own sub-links. The 'Monitoring' section is also visible. A red arrow points from the 'Audit' link in the 'Monitoring' section down to the 'Audit' screen in the bottom-left corner of the page content area.

Figure 8.1: Observability and management in OCI

2. In the **Audit** screen, we have different options such as **Request Action Types: GET, POST, PUT, DELETE, PATCH**. We can **Filter by time** for the **Past 5 minutes** etc. and add our **custom filters**, as follows:

The screenshot shows the 'Audit' screen in Oracle Cloud. The left sidebar shows 'Audit' selected. The main content area is titled 'Audit in dinesh_demo_compartment Compartment'. It includes sections for User, Resource, Request action types, Event type, and a 'Custom filters' input field. There is also a 'Filter by time' dropdown set to 'Past 5 minutes'. At the bottom right, there are 'Reset', 'Convert to search', and 'Apply' buttons. A red arrow points to the 'Request action types' dropdown, which is currently showing 'GET' as the selected option. Another red arrow points to the 'Filter by time' dropdown. A third red arrow points to the 'Convert to search' button.

Figure 8.2: Audit in OCI

3. To view audit log results on the search page, we can use the **Convert to search** option (as shown in *Figure 8.2*). This will help you search further and perform analysis across other logs in the system. When you use this option, the *advanced search version* of the **Search** page is filled with the chosen filter parameters (available in the *Query* field).
4. Click **View query syntax** to view the actual syntax query statements associated with your filter settings. We can also explore and visualize the results, as shown in the figure:

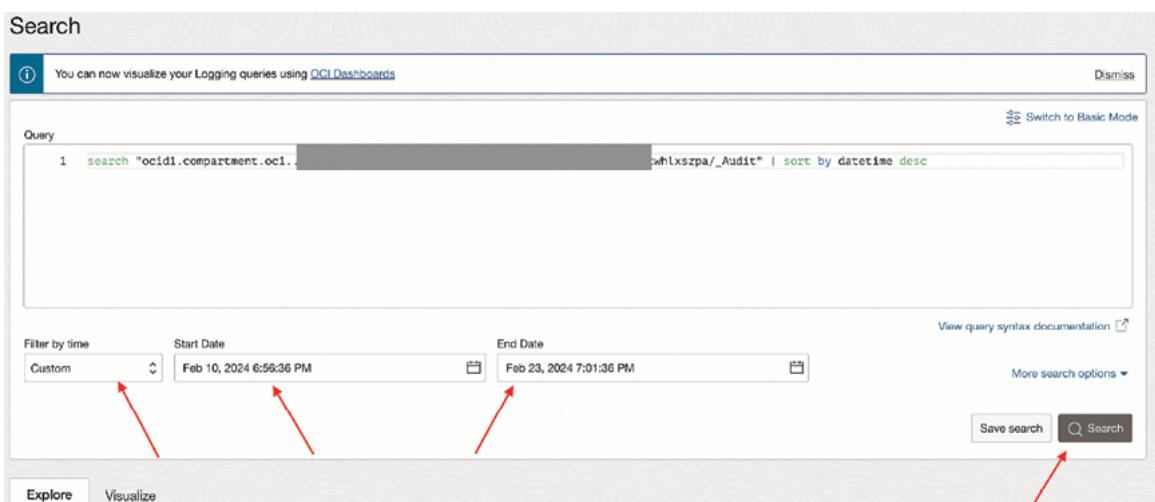


Figure 8.3: Audit query explorer in OCI

5. We can export the audit events using the connector hub.

Note: The steps to configuring an audit are explained in the upcoming sections.

Service logs

We have various OCI native services such as API Gateway, VCN flow logs, functions, load balancers, and object storage. These services come with default and predefined logging categories, which we can enable or disable based on our respective needs for resources.

Custom logs

We have discussed and seen the steps for configuring the custom logs in the previous sections. These are logs containing diagnostic information from custom applications, other cloud providers, or an on-premises environment that serves as a repository for specialized data beyond the standard logs provided by OCI. These

custom logs can be integrated into the OCI through two main methods. Firstly, they can be ingested through the API, allowing for a programmatic and flexible means of incorporating data from various sources into the logging system. Alternatively, custom logs can be configured using the *unified monitoring agent*, a tool designed for seamless integration of diverse log data. This agent simplifies the process of collecting and forwarding custom logs, offering a unified approach to monitoring across different environments. For OCI compute instances or resources, there is an additional option to directly upload custom logs through the unified monitoring agent. This feature streamlines the integration process, ensuring that diagnostic information from custom applications is efficiently included in the logging framework. It is worth noting that the support for custom logs extends to both virtual machine and bare metal scenarios, providing versatility in logging capabilities across different infrastructure configurations. This flexibility ensures that organizations can tailor their logging setup to specific application requirements and infrastructure preferences within the Oracle Cloud environment.

In OCI, we have a concept to configure our own custom rules, which we refer to as *detection rules*, which help us detect events of our interest and thereby post metrics in OCI monitoring services.

Detection can occur during the ingestion process when the log content aligns with a specified label and additional settings or through a scheduled search triggered by a predefined query.

If we want to detect specific content in the log records, we can create an ingest time detection rule and metrics can be posted to the OCI monitoring service by providing specific permissions to allow the ingest time rule.

OCI enables us to configure alarms for events detected either during ingestion or through scheduled searches. This involves defining the threshold, time range, and notification settings. If the search criteria surpass the specified threshold within the designated time interval, an alert is triggered, and a notification is dispatched to the designated recipient.

The following APIs are available in OCI logging:

- Logging Management API
- Logging Ingestion API
- Logging Search API

Let us discuss each of these APIs in brief:

- **Logging Management API:** Use the Logging Management API to create, read, list, update, move and delete log groups, log objects, log saved searches, and agent configurations. This API helps in automating log management, enabling better operational insights, compliance, and real-time monitoring within OCI. This is a set of RESTful APIs that allow developers and administrators to manage and interact with logging services programmatically.

Few of the key features of Logging Management API are log management, log querying, event-based logging, and log delivery.

- **Logging Ingestion API:** Use the Logging Ingestion API to ingest your application logs. Logging Ingestion API provides a flexible way to bring external or custom log data into the OCI ecosystem for analysis, monitoring, and troubleshooting. This is a REST API that enables users to programmatically submit log data to OCI's centralized logging service from multiple sources. It is mainly used to ingest logs from applications, custom sources, or third-party systems into OCI's logging service, where the logs can be stored, monitored, and analyzed. Few of common use cases of this API are Application Monitoring, Custom System Logs, Realtime Monitoring and alerting.
- **Logging Search API:** Use the Logging Search API to search for logs in your compartments, log groups, and log objects. It allows users to search and filter log records using various criteria, such as time range, log content, and specific attributes, allowing for quick log retrieval and analysis for troubleshooting, monitoring, and auditing. Few of the common use cases of logging search API are for troubleshooting, log analysis, monitoring, and auditing.

Cloud Guard

Oracle Cloud Guard offers a consolidated perspective of your security status across all clients using OCI. It recognizes emerging threats, identifies misconfigurations in OCI resources, detects insecure activities across tenants, reveals malicious threat actions, and grants security administrators the visibility needed to assess and address cloud security concerns.

Cloud Guard examines your OCI resources for security weaknesses related to configuration and monitors your operators and users for risky activities.

In OCI, optimization of security postures is carried out using Oracle Cloud Guard. One of the Important design principles of Oracle Cloud Guard is Oracle's integration of Embedded Expertise. Oracle framework has deep knowledge of the available security controls and how to implement them effectively at scale. They also understand the key risks to watch for and how to mitigate them using security features. Oracle Cloud Guard comes with built-in rules that leverage this expertise to detect common issues and deviations from the established baseline set during the design phase and then optimize accordingly. This approach reduces the burden on users, eliminating the need to create these policies from scratch. Oracle Cloud Guard has two main configuration options: detector recipes and responder recipes. Detector recipes deal with how certain violations are detected, and responder recipes deal with how the violations are responded to. These design principles of cloud guard allow to achieve optimization.

The following are a few benefits of enabling Cloud Guard:

- Cloud Guard monitors and detects any security violations.
- Detects and remediate respective threats that are detected.
- Protects customer tenancies.
- Automatically remediate security problems.

Provides a comprehensive and detailed view of risk posture.

Now, let us understand the terminologies used in Cloud Guard, as follows:

- **Target:** Establishes or defines the parameters for Cloud Guard to examine or defines the scope of what Cloud Guard is to check. In the case of OCI, this framework is linked to the compartment where the designated target is specified, encompassing all subsequent child compartments until a different target is identified. The subsequent target then assumes control from that point onward, extending into any subordinate compartments.
- **Detector:** Detector performs checks and identifies potential security problems based on their type and configuration.
- **Detector recipe:** Provides the baselines for examining the resources and activities in the target. Accessing a detector recipe from the detector recipes page allows for varied rule configurations. Configure the detector rules specifically for each compartment based on a review of our business needs. It is important to note that we must define separate targets for each compartment. OCI configuration detector rules, OCI activity detector rules, and OCI threat detector rules. More often we use either the *Oracle-*

managed detector recipe or *user user-managed detector recipe*. *Oracle-managed detector recipe* is provided by Cloud Guard, and this allows setting only the scope of resources for which a rule triggers a problem but does not permit you to disable or change the rule's risk level. In contrast, a *user-managed detector recipe* is created by cloning an Oracle-managed recipe, and unlike an Oracle-managed detector recipe, this allows you to disable individual rules and change a rule's risk level, in addition to allowing setting the scope of resources for which a rule triggers the problem.

All compartments will be impacted by the target configuration. The detector and responder rule settings for a target apply to the top-level compartment assigned to that target and any subordinate compartments below it in the compartment hierarchy.

Oracle Cloud Guard offers a comprehensive exploration of issues classified by severity levels, such as critical, high, medium, low, etc. Additionally, it furnishes risk scores and actionable insights aligned with threat priorities to facilitate the resolution of security issues within the tenancy.

Oracle has enhanced Cloud Guard's security capabilities by incorporating built-in recipes, including *Detector* and *Responder* recipes. This enables Cloud Guard not only to identify cloud security issues but also to automate the remediation process.

Cloud Guard offers two types of detector recipes:

- **Configuration detector:** This can identify changes in Cloud configuration.
- **Activity detector:** This can pinpoint changes in user activity.

Utilizing these detector recipes, Cloud Guard identifies and reports insecure configurations, such as instances with public IP addresses. The security scans conducted by Cloud Guard within the tenancy identify potential threats through detector recipes, converting them into actionable items. These threats are then addressed using pre-defined responder recipes.

It is important to make the following considerations while choosing or selecting the right reporting region:

- **Legal Requirements:** The Reporting region must comply with all the legal requirements of the country.
- **Disable Cloud Guard:** It is important to note that all customizations and existing problems, including history, are lost when you disable Cloud Guard.

- **API Calls:** All API calls except for READs must be made on the reporting region.

The following are the steps to enable the Cloud Guard:

1. Log in to the OCI Console as the Oracle Cloud Guard user you created in prerequisites in the creating the **Cloud Guard** user and **Group** section. Open the navigation menu and click **Identity & Security**.

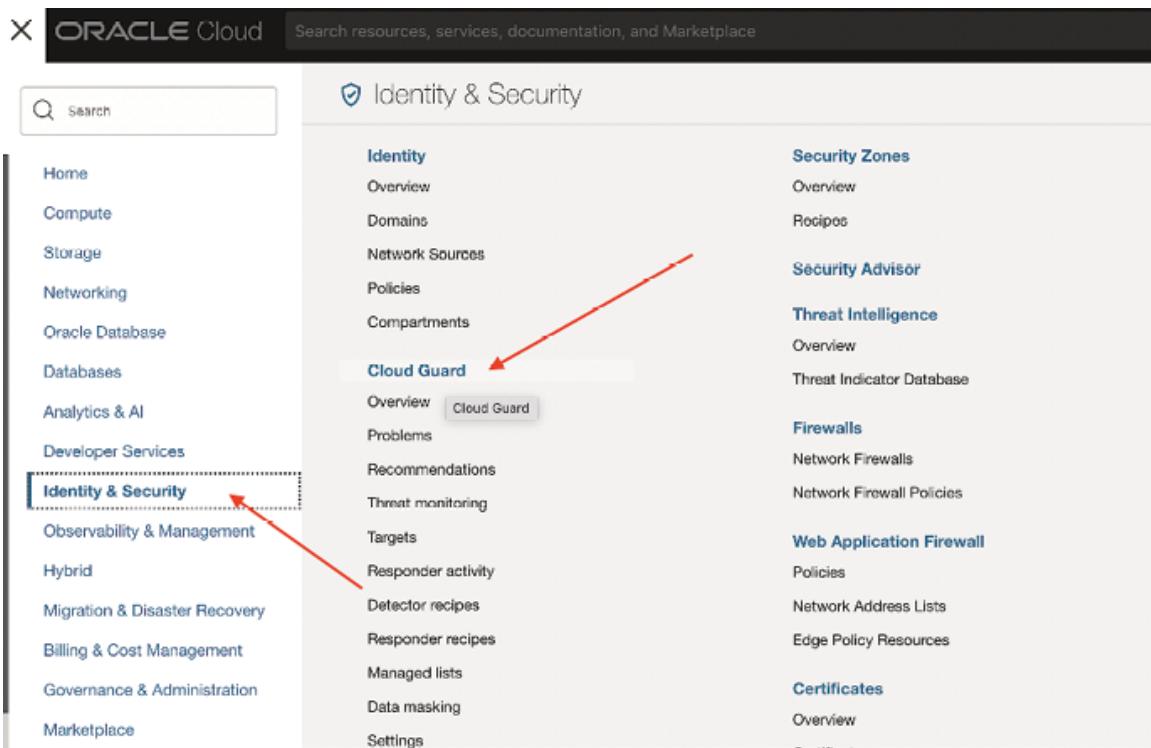


Figure 8.4: Cloud Guard in OCI

2. On the Cloud Guard page, click the enable **Cloud Guard** button at the top right, as shown in the following figure:

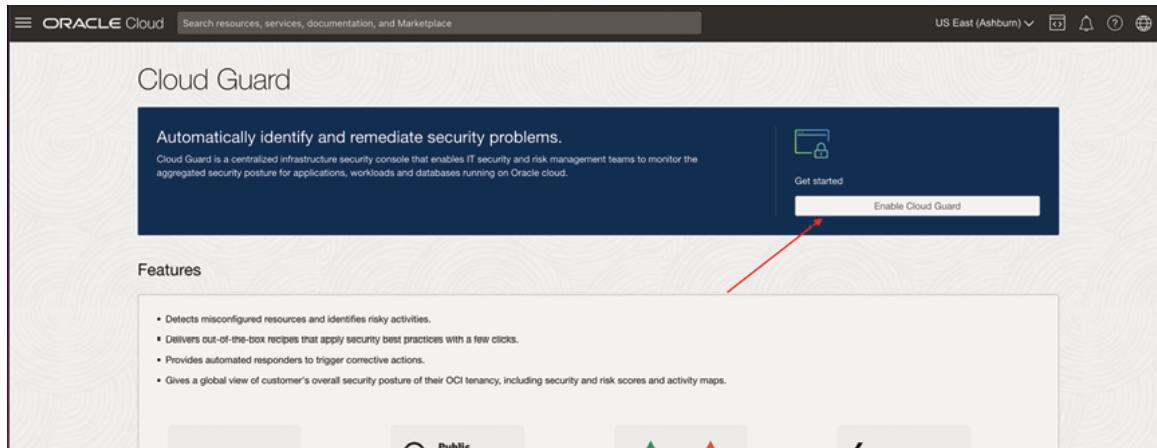


Figure 8.5: Enabling Cloud Guard in OCI

Monitoring using Cloud Guard

Cloud Guard can detect patterns of activity that indicate possible malicious attempts to gain access to resources in your environment and use them for corrupt purposes. Cloud Guard is a security tool or service designed for cloud environments that helps to identify and respond to suspicious activities that may be indicative of a security threat. Cloud Guard can detect patterns of activity that indicate possible malicious attempts to gain access to resources in your environment and use them for corrupt purposes. Cloud Guard performs the role of *Detector* and *Responder*. These are described below:

- **Detects patterns of activity:** The tool is designed to analyze and monitor various activities and behaviors within the Cloud environment. It looks for specific patterns or sequences of actions that might be considered abnormal or malicious.
- **Malicious attempts to gain access:** The focus of Cloud Guard is on identifying activities that suggest an unauthorized entity is trying to access resources within the Cloud environment. This could include unauthorized login attempts, unusual network traffic, or other suspicious actions.

To understand the monitoring of Cloud Guard, we need to understand the concept of *Threat Detector*. The **Threat Detector** represents an innovative or cutting-edge recipe within Oracle Cloud Guard, persistently overseeing OCI audit events to identify potential malicious actions. This employs a robust data platform capable of executing **machine learning (ML)** models focused on behavioral attack patterns across extended durations. These models are closely aligned with MITRE ATT&CK techniques, striking a balance between specificity to convey clear intent and generality to withstand procedural evolution effectively. The MITRE

ATT&CK framework is a comprehensive library of strategies, **tactics**, **techniques**, and **procedures (TTPs)** used by threat actors to carry out attacks. The MITRE ATT&CK framework is a valuable tool to use in conjunction with threat modeling.

The threat detector manages user profiles containing the sequence of observed attacks and their corresponding risk scores. These risk scores are designed to monitor the evolution of attacks, taking into consideration the severity and confidence level of each observation, the tactics and techniques employed, and their timing.

Threat detector can be enabled by adding the *OCI Threat Detector* recipe which is Oracle-managed, to your root compartment target.

To summarize, a threat detector collects and processes information on potential threats. The information, which is collected from Cloud Guard targets, is information on potential threats.

Threat intelligence services are run through models that are aligned with *MITRE ATT&CK* techniques. These models produce *sightings* which are scored to assess the *seriousness* of the consequences if the attack is real and the *likelihood* that the attack is real. Finally, the risk level is assigned, based on the highest risk score of the last 14 days. In scenarios where the risk level becomes critical, a problem is generated. *Sightings* can be referred to as a specific instance of potential malicious behavior that Cloud Guard has detected.

The following are a few parameters reported for sightings:

The following parameters are monitored. (Some of these parameters appear only on the *threat monitoring* page or the *threat monitoring details* page):

- **Resource, resource ID, resource name:** An identifier for the resource targeted in the sighting.
- **Compartment:** The OCI compartment where the resource is located.
- **Target:** The Cloud Guard target contains the OCI compartment.
- **Regions:** the region or regions in which the sighting was detected.
- **First detected:** the date and time at which the sighting was first detected.
- **Last detected:** The date and time at which the sighting was last detected.
- **Peak risk score:** The highest risk score for a particular risk profile.
- **Peak date:** The date of the highest risk score for a particular risk profile.

Cloud Guard can also be leveraged for the identification and response to security vulnerabilities detected by the OCI vulnerability scanning Service. While all resources and reports related to vulnerability scanning are regional, the scan results are additionally presented as issues within your Cloud Guard global reporting region. **Vulnerability Scanning Service** in OCI enhances security posture by regularly scanning hosts and container images for potential vulnerabilities. It provides developers, operations teams, and security administrators with comprehensive insights into misconfigured or vulnerable resources, generating detailed reports that include metrics, vulnerability information, and remediation guidance.

Logging analytics

Oracle logging analytics in OCI is a cloud solution that lets you index, enrich, aggregate, explore, search, analyze, correlate, visualize, and monitor all log data from your applications and system infrastructure on the cloud or on-premises.

In this section, we will describe how to create log analytics and enable or visualize the same in the dashboard.

We can gain operational Insights by leveraging the concepts of Oracle Logging Analytics. There are multiple different ways to accomplish these, such as using the log explorer UO, aggregating the log information into dashboards, and utilizing the APIs to ingest and analyze data.

For a new user, to start using *logging analytics*, the option is available from the top-level OCI console menu. The following steps are to be followed:

1. Navigate to **Observability & Management** and click **Logging Analytics**:

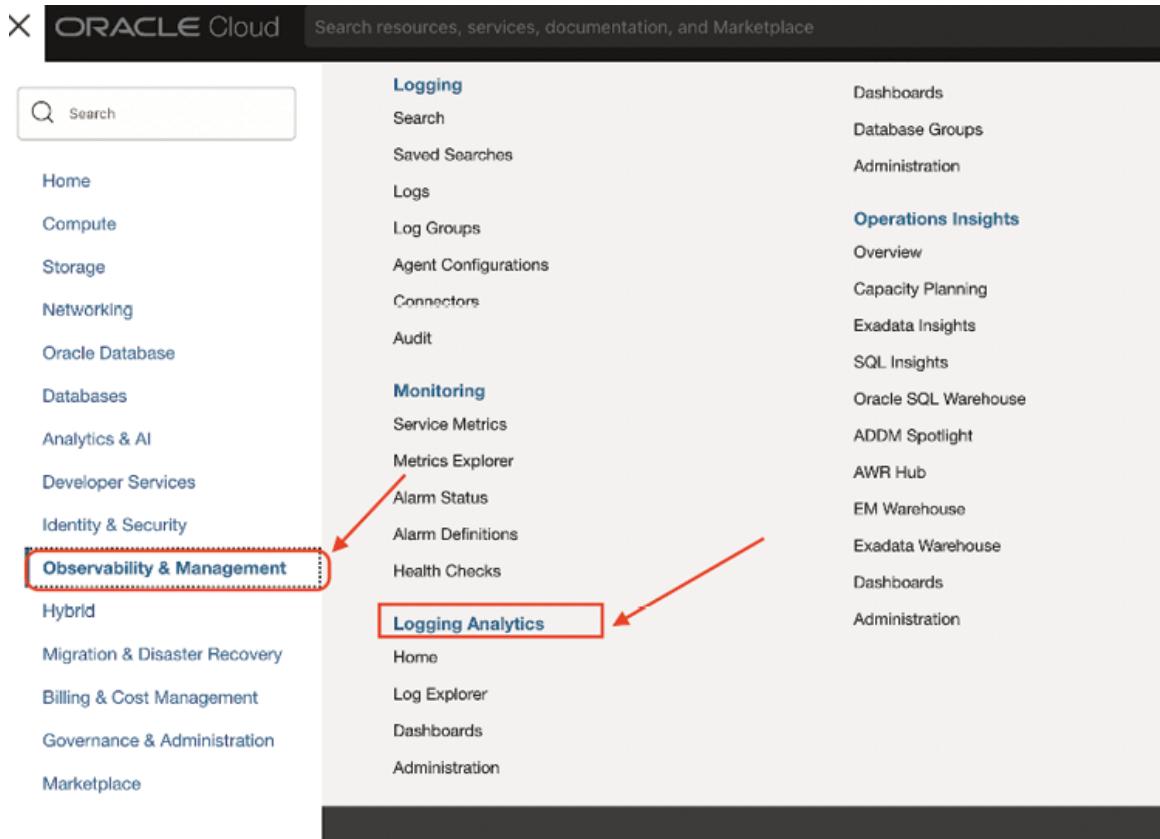


Figure 8.6: Logging analytics in OCI

2. The onboarding page as shown in the following figure will give you some high-level details of the service and an option to start using the logging analytics service. Click **Start Using Logging Analytics**.

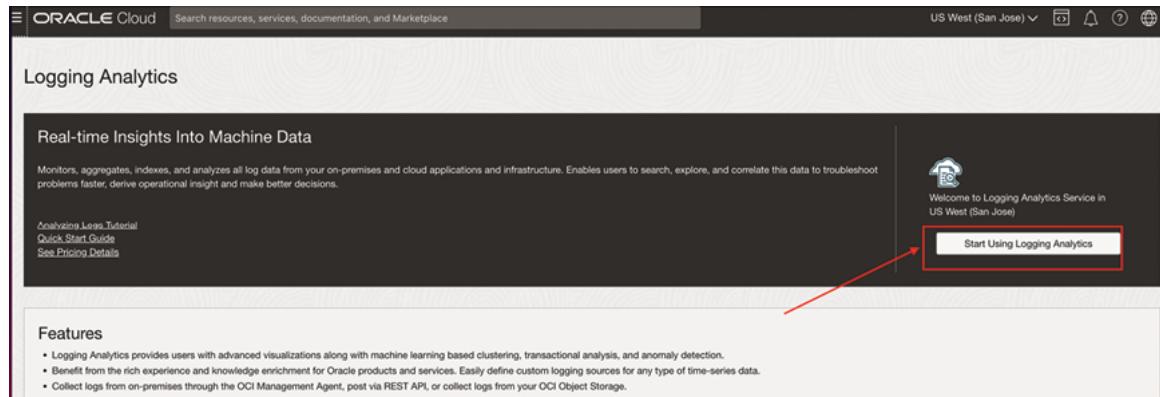


Figure 8.7: Starting using logging analytics in OCI

Click **Next** as shown in the following figure, to redirect to the policies section:

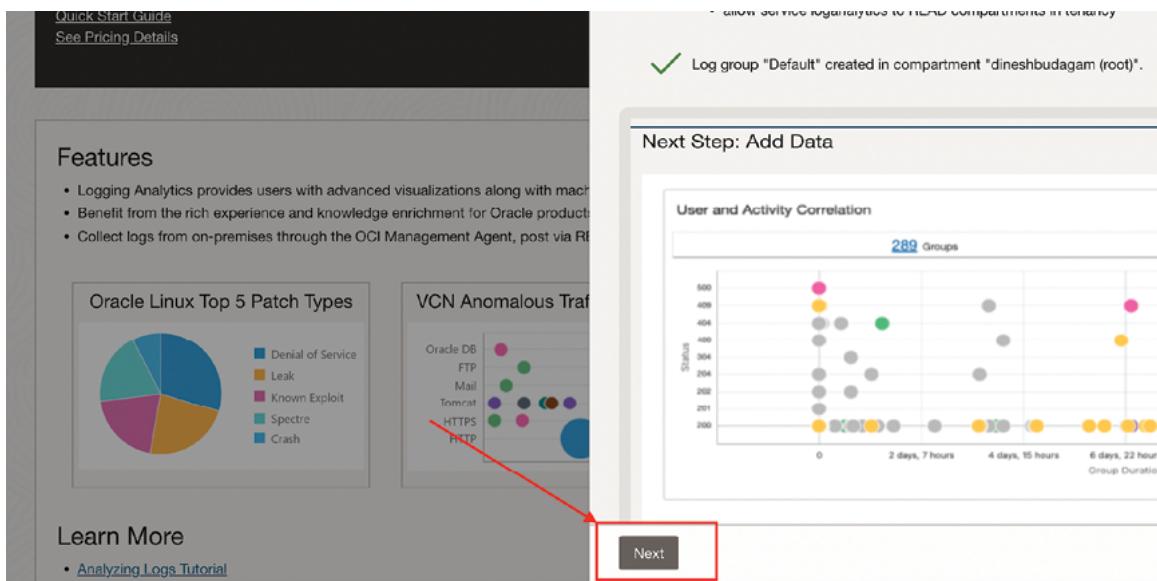


Figure 8.8: Enabling logging analytics in OCI

In this use case, clicking **Next** will configure OCI audit log policies:

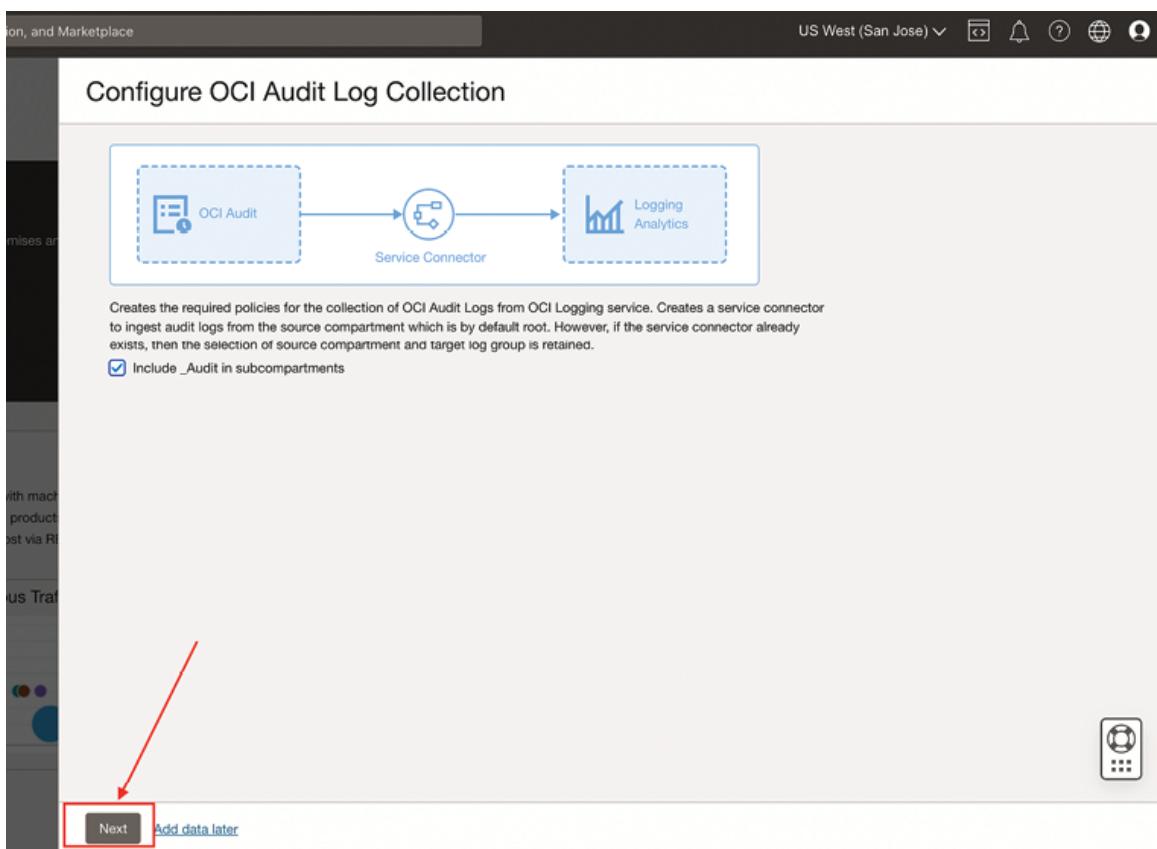


Figure 8.9: Configuring OCI audit log collection in OCI

3. The following figure shows the successful setup of OCI audit log collection. We can either click **Take me to Log Explorer** or **Go to OCI Audit Analysis Dashboard**:

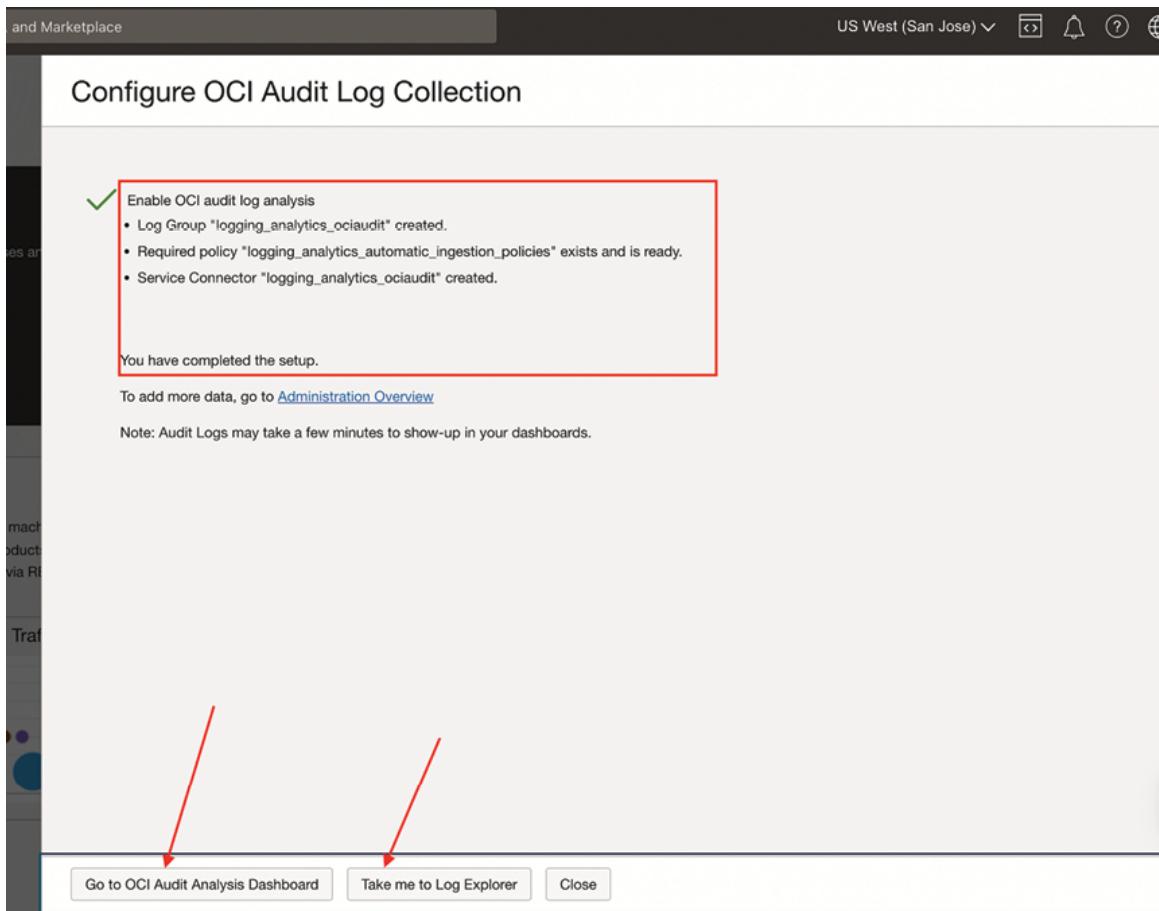


Figure 8.10: Successful configuration of OCI audit log collection in OCI

In this example, click **Go to OCI Audit Analysis Dashboard**, which is based on the data automatically collected from the OCI audit logs during the logging analytics enabling process. Depending on the cloud account you used, this data will vary.

Note: This environment has two active users and over 9 OCI audit logs collected in the last 60 days. You can see the data by compartments, examine the Trend, and Active Users per hour.



Figure 8.11: Dashboard of OCI audit log collection in OCI

4. Further down the page, you will find additional data analysis, including correlation and the organization of information to facilitate the identification of issues. In this example, we can view **Audit Event by Type** and **User Agents**.



Figure 8.12: Dashboard of OCI audit log collection in OCI-user agents

Below [Figure 8.13](#) represents high-level architecture of Oracle Logging Analytics service:

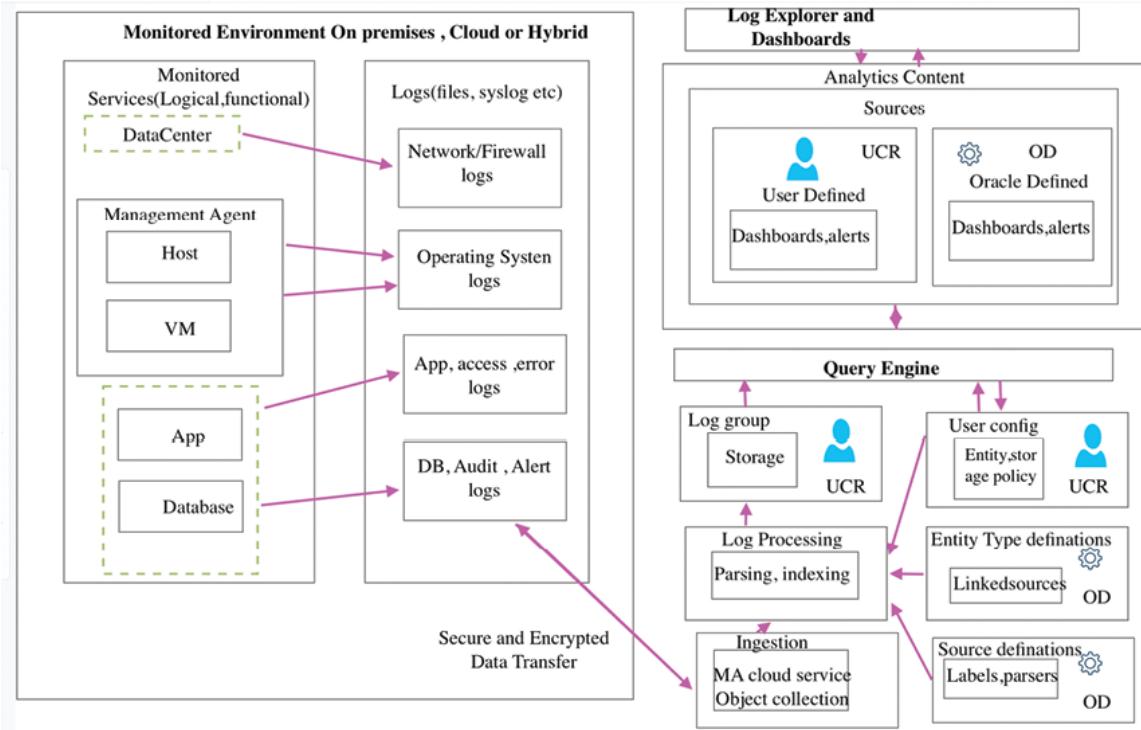


Figure 8.13: High level architecture diagram of OCI logging analytics service

The standard workflow for configuring and utilizing Logging Analytics is as follows:

- Identify the sources from which logs should be collected.
- Identify the approach for log ingestion, considering factors such as the location of logs and the purpose of ingestion. If your logs are stored in a location where installing the Management Agent is not feasible, or if they originate from an OCI service that cannot be accessed by Oracle Logging Analytics, then opt for on-demand upload. In case the logs are created on your on-premises or cloud host, proceed with installing the Management Agent. Alternatively, if your logs are in OCI Object Storage or another OCI service accessible through the service connector, ingest them directly from the service. With context to purpose of ingestion, if you plan to continuously collect, process, and analyze logs, install the Management Agent on your host. Conversely, if you want to upload logs in bulk for the analysis of a specific set, use on-demand upload.
- Configure your Oracle Cloud Infrastructure tenancy to utilize Oracle Logging Analytics by completing the prerequisite tasks.

- Create Oracle Logging Analytics resources such as log groups, entities, sources, and parsers depending on your end use and method of ingestion and ingest the logs using the method that you selected earlier.
- Choose from the charts and controls in the visualization panel according to your parameters to gain insights into your log data.
- Search the logs and drill down to specific log entries to resolve problems quickly. Perform advanced analysis of the log data to root cause issues, find potential issues, detect anomalies, and fix the issues. Use our advanced analysis tools such as *Cluster*, *Link*, and *Link by Cluster* for the purpose.
- Save the searches that you performed using the Oracle Logging Analytics console or by writing queries, as *Saved Search*.
- Build custom dashboards by incorporating both Oracle-defined and user-defined widgets. Utilize the dashboard as your single pane view for aggregated analysis in *Oracle Logging Analytics*.

Custom logs connectors

In this section, we will discuss the steps to create connectors and explore different sources and targets. The steps are as follows:

1. In the OCI console, go to **Observability & Management** and click **Connectors**:

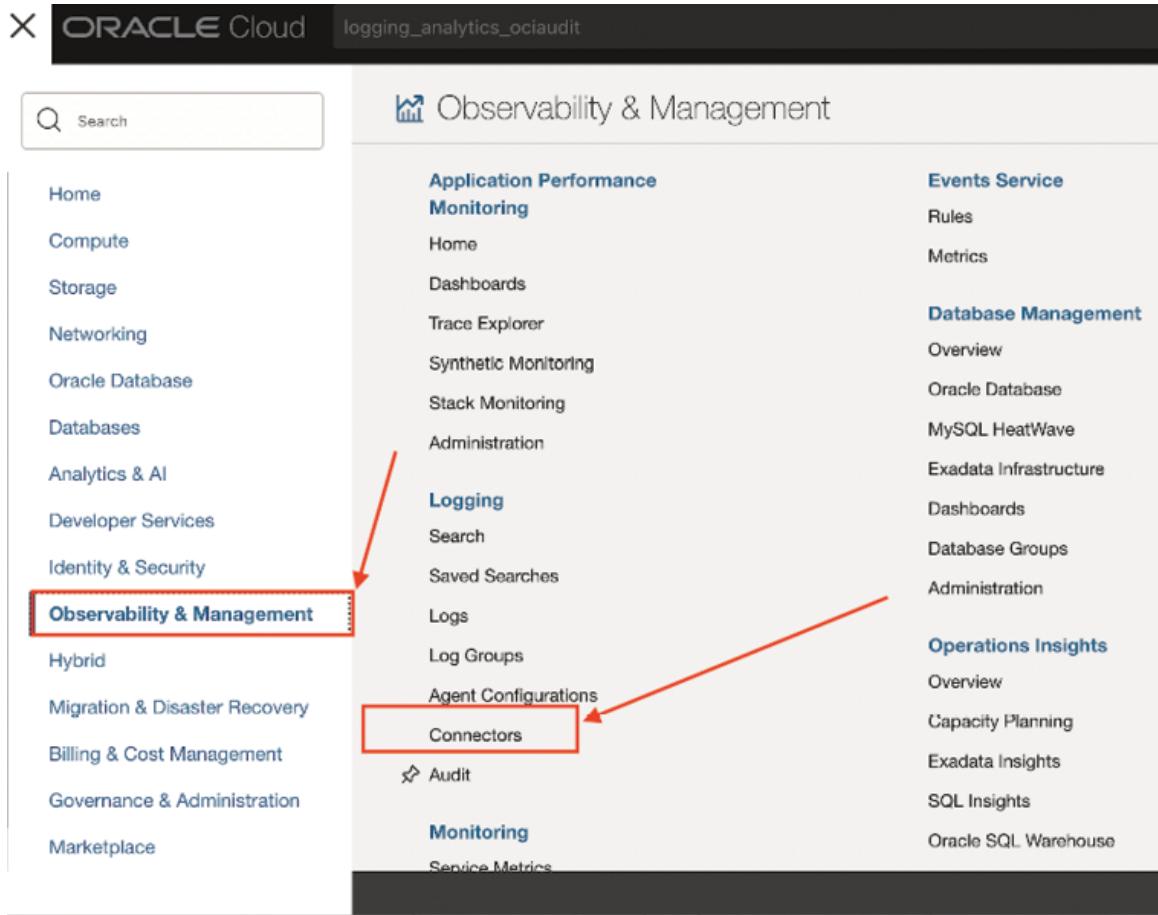


Figure 8.14: Connectors in OCI

Next, click **Create Connector** to create a new connector for the respective **Compartment**:

The screenshot shows the Oracle Cloud Logging interface. On the left, there's a sidebar with options like Search, Saved Searches, Logs, Log Groups, Agent Configurations, Connectors (which is selected and highlighted in blue), and Audit. Below these are List scope, Compartment (set to dineshbhdemo (root)), and Filters (State set to Any State). The main area has a title "Connectors in dineshbhdemo (root) Compartment" and a subtitle "Connector Hub allows you to transfer data from a source service to a target service in Oracle Cloud Infrastructure." A red box highlights the "Create Connector" button at the top of the table. A red arrow points from this button to the table below. The table has columns for Name, Status, Source, and Target. It contains two rows: one for "test" (Status: Active, Source: Logging, Target: Logging Analytics) and another for "logging_analytics_ociaudit" (Status: Active, Source: Logging, Target: Logging Analytics).

Name	Status	Source	Target
test	Active	Logging	Logging Analytics
logging_analytics_ociaudit	Active	Logging	Logging Analytics

Figure 8.15 (a): Creation of connectors in OCI

Enter the **Connector name** and **Select source** from the source drop-down. In this example, we are selecting **Logging** as the source:

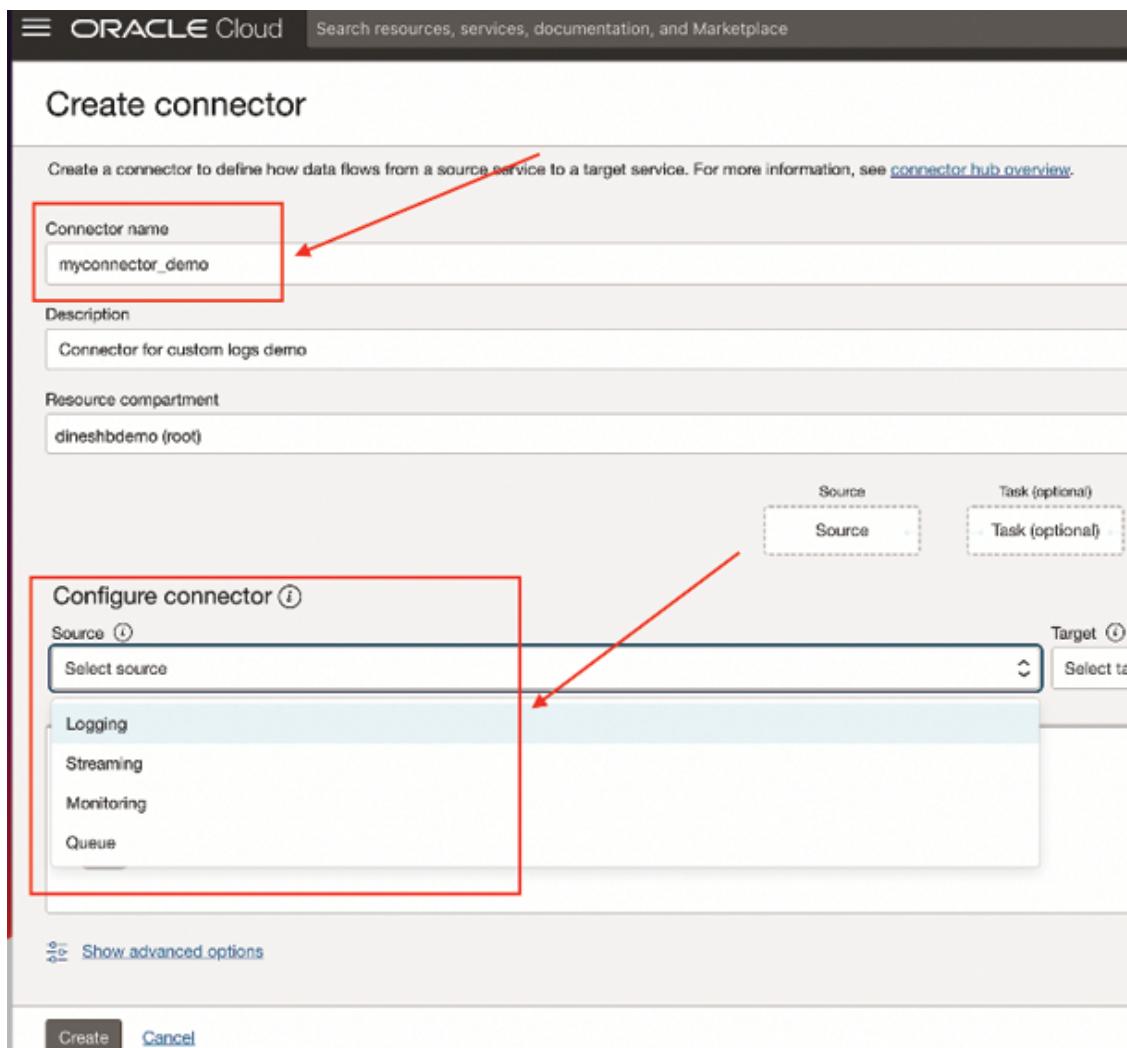


Figure 8.15 (b): Creation of Connectors in OCI

2. Enter the **Target** as **Logging Analytics** as shown in the following figure:

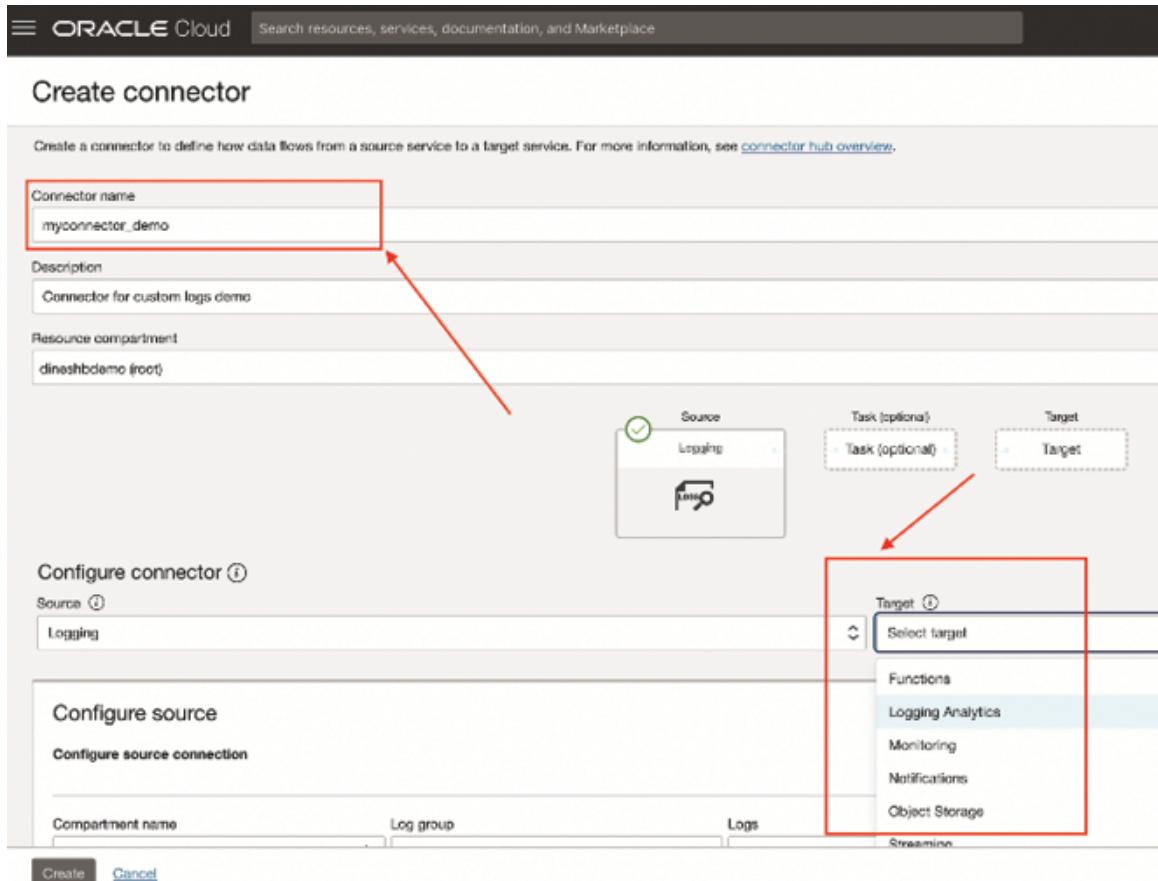


Figure 8.15 (c): Creation of connectors in OCI

3. Configure the sources by selecting the **Log Group** and **Logs**:

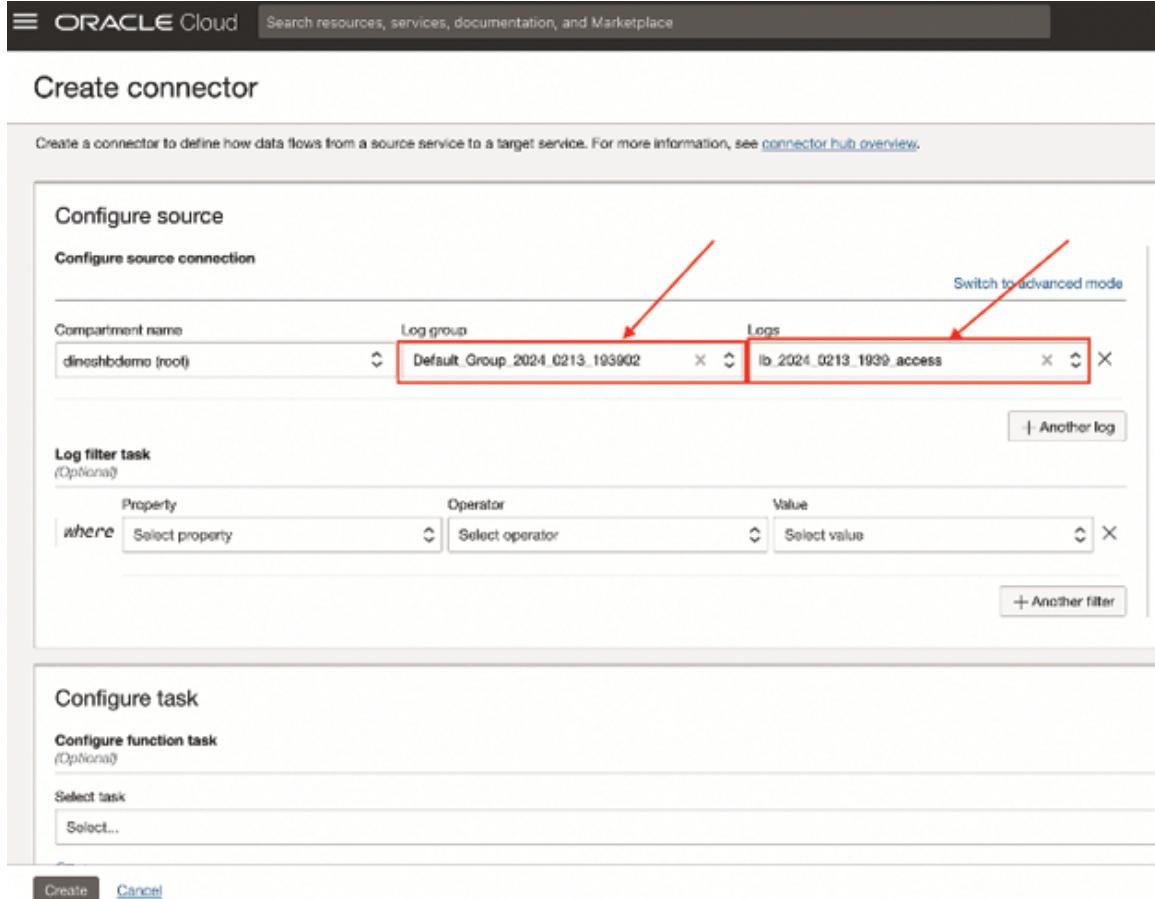


Figure 8.15 (d): Creation of connectors in OCI

Configure the target by selecting the **Log group**. (In this example, we already created a log group in the previous section) and click **Create**, to create a connector:

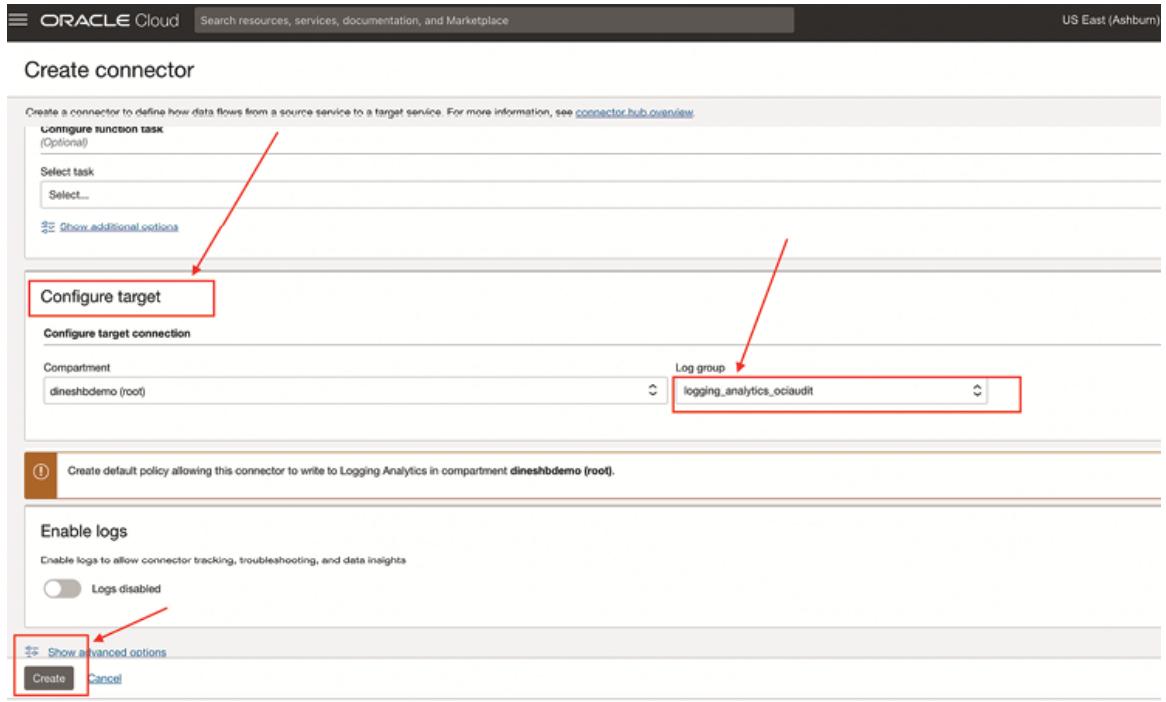


Figure 8.15 (e): Creation of connectors in OCI

4. **Myconnector_demo** is created as in the following figure with **Source** and **Target** as mentioned:

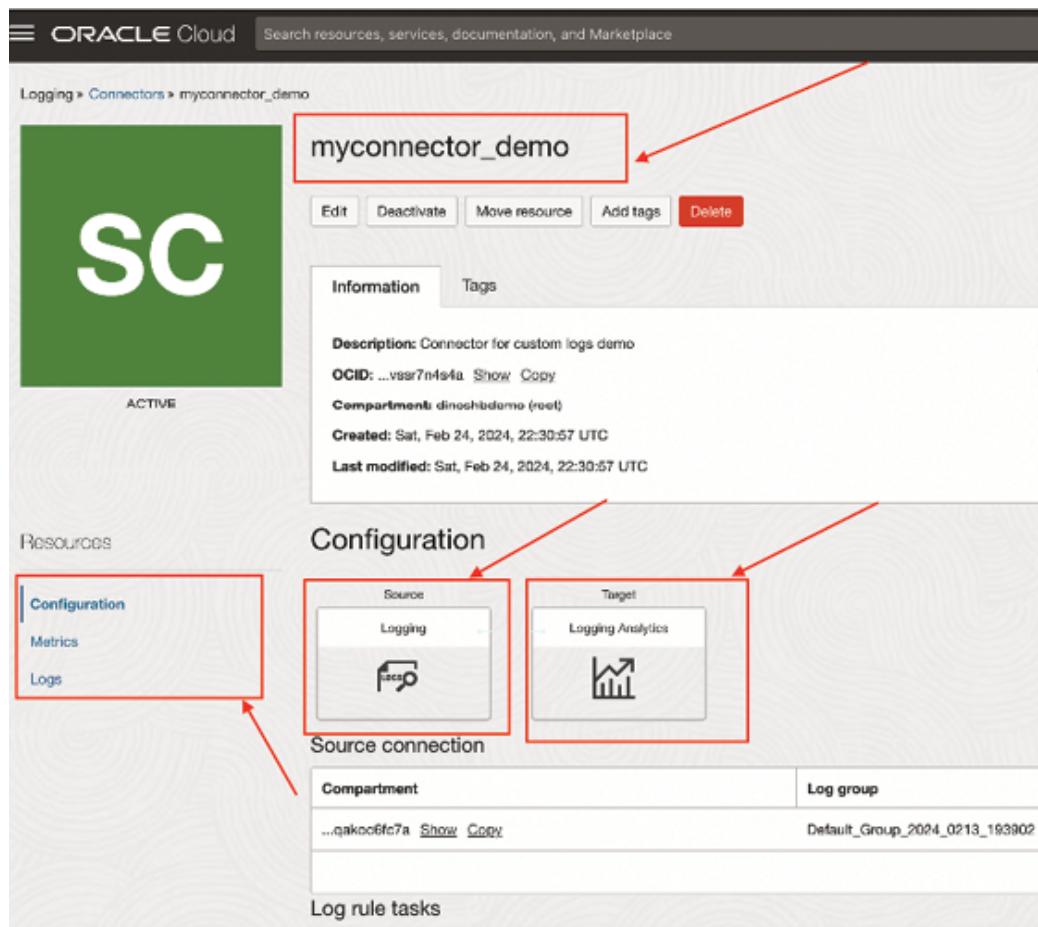


Figure 8.16(a): Connectors in OCI

5. We can view the **Metrics** and **Logs** as follows by filtering the time of different frequencies:

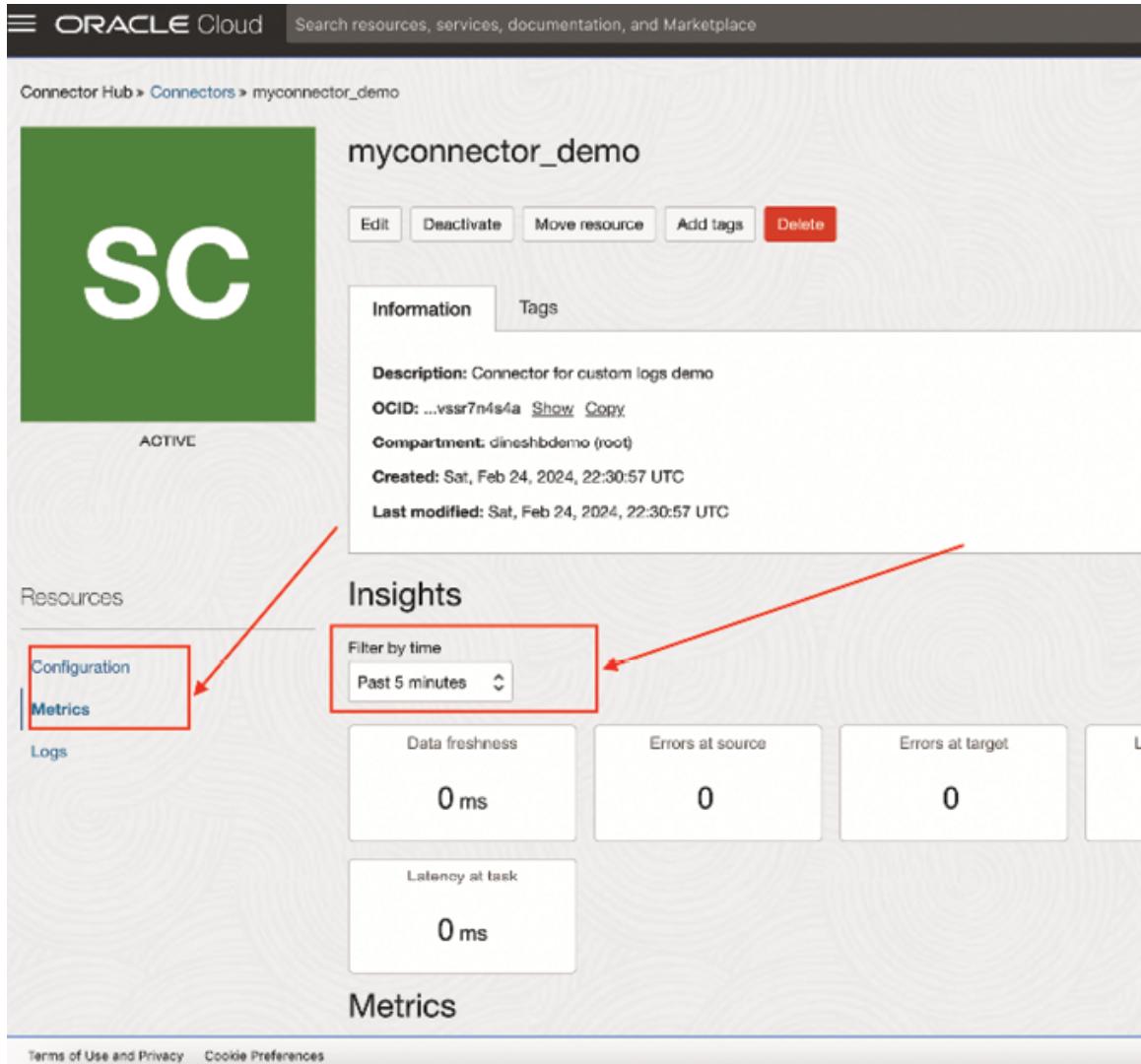


Figure 8.16 (b): Connectors in OCI

Best practices for logging and monitoring

In this section, we will highlight a few important recommendations for implementing logging and monitoring in OCI. A few of them are mentioned, as follows:

Log retention controls how long, activity logs should be retained. It is recommended to set the log retention period to 365 days. Retaining logs for at least 365 days or more will provide the ability to respond to incidents and is also needed for governance and compliance.

It is advisable and recommended to configure notifications for user changes. Observing and receiving alerts for modifications to user profiles can aid in recognizing alterations to the overall security stance.

Ensure a notification is configured for VCNs and changes to route tables. Route tables manage the flow of traffic to and from VCN and subnets. Keeping track of and receiving alerts for changes to route tables can assist in pinpointing alterations to these traffic patterns.

Ensure a notification is configured for IdP group mapping changes—IAM Policies govern access to all resources within an OCI Tenancy (detailed IAM policies are discussed in [*Chapter 2, Mastering Identity and Access Management*](#)). IAM policies use OCI groups for assigning privileges. Identity provider groups could be mapped to OCI Groups to assign privileges to federated users in OCI. Monitoring and alerting on changes to identity provider group mappings will proactively help in identifying changes to the security posture.

Configure notifications for the IAM group and IAM policy changes. Monitoring and alerting on changes to IAM Groups will help in identifying changes to satisfy the least privilege principle.

OCI identity providers enable the administration of user ID or password combinations in external systems, allowing the utilization of these credentials to access OCI resources. Identity providers offer users the convenience of a single sign-on to the OCI console, along with the ability to manage other OCI credentials, such as API keys. Implementing monitoring and alert systems for changes to identity providers is crucial for promptly identifying any alterations to the security posture of the OCI environment.

It is recommended to configure notifications for security lists, network gateways, and network security groups. Security list, as discussed in [*Chapter 3, Navigating Network Security in OCI*](#), controls traffic flowing into and out of subnets within a VCN, network security groups control traffic flowing between virtual network cards attached to compute instances and network gateways act as routers between VCNs and the internet, oracle services networks, other VCNs, and on-premise networks. Monitoring and alerting on changes to these components will help in identifying changes to the security posture.

Use default tags on resources. In the event of an incident, applying default tags such as *CreatedBy* will provide all the required information about the creator of the resource without the need to search through audit logs.

Create at least one notification topic and subscription to receive monitoring alerts—establishing one or more notification topics enables administrators to receive notifications about pertinent changes made to OCI infrastructure.

Regularly review your policies to ensure they align with best security practices. This can be achieved in OCI by using **Policy Auditor**. A policy auditor can

conduct ad-hoc reviews of IAM policies through the Oracle Cloud Infrastructure console. Additionally, several options are available to generate policy reports for offline analysis. Oracle recommends incorporating the Security Policy Modified detector to initiate an event that triggers a manual policy review, or to Invoke a function to carry out investigation or remediation.

SSL inspection and its need

SSL inspection is referred to as the process of intercepting and reviewing SSL-encrypted internet communication between the client and the server. The inspection of SSL traffic has become critically important as most of the internet traffic is SSL encrypted, including malicious content. This is a process where encrypted traffic is decrypted, inspected, and then re-encrypted before it reaches its destination. This is commonly done to inspect the content of encrypted traffic for security purposes.

OCI offers a range of security features to safeguard against network threats, such as **intrusion detection and prevention (IDP)** and SSL Inspection. IDP enables administrators to monitor network traffic in real-time, providing alerts when suspicious activities are detected, and can also automatically respond to neutralize identified threats. SSL Inspection, on the other hand, allows administrators to examine encrypted traffic to ensure it is not being used to spread malware or other harmful content. Together, these features strengthen the security posture of cloud environments by adding extra layers of protection against potential threats.

However, implementing SSL inspection in OCI involves various considerations. We will discuss these considerations in this section.

The following is a general guide that we need to consider in OCI for SSL inspection:

- **Security considerations:** Protect the private keys used for SSL inspection to prevent unauthorized access. Regularly update SSL inspection devices and related software to patch vulnerabilities.
- **Logging and monitoring:** Implement logging and monitoring for SSL inspection activities to detect any issues or security incidents. Monitor the performance of SSL inspection devices to ensure they can handle the expected traffic load.
- **Compliance and legal considerations:** Ensure that your SSL inspection practices comply with relevant legal and regulatory requirements. Inform end-users about SSL inspection practices in compliance with privacy laws.

Let us discuss why we need SSL inspection in the first place. The widespread use of SaaS applications and cloud services in the current generation digital landscape, results in a higher volume of data circulating on the internet, increasing its vulnerability to potential risks. Encryption, therefore, becomes a crucial element in safeguarding confidential and sensitive information. This is why modern browsers, web servers, and cloud applications routinely employ encryption for both outgoing data and data exchange through HTTPS connections.

However, this protective measure has a dual impact—while it shields sensitive data within HTTPS traffic, it also provides a hiding ground for potential threats. Consequently, effective SSL inspection is equally indispensable. This process allows organizations to thoroughly examine the contents of decrypted traffic, enabling them to make informed decisions such as blocking malicious content or re-encrypting it to ensure secure continuation of the data flow.

To summarize, the primary benefits of SSL inspection are as follows:

- Safeguard against data breaches by detecting concealed malware and thwarting attempts by hackers to infiltrate defenses.
- Meet regulatory compliance requirements and support a multilayered defense strategy that keeps the entire organization secure.

In OCI, we have a service termed as *Oracle Cloud Infrastructure Network Firewall Service*, which inspects all requests, including **Transport Layer Security (TLS)** encrypted traffic, as it passes through the firewall. We can define our own custom-defined firewall policy rules based on user-defined firewall policy rules; the service can take actions such as allow, reject, drop, intrusion detection, or prevention. Network firewall service provides exceptional advanced capabilities and safeguards OCI workloads against different security threats. The OCI enhances the features of the **next-generation firewall (NGFW)**. It safeguards OCI workloads, offering centralized protection against cyberattacks. The main function of a network firewall service is to streamline operations and management by removing the issues associated with deploying a third-party virtual firewall appliance.

Intrusion detection system (IDS) and intrusion prevention system (IPS) controls are applied to network traffic with the capability provided by *next-generation firewalls*. This capability is achieved even when using encrypted channels such as SSL or TLS. NGFW should have the capability to decrypt SSL or TLS-encrypted traffic. While the notion of decrypting traffic within a supposedly secure, encrypted channel may seem counterintuitive, the NGFW, as a trusted device, can be configured to decrypt incoming SSL or TLS connections to

servers within OCI and establish outgoing connections by effectively *impersonating* the remote server. This entire end-to-end process remains transparent to the end user thereby enabling the NGFW to effectively analyze and safeguard against potential security threats embedded within encrypted communications.

OCI includes a detailed set of security features designed to strengthen and improve defenses against various network threats. A few defense mechanisms to consider are **intrusion, detection, prevention (IDP)**, and SSL inspection. IDP empowers administrators by enabling real-time monitoring of network traffic, triggering alerts upon detecting any suspicious activities. Moreover, IDP can autonomously take preventive measures to thwart identified threats and mitigate potential harm.

SSL inspection, as discussed above, is another pivotal feature that provides administrators with the ability to scrutinize encrypted traffic. This ensures that the encrypted communication is not exploited for the dissemination of malware or other malicious content. These integrated security features contribute significantly to upholding the overall security posture of cloud environments, furnishing additional layers of protection against potential threats.

To illustrate, administrators may configure IDP to effectively detect and prevent brute-force attacks targeting cloud resources. Simultaneously, SSL inspection can be employed to monitor encrypted traffic flowing to and from sensitive databases, reinforcing the security measures in place and mitigating risks associated with potential malicious activities.

To summarize, OCI network firewall policy consists of the following lists:

- **Application and URL lists:** Application lists allow you to create a list of applications and define protocol types and port ranges for each. URL lists where you can create a list of URLs that you can allow or deny access to.
- **IP address lists:** This list allows you to create a list of IPv4 and IPv6 addresses or CIDR ranges that you can allow or deny access to.

Application, URL, and IP address lists serve to permit, deny, conduct intrusion detection, intrusion prevention, and reject traffic as dictated by security protocols. Additionally, they facilitate the decryption of traffic through SSL forward proxy and SSL inbound inspection.

Conclusion

In this chapter, we discussed logging and monitoring in OCI, highlighting their significance in ensuring that cloud environments remain reliable, high-performing, and secure. This is achieved by delving deeper into the fundamentals of monitoring and logging concepts and focusing on the various tools, techniques, and methods to achieve operational excellence within the ever-changing OCI framework. We have examined the diverse range of OCI monitoring tools and services, emphasizing their capabilities in providing real-time visibility into resources. The features incorporated in the logging and monitoring of OCI are useful in accessing infrastructure health and timely detection and resolution of possible problems that affect the cloud infrastructure. Throughout the chapter, we have covered major concepts, methods, and best practices relevant to logging and monitoring in OCI, which will help experienced cloud specialists and beginners in the Cloud environment unleash the full potential of logging and monitoring. We covered concepts such as logging analytics, Cloud Guard, custom logs, and best practices for logging and monitoring.

In the constantly changing world of cloud computing, the security aspect of logging and monitoring cannot be ignored. These practices are preventive measures in OCI environments that contribute to improving the security of the environment.

To solidify your understanding and application of the concepts discussed, the chapter concludes with practical skill development and implementation guidance. Real-world case studies and scenarios offer insights into successful logging and monitoring implementations, providing valuable lessons and reinforcing the practical relevance of the discussed concepts.

This chapter will equip you with a robust understanding of logging and monitoring in OCI, SSL inspection and its need in OCI, best practices for logging and monitoring, logging and detection control laying the foundation for proficient cloud management. As you begin on your journey through OCI, the knowledge gained here will serve as a valuable guide for leveraging logging and monitoring practices to optimize the performance, security, and reliability of your cloud environment. In the *Chapter 9, Compliance, IDR, and Vulnerability Management in OCI*, we will discuss the concepts of compliance, **Incident Detection and Response (IDR)**, Vulnerability Management within OCI and focus on explaining how to develop sound and impactful approaches for ensuring security and compliance, highlighting top-notch tactics and built-in controls.

Exercise

1. You are part of a team that manages a set of workload instances running in an on-premises environment. The solutions architect team is tasked with designing and configuring the OCI logging service to collect logs from these instances. There is a requirement to archive the info-level logging data of these instances into the OCI object storage.

Which two features of OCI can help you achieve this? (Choose two.)

- a. Cloud agent plugin
- b. Agent configuration
- c. Grouping function
- d. Service connectors
- e. Object collection rule

2. Which of the following statements is true about the OCI object storage server-side encryption?

- a. Each object in a bucket is always encrypted with the same data encryption key.
- b. Encryption of data encryption keys with a master encryption key is optional.
- c. Customer-provided encryption keys are always stored in OCI Vault service.
- d. Encryption is enabled by default and cannot be turned off.

3. Which two statements are true about the OCI logging service? (Choose all correct answers)

It can analyze critical diagnostic information that describes how resources are performing and being accessed.

- a. It enables you to monitor cloud resources using metrics and alarms.
- b. It enables you to analyze cloud resources using custom metrics.
- c. It is a centralized single pane of glass for all logs in a tenancy.
- d. It can index, enrich, and aggregate log data from applications.

Answers

- 1. b and d**
- 2. d**
- 3. a and d**

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CHAPTER 9

Compliance, IDR, and Vulnerability Management in OCI

Introduction

In this chapter, we will explain what best security and compliance practices are available, how to implement effective strategies, and how to achieve compliance in security, along with the concept of design of resilience. There are many ways for cybersecurity risks to occur, which can disrupt operations and compromise sensitive data. We see many organizations facing various cybersecurity risks. These kinds of risks are capable of comprising customers' sensitive data. These kinds of data breaches cause disruptions in operations and thereby lose the trust of the customers. To avoid cybersecurity risks, it is essential for us to enforce compliance, vulnerability management and implement incident detection and response. By implementing the compliance regulations, we can achieve benefits such as establishing confidence among various stake holders since these compliance regulations allow us to implement best security practices. Only compliance will not solve all the cybersecurity risks; in addition to compliance, we need to make sure **incident detection and response (IDR)** capabilities are adopted to solve security incidents in real-time. Organizations should adopt monitoring tools and threat intelligence mechanisms. These kinds of monitoring tools help organizations actively detect, investigate, and prevent security incidents. By Implementing comprehensive vulnerability scanning, efficient patch management, and adopting proper risk assessment processes, organizations can secure the software architecture. In this chapter, we will understand the concepts involved in compliance, IDR, and vulnerability management. We will also cover the regulatory landscape, fundamental principles, best practices, and emerging trends in cybersecurity. By understanding the importance of these concepts and

implementing them, organizations can reduce the risks and protect their critical infrastructure.

Structure

In this chapter, we will discuss the following topics:

- Technical requirements
- Compliance
- Best strategies for security and compliance
- Creating a design strategy
- Creating a monitoring and auditing strategy
- Best security and compliance practices
- Design for attackers
- Leveraging native controls
- Design for resilience
- Governance
- Incident detection and response

Objectives

The core objective of this chapter is to provide a comprehensive understanding of compliance in **Oracle Cloud Infrastructure (OCI)**, defining the concept of compliance and exploring the regulatory landscape and industry standards applicable to OCI. By adhering to these goals and adopting customized best practices, organizations can efficiently utilize Oracle Cloud Infrastructure to reach their business objectives, minimizing risks and optimizing the advantages of cloud computing.

This chapter offers guidance and best recommendations adhering to OCI standards for implementing OCI compliance features, and tools tailored to the unique requirements and use cases of organizations leveraging OCI. By the end of the chapter, readers will understand the concepts in compliance, creating design strategy, best strategies for security and compliance, best security and compliance practices, and governance framework in OCI.

Technical requirements

In order to actively participate and understand the contents of the chapter, readers should be equipped with an understanding of computer systems, concepts in networking, and basic knowledge of information technology.

In addition to the above technical requirements, readers are advised to have an understanding of the below specification for technical needs:

- **Internet access:** To utilize online resources, references, and examples related to cloud computing, readers need a stable internet connection.
- **Computing device:** Additionally, a computing device such as a desktop computer or laptop equipped with a modern web browser is essential for reading the chapter content and accessing any online materials.
- **Web browser:** It is recommended to have the latest version of web browsers, which ensures compatibility and optimal and best viewing experience of web-based resources and interactive content. Here are a few web browsers recommended: *Google Chrome, Mozilla Firefox, Microsoft Edge, or Safari*.
- **Basic knowledge of any of the cloud services:** Readers are advised to have knowledge of any of the cloud services and basic functionalities.
- **Knowledge of IAM, logging and monitoring:** Users are expected to have strong knowledge of IAM concepts such as managing users and groups along with capturing and analyzing the security threats.
- **Understand the compliance standards:** Readers are expected to have understanding of few major compliance standards in various domains such as Payment Card Industry-PCI, and Healthcare Insurance Portability and Accountability Act-HIPAA.
- **Knowledge of OCI services:** Strong knowledge of different OCI services appropriate to compliance, IDR, and vulnerability management, such as logging, monitoring, security zones, incident response, risk assessment methodologies and IAM, security lists, and VCN, will be useful for readers to understand concepts in this chapter.

Compliance

In **Oracle Cloud Infrastructure (OCI)**, compliance means following a range of regulatory, security, and industry standards to ensure that data and applications on

OCI meet legal and industry-specific requirements. This is essential for organizations that manage sensitive data, including personal information, financial records, or health information.

Compliance in OCI encompasses several key aspects, such as regulatory compliance, industry standards, and security certifications. Each of them is described below:

- **Regulatory compliance:** OCI adheres to various global and regional regulations. Some of them are discussed in this section. The *Federal Risk and Authorization Management Program* provides a uniform method for U.S. federal agencies to implement cloud security assessments and authorize the continuous monitoring of cloud services. The program is used primarily by federal agencies, but OCI also follows other regulations and standards to help ensure data security and integrity in the cloud. We categorize the standards for protecting payment card data and the medical domain. For example, **Payment Card Industry Data Security Standard (PCI DSS)**, are known for protecting payment card data. HIPPA is for protecting health records. While others, like ISO/IEC 27001 and the two standards that follow it, are known for in-depth security throughout the life of a system. There is a difference between.

ISO/IEC 27001 is considered the world's best-known standard for **information security management systems (ISMS)**. It defines the requirements an ISMS must adhere to.

ISO/IEC 27017, on the other hand, is a security standard developed for any cloud service provider and its users to make a safer cloud-based environment and reduce the risk of security problems.

- **PCI DSS:** The PCI DSS defines security requirements to protect environments where payment account data is stored, processed, or transmitted.

In addition to the above standards, OCI offers a few of the standard certifications, which are based on principles like security, availability, processing integrity, confidentiality, and privacy to its users. Examples of these are SOC1, SOC2 and SOC3. OCI provides compliance tools and services to assist customers to achieve and maintain compliance.

OCI provides users with different types of compliance tools and services which will help organizations to achieve compliance. These compliance tools help customers to achieve standard compliance along with security

controls, encryption, and audit trails. We usually refer to this approach as **Oracle Cloud Compliance**. Organizations should adopt the compliance reports and certifications process to make sure compliance reports and certifications are aligned with industry standards. To establish effective governance and risk management practices, organizations should adopt IAM and Audit Service. We need to follow several steps to set up the policies and meet compliance requirements. We will discuss each of the steps in the following sections.

The first prerequisite is to start identifying appropriate compliance requirements that are needed for your organization.

Legal and compliance experts can assist in determining which regulations and standards are appropriate to your industry and the geographic location of the industry.

- **Define the scope of the policies:** We need to define the scope of policies once we identify the compliance requirements. Here, we identify the data and systems and include the controls which are to be implemented.
- **Create policies and procedures:** Based on the identified requirements and defined scope, develop detailed policies and procedures. These documents should outline the necessary controls and steps to achieve compliance. Stakeholders should be notified of these policies. Always make sure policies are updated and well-documented.
- **Implement and enforce the policies:** Once the policies are developed, we need to implement them by configuring your cloud infrastructure and applications to be compatible with policies. These policies should be monitored continuously.
- **Regularly review and update the policies:** There will be frequent changes in Compliance requirements and industry standards. It is, therefore, important to regularly review and update your policies. This ongoing activity helps maintain compliance and addresses any new regulatory changes or emerging threats.

By following these steps, organizations can establish robust policies that ensure compliance with various regulatory and industry standards, safeguarding sensitive data and maintaining the integrity of their cloud operations.

Please refer to [*Figure 9.1*](#), which shows where to locate the compliance documents in OCI:

The screenshot shows the Oracle Cloud interface for 'Compliance Documents'. The left sidebar lists various security and compliance services: Access Governance, Cloud Guard, Security Zones, Security Advisor, Threat Intelligence, Firewalls, Web Application Firewall, Certificates, Scanning, Key Management & Secret Management, Managed Access, Bastion, and Compliance. The 'Compliance' section is highlighted with a blue arrow. The main content area displays a table of 'Compliance Documents' with columns for Name, Type, and Created. The table includes entries such as 'OCI SOC 3 Report - September 2023', 'OCI SOC 2 Report Period End 3-31-2024', and 'OCI SOC 1 Report Period End 6-30-2024 FINAL NC'. A search bar at the top right says 'Search resources, services, documentation, and Marketplace'.

Name	Type	Created
OCI SOC 3 Report - September 2023	Audit	Mon, Dec 4, 2023, 20:22:44 UTC
OCI SOC 2 Report Period End 3-31-2024	Audit	Thu, May 23, 2024, 20:08:13 UTC
OCI SOC 1 Report Period End 6-30-2024 FINAL NC	Audit	Tue, Aug 14, 2024, 20:02:16 UTC
OCI SUC 2 Report - September 2023	Audit	Mon, Sep 4, 2023, 20:04:19 UTC
PaaS Built On OCI SOC 1 Report - Period Ending March 2024 Bridge Letter_August 2024	Bridge Letter	Thu, Aug 1, 2024, 21:27:30 UTC
Oracle OCI IaaS and PaaS NIST Security Reference (English) - Dec 2019	Audit	Thu, Jan 9, 2020, 00:00:00 UTC
Oracle (PaaS) HIPAA Report - 2023	Audit	Mon, Apr 24, 2023, 19:03:17 UTC
Oracle (PaaS Built-On OCI) SOC 2 Type 2 Report - 2023	Audit	Mon, Apr 24, 2023, 19:12:23 UTC
Oracle (PaaS Built-On OCI) SOC 1 Type 2 Report - 2023	Audit	Mon, Apr 24, 2023, 19:09:59 UTC
Oracle (PaaS Built-On OCI) HIPAA Report - 2023	Audit	Wed, Dec 13, 2023, 22:35:09 UTC
Oracle (PaaS Built-on OCI) - SOC 1 Type 2 Report - March 2024	Audit	Wed, Apr 17, 2024, 17:35:32 UTC
Oracle (PaaS Built on OCI) ISO 27001-2013 Certificate - 2023	Certificate	Wed, Dec 13, 2023, 22:31:11 UTC
Oracle (PaaS Built on OCI) ISO 27001-2013 Certificate - 2023	Certificate	Tue, May 2, 2023, 21:43:11 UTC
OCI SOC 3 Report - September 2023	Audit	Mon, Dec 4, 2023, 20:22:44 UTC
OCI SOC 2 Report Period End 3-31-2024	Audit	Thu, May 23, 2024, 20:08:13 UTC
OCI SOC 1 Report Period End 6-30-2024 FINAL NC	Audit	Tue, Aug 14, 2024, 20:02:16 UTC

Figure 9.1: Screenshot of Compliance Documents

Best strategies for security and compliance

Let us discuss different strategies we can adopt for security and compliance. Some of the strategies are discussed as follows:

- **Detailed security architecture design:** We need to ensure the security architecture designed is robust and accommodates the needs of the organization. The architecture designed must adopt the OCI's security features, such as IAM controls, security groups, and defense in-depth principles.
- **Implement IAM:** For any secured architecture, it is essential to adopt IAM principles at a very granular level. This will allow managing user access and permissions in a very effective pattern. To achieve compliance, we need to regularly review and update access privileges. We have discussed the details of IAM in [Chapter 2, Mastering Identity and Access Management](#).
- **Implement data encryption approach:** Data is a critical asset for any organization, and it needs to be protected at rest as well as in transit. To achieve this, organizations should implement an encryption mechanism. Oracle provides two types of encryption mechanisms: Oracle key management service and transparent data encryption. In addition to encryption, organizations should implement data masking and tokenization techniques. Unauthorized access to sensitive data can be reduced by implementing data masking and tokenization techniques.

- **Monitoring and logging tools:** Monitoring and logging tools integrated with third party SIEM tools will help organizations achieve threat detection and incident response in real time. To achieve compliance standards, regular review of audit logs should be performed.
- **Automate security compliance:** Oracle provides various automation tools such as *Resource Manager* and *Terraform*, which will allow to automate compliance checks and validate security configurations. These tools help to define security base lines in align with compliance policies with industry standards and regulations.
- **Incident response and remediation:** In this step, we need to develop and test an incident response plan. This approach will help respond to security incidents and data breaches in OCI. Roles and responsibilities should be defined. Communication channels should be established.
- **Vendor risk management:** Security of any third-party vendors which integrate with OCI should be examined. Third party risk assessment should be conducted in depth. This includes contractual agreements, to ensure compliance with security and privacy requirements.
- **Employee training and awareness programs:** Educate the employees with security training. Provide awareness programs and share the knowledge of compliance requirements with best security practices.
- **Regular security assessments and penetration testing:** For any of the design or architecture change, Organizations should always conduct incremental and full cycle of security assessments and penetration tests for any of the Web UI or API changes on regular base. This will help identify vulnerabilities and threats in the applications. Configure automated scanning tools to simulate real-world attack scenarios.
- **Regulatory compliance management:** Employees should be kept updated with regulatory requirements and industry standards relevant to their organization's operations in OCI. Compliance policies should be regularly reviewed. Regulatory authorities and industry groups.

Key members should be included in the discussion related to understanding the complex compliance requirements.

By implementing these strategies, which are considered to be best and aligned with industry standards, organizations can enhance security and compliance in Oracle Cloud Infrastructure, mitigating risks and maintaining trust with customers, partners, and regulators. In summary, an effective approach to security and

compliance involves three primary strategies. Design, monitoring, and optimization. These strategies are implemented in a regular pattern manner, with each informing and enhancing the others throughout the process. We will discuss each of the strategies in the next sections. In summary, an effective approach to security and compliance involves three primary strategies: design, monitoring, and optimization.

Creating a design strategy

We need to follow multiple steps in process of designing any design strategy in OCI. This design strategy makes sure infrastructure is robust, scalable, secure, and cost-effective. A security design strategy is critical to the success of OCI because it assures security through robust identity management practices.

Identity management practices have two important processes **authentication** and **authorization**. Authentication defines who has access, while authorization defines what level of access users have. These components ensure that only authorized users can access sensitive information and at the same time, it will ensure compliance and regular requirements are met. Through continuous monitoring and updating of identity management protocols, a security design strategy ensures that access controls remain effective and adapt to evolving security threats, thereby maintaining the integrity, confidentiality, and availability of the organization's resources.

In creating a design strategy, we need to follow various steps such as defining objectives and requirements, architecture design, having a proper implementation plan, cost management and having an accurate testing plan. The following is a step-by-step guide to help you develop a comprehensive design strategy in detail:

- 1. Define objectives and requirements:** This step involves establishing the foundational goals, needs, and constraints that will shape the subsequent architectural decisions. A few of the steps are identifying the business objectives, identifying the technical requirements, performing risk assessment, and assessing budget constraints, followed by stakeholder engagement. Below are steps in detail.
- 2. Business objectives:** In this step, the organizations should understand the business goals and objectives. This should include the need for scalability, availability, performance, and compliance.
- 3. Technical requirements:** In this step, organizations should identify technical needs such as compute, storage, network demands, data management, and security requirements.

4. **Budget constraints:** Set budget constraints to ensure cost-effective decisions.
5. **Architectural design:** In this step, several key activities are performed to create a robust and effective infrastructure within OCI. This involves evaluating the various parameters such as selecting regions, availability domains, selecting network architecture, compute resources and storage resources based on our use cases, followed by designing architecture with all security controls implemented.

Let us discuss a few of them outlined as follows:

- **Region and availability domains:** Select the appropriate OCI region and availability domains to ensure high availability and disaster recovery for your application.
- **Network architecture:** OCI offers a robust high performance networking infrastructure with a Zero Trust model.
- **Network architecture:** A typical OCI networking architecture has the following network components such as VCN, Compute resources etc. OCI offers a robust high performance networking infrastructure with a Zero Trust model.
 - **Virtual Cloud Network (VCN):** This is one of the network security designs where a VCN needs to be configured with subnets, route tables, gateways such as internet gateway and NAT gateway, and security lists.
 - **Network security:** In this approach, security standpoint, it is always recommended to have network security groups, firewalls, and load balancers. This will ensure the network is secured and traffic is managed efficiently.
 - **Compute resources:** Compute is considered as one of the pillars on which OCI is built. Oracle provides compute instances to provision and manage Compute hosts.
 - **Instances:** Select the correct compute instance shapes based on performance and workload requirements.
 - **Autoscaling:** Implement auto scaling policies to manage variable workloads effectively.
- **Zero Trust:** Oracle designed OCI with a strong focus on security from the start, incorporating core Zero Trust principles throughout. This

includes features such as hardware-based Root of Trust, isolated network virtualization, and hyper-segmentation to enhance protection. OCI follows a Zero Trust security model. With this model, it operates under the assumption that all network traffic is untrusted, regardless of its origin. Resource access is restricted to authorized users based on necessity and granted only with the proper permissions. This kind of approach mandates continuous verification of both device and user identities, along with their security status, before allowing access to any resources. Zero Trust follows principles such as applying least privileged access, always assuming the breach to occur in the systems, and verifying the trust explicitly.

These principles are applied across a comprehensive control plane to provide multiple layers of defense. The initial and first step in adopting a Zero Trust model is achieved by implementing the identity and access controls. OCI's IAM service assists in this process by ensuring that only authorized individuals, devices, and processes are granted access to your resources.

The second mechanism to uphold the principles of a Zero Trust is by requiring explicit permission for access rather than assuming it is automatically allowed. This can be achieved by applying least privileged access. The third principle to achieve zero trust model is always assume breach in your systems. OCI IAM evaluates risk at every authentication request. OCI IAM Adaptive Security provides risk-based authentication, enabling the user's session context to be examined and evaluated against several risk factors, including historical behavior, to determine whether to allow the request, block it, or challenge for an additional authentication factor.

By adopting a zero-trust security model, it provides customers a strong foundation for addressing risk in cloud platforms. Zero trust security is not a product or a checkbox to enable something within an application at a given point in time. Zero trust is an approach, not a single action, and take time, effort, and investment to adopt.

- **Storage solutions:** OCI provides customers with high-performance computing and low-cost cloud storage options. Data like transactional data, compute images, backup of databases, OS, data from compute instances, etc. are stored in storage service of OCI.

- **Block storage:** This approach is recommended for use cases which require low-latency storage with high-performance applications.
 - **Object storage:** Object storage is recommended for storing unstructured data and backups.
 - **File storage:** Suitable for shared file systems.
- **Database solutions:** OCI offers a comprehensive suite of database services designed to meet the diverse needs of modern businesses. Database services provide benefits such as high performance, scalability, security, and flexibility, making them compatible with various applications and workloads.
 - **Autonomous databases:** opt for self-managing and self-patching database solutions.
 - **Database systems:** Choose customizable database configurations.
- **Security architecture:** OCI's security approach is based on seven core pillars. Each pillar has multiple solutions designed to maximize the security and compliance of the platform.
 - **IAM:** In this approach of security architecture, we need to define roles and configure groups and policies to control access to resources.
 - **Encryption:** Organizations should implement encryption for data which is at rest and in transit.
 - **Monitoring and auditing:** To enhance security and compliance, organizations must adopt monitoring and auditing. for monitoring, we need to use OCI monitoring, logging. For audit, organizations should leverage OCI Audit.

6. Implementation plan: Within the implementation plan of a design strategy, we describe the thorough steps and procedures essential for actualizing the architectural design. This stage converts the conceptual architecture into a tangible, operational infrastructure. Below are a few of the steps outlined below.

- a. **Resource provisioning:** This is one of the design strategies where organizations should adopt a plan for the automated deployment of resources. This can be implemented using terraform or OCI resource manager.
 - b. **Continuous integration and continuous deployment (CI/CD) pipeline:** In this approach, teams must set up CI/CD pipelines for continuous integration and continuous deployment. This can be achieved using tools such as Oracle Developer Cloud Service or other third-party tools.
 - c. **Backup and recovery:** This is one of the important and critical steps in design strategy. Organizations should develop a backup and disaster recovery plan. This will ensure data integrity and availability.
7. **Cost management:** The primary goal of the cost management step in the design strategy is to optimize spending while ensuring that resources meet performance and availability requirements. Through the implementation of effective cost management practices, organizations can optimize the value gained from their OCI investments, all while managing expenses effectively and minimizing unnecessary spending. This involves steps such as tracking the budget, analyzing the cost, and optimization of cost:
- a. **Cost analysis:** Regularly analyze usage and costs using OCI Cost Management tools.
 - b. **Budget tracking:** Use OCI Budgets to track spending and set alerts.
 - c. **Optimization:** Continuously optimize resources for cost-efficiency, including right-sizing instances and utilizing reserved instances.
8. **Testing and validation:** During the *testing* and *validation* phase of the design strategy, various vital tasks are performed to confirm that the proposed architecture aligns with its intended objectives and works as anticipated. This involves tests such as functional, performance, scalability, and security, followed by validating the compliance checks:
- a. **Performance testing:** Organizations should deploy different kinds of testing teams. A few of the testing metrics are performance testing, functional and system testing. This testing should be conducted frequently to ensure performance benchmarks of the architecture are met.

- b. **Security testing:** Any of the security assessments should undergo penetration testing. This will help teams to identify and mitigate risks and vulnerabilities.
- c. **Compliance checks:** Always organizations need to ensure the architecture complies with industry standards and regulations.

In addition to the above-discussed strategies, it is highly recommended to implement deployment and monitoring strategies such as monitoring the log activities, performing regular reviews, and providing documentation and training to the team.

Creating a monitoring and auditing strategy

An effective monitoring strategy places emphasis on health modeling, which involves activities directed at preserving the security posture of a workload through ongoing monitoring.

Health modeling serves as a proactive approach to ensuring the effectiveness of security practices and identifying any emerging requirements. It typically involves the following categories:

- **Monitoring the workload and infrastructure:** This involves continuous monitoring of both the workload itself and the underlying infrastructure where it operates, such as tracking performance metrics, resource utilization, and potential security vulnerabilities.
- **Performing regular audits:** It is strongly recommended to have regular audits to assess the compliance of workload and infrastructure with security policies, industry standards, and regulatory requirements. Audits help identify gaps in security controls and areas for improvement.
- **Enabling, obtaining, and storing audit logs:** Enabling logging mechanisms to capture relevant security events and activities within the environment is encouraged to have comprehensive security related events. Acquiring and storing audit logs securely ensures that a comprehensive record of security-related events is available for analysis and investigation.
- **Updating and implementing the patches for security fixes:** To address any kind of known security vulnerabilities, organizations must ensure patches are updated regularly. Organizations must make sure software is updated and patched in a timely manner. These will reduce the risk of threats from attackers **Proactive**.

- **Incident response procedures:** Organizations should implement procedures for incident response. These will ensure incidents are detected, analyzed, and mitigated. Incident response procedures will not only restore affected services but also prevent them from occurring.
- **Conducting simulated attacks modeled on real incidents:** This process involves conducting simulated attacks or security exercises based on real-world scenarios to test the effectiveness of security controls and incident response procedures. These simulations help identify weaknesses in the security posture and improve readiness to handle actual security incidents.

By incorporating these health modeling activities into the monitoring strategy, organizations can proactively safeguard their workloads, detect security threats in a timely manner, and continuously improve their security posture to mitigate risks effectively.

Best security and compliance practices

In this section, we will discuss cloud security compliance and the essence of compliance.

Cloud security compliance makes sure organizations adhere to regulatory mandates and industry benchmarks.

Cloud security compliance ensures data and assets within cloud environments are safeguarded. This comprises a set of protocols and methodologies that safeguard sensitive data, maintain data confidentiality, and prevent security vulnerabilities. Organizations can adopt different compliance frameworks such as CSA, NIST, and ISO.

Ideally, we consider the cloud provider as a well-architected cloud when it offers a detailed set of guidelines for maintaining robust security and compliance standards. There should always be shared responsibility between organizations and **Cloud Service Providers (CSPs)**. Organizations are accountable and responsible for securing their data and applications within the cloud environment, implementing effective access controls, encryption protocols, and monitoring systems. The role of CSP is to safeguard the security of cloud infrastructure and make sure compliance certifications are implemented and maintained accurately. This kind of shared responsibility between organizations and CSPs is very critical to achieving transparent communication and establishing a resilient security framework. The main business goal of security and compliance is to focus on key areas such as user authentication, resource isolation and access control, compute security, database security, data protection, and network security.

Let us discuss the different key steps to achieve cloud compliance:

1. **Risk assessment:** Every organization should have a third-party risk assessment team. These teams establish the process of how to conduct a detailed risk assessment. These types of risk assessment analyses will help organizations identify potential security risks and vulnerabilities in the cloud environment. The risk assessment will involve different steps, such as evaluating and examining the sensitivity of data, assessing potential threats, and finally, determining the impact of security breaches in the organization. Understanding the types of data at risk and the potential impact of exposure is very important for any organization, as this will allow measures to be put in place to reduce the identified vulnerabilities. Some of the measures discussed earlier such as encryption, access controls, regular security audits, and employee training. Organizations should conduct detailed scans and security assessments to identify weaknesses and threats at the initial stages of projects. Here risk team will be processed to examine potential entry points, weak encryption protocols, and outdated software that could pose significant security risks.
2. **Policy development:** Develop and implement security policies and procedures tailored to the organization's specific requirements and regulatory obligations. These policies should address data protection, access controls, encryption, incident response, and other critical security measures. Through the clear specification of roles and responsibilities, organizations can prevent unauthorized access and uphold data security. Another critical issue addressed by policy development is data governance, which encompasses defining data ownership, integrity, and quality standards to ensure consistency and reliability across the organization's data assets. Procedures implemented in secure transfer protocols will ensure with confidence that the data exchanged in the cloud is always encrypted and secured from extensor threats or security breaches. Establishing industry-standard protocols for data transfers will improve the security posture by safeguarding sensitive information and complying with data protection regulations.
3. **Service provider review:** Organizations should conduct a service provider review before selecting a specific cloud vendor. They must review based on parameters such as security controls and compliance certifications and ensure that they are adhering to industry standards. Select cloud service providers which demonstrate a commitment to security and compliance, and in addition, these selected providers should be capable of providing robust security features and controls. Organizations should also evaluate if the

service providers are following regulatory compliance, which is aligned with industry standards. This will reduce the risk of penalties and legal issues in case any kind of noncompliance occurs. By following the above steps, organizations can ensure overall security stance and confidence in the cloud service provider.

4. Data backup and encryption: By Implementing different kinds of data backup mechanisms and encryption measures, organizations can protect sensitive and critical data from external threats such as unauthorized access and distributed denial of service. This will ensure data integrity is achieved. The backup should be configured regularly by scheduling as per the use case. By following data backup methods, data loss can be prevented in case of any security incident or system failure. By encrypting data at rest and in transit, we can enhance data protection capabilities. The data protection team must ensure they follow complex and robust algorithms. This approach will ensure data is safeguarded while resting and in transit. Data protection and encryption techniques will prevent unauthorized access to sensitive information, thereby enhancing security. In summary, consistent data backup and encryption techniques will help organizations reduce the chances of occurrence of data loss and eventually help business continuity. These procedures not only adhere to cloud security compliance standards but also bolster a resilient security stance that fosters confidence among users and clients.

By Adhering to the above steps, cloud security can be enhanced, and thereby, risks can be minimized. All these strategies help organizations achieve regulations.

Design for attackers

Design for attackers can be considered a process for adopting a proactive security approach, which involves focusing on anticipating and mitigating potential threats and attacks from malicious actors. This design principle is considered one of the best security compliance practices. Unlike conventional traditional security approaches, which primarily depend on defensive measures such as firewalls and intrusion detection systems. Design for attackers involves a comprehensive strategy that considers how attackers might exploit vulnerabilities within the cloud environment. This approach includes several key elements discussed as follows:

- **Threat modeling:** To figure out how potential attackers could infiltrate their systems; organizations carry out intense scrutiny. They assess the very structure of their cloud infrastructure. They also look closely at essential

assets that are prime targets and at vulnerabilities that nefarious sorts could exploit. In such examinations, the kinds of attack vectors that would be used are identified.

- **Security by design:** When it comes to developing cloud services and applications, security must be part of the design phase. This means that the developers must embrace secure coding practices, which lead to more robust systems with fewer vulnerabilities. It also means that they must enforce something akin to *least privilege* to control who or what can get to certain sensitive resources. Finally, the phase must also make sure it implements and holds the concept of encryption for data in transit and at rest.
- **Continuous monitoring and response:** Continuous monitoring and response should be adopted by organizations. This approach will help security teams to detect, respond, and fix security breaches in real-time environments. There are many ways we can achieve this step. One of the common ways is by deploying security analytics tools. Security analytics tools analyze logs and detect suspicious activities in the logs based on specific patterns configured. This approach will also let the system configure automated response mechanisms which mitigate threats proactively.
- **Security by design:** Security should be the primary component to be reviewed while initiating the design of the project. This can be achieved in multiple ways. This can be achieved by implementing secure coding practices. This will ensure the cloud services and applications themselves are not only safe but also this approach reduce the vulnerabilities in the underlying cloud platform. Secure code should be a starting point while designing the cloud platform. This approach will make it very difficult for the hacker to penetrate the systems.
- **Redundancy and resilience:** Designing systems with redundancy and resilience facilitates the security teams to reduce the impact of potential attacks from various sources. Organizations are encouraged to implement backup and disaster recovery measures and ensure business continuity is achieved in the event of a security breach or outage. These mechanics will drastically reduce the impact on operations and minimize downtime.
- **Security awareness and training:** It is a very important and key component of security to Educate employees and stakeholders about security threats and best practices to be adopted for enhancing security posture.

A few of the ways include providing training on how to recognize and respond to common vectors used by attackers, such as phishing attempts and social engineering attacks, to reduce the risk of successful compromises.

Implementing penetration testing to simulate one-time attacks. Encouraging red teams to simulate long-term persistent attack groups.

Drafting the policies with the utmost granularity concerning the target resources and the necessary access privileges and enforcing network segmentation restricts the traffic to isolate application deployments from each other at a network level.

Organizations can proactively identify and mitigate security risks in their OCI environment by adopting a *design for attackers* approach. This approach will enhance the overall security posture and provide a resilient feature against any potential threats. Organizations can stay ahead of evolving threats and maintain the integrity and confidentiality of their data and resources in the cloud.

Another best security design principle is **leveraging the native controls** or giving preference to the native security controls integrated into cloud services rather than relying on external controls from third-party vendors. These native security controls are maintained and supported by the service provider, lessening or eliminating the need to integrate external security tools and continually update those integrations as time progresses.

Leveraging native controls

It is always recommended and advised to prefer using native security controls, which are built into cloud services, compared to using any external controls that come from these parties. Native Security controls provide benefits such as reducing the efforts required to integrate with external security tools. Other major benefit is they are maintained and supported by service provider.

Design for resilience

The **design of resiliency** in OCI involves architectural strategies and practices aimed at ensuring systems and applications stay operational and recover swiftly in case of failures or disruptions. High availability, reliability, and continuity of services can be achieved by implementing the concept of design of resilience.

When we design the security strategy, we should always assume that controls may fail, and the design should be based on this approach. Strengthening your security

posture requires a combination of multiple approaches working together. A few of the approaches are below:

- **Defense in Depth:** In this mechanism, we need to consider additional controls in the design to mitigate risk to the organization in case any event related to primary security control fails. The design should account for the possibility of the primary control failing, the potential risk to the organization if it does, and the effectiveness of the backup control, particularly in scenarios where the primary control is most likely to fail.
- **Defense at Edge:** In this approach, we need to focus on or consider adopting effective integrated edge security to control threats before they impact your applications. This is very important to maintain the information security policy compliance.

OCI Architecture by itself is designed with resiliency at its basic core design which includes multiple components which are capable of performing the same tasks to ensure continuous operation is accomplished. This redundancy is important to maintain high availability and reliability. Let us discuss a few key points related to OCI's resilient architecture:

- **Redundant components:** In OCI, **redundant components** are referred to as multiple, independent units of infrastructure and services which can perform the same function. This redundancy ensures that if one component fails, others can continue to operate, maintaining the availability and reliability of applications and services. Your security strategy should anticipate control failures and be designed to handle them accordingly.

The following are the redundant components offer the below benefits:

- **High availability:** In high availability, we will use the redundant components in the design. This will ensure that services remain available even if some parts of the infrastructure fail.
- **Fault tolerance:** Fault tolerance will ensure the system can tolerate faults without having a significant impact on operations.
- **Load distribution:** Distributing workloads across multiple components can balance the load and prevent overloading individual components.
- **Scalability:** Redundant components can be scaled horizontally, adding more instances or services as needed.
- **Disaster recovery:** To implement disaster recovery strategies organizations will use the concept of redundancy. This provides a strong

foundation for disaster recovery strategies, which will ensure that data and services can be restored quickly in the event of any system failure.

Redundant components provide essential components required for designing resiliency and high availability in OCI. These can be achieved by multi-instance deployment or active-active and active-passive setups:

- **Multi-instance deployment:** In this kind of use case, organizations will deploy critical applications and services across multiple instances, which are often spread across different **availability domains (ADs)** or fault domains within a region.

Multi-instance deployment ensures that in case one instance fails, others can seamlessly take over the control.

- **Active-active and active-passive setups:** In the concept of disaster recovery strategies, this can be considered as the best option. In these use cases, systems can be configured in active-active where all instances handle traffic simultaneously or active-passive where standby instances are activated if primary instances fail) modes, providing flexibility in failover strategies.

- **Health monitoring:** Health monitoring is configured to continuously observe the cloud services and cloud resources. This will allow the users to understand the assessment of the state and performance of its services. All services should be configured with health monitoring tools which will help identify potential issues and ensure the smooth operation of applications. High availability is the key benefit of health monitoring. These can be implemented by performing continuous health checks and service level monitoring as explained below:

- **Continuous health checks:** Health checks can be configured to help OCI monitor the health and performance of its services continuously or based on schedule. Service unavailability, latency spikes, or resource depletion are a few metrics measured by configuring the continuous health checks.
- **Service-level monitoring:** Configuration of service-level monitoring should be enabled at both the infrastructure and application levels. This level of detailed monitoring ensures any potential issues are detected at a much earlier stage of design, which helps take proactive action.

Benefits of health monitoring in OCI:

- **Proactive issue detection:** This is one of the major advantages of health monitoring. Even before end users seeing the problems, health check will

identify these and provide remediation measures.

- **Improved availability:** High availability is another outcome of health monitoring. This is achieved by ensuring that resources are healthy and performing optimally.
- **Efficient resource utilization:** Resources scale automatically based on real-time performance data and data load to match demand.
- **Enhanced security:** Monitoring for security threats and compliance issues to protect data and applications.
- **Faster troubleshooting:** Aggregating logs and metrics to quickly identify and resolve issues.
- **Automatic failover:** This is a process by which the system automatically transfers operations from a failed component to a standby or backup component without manual intervention. This mechanism ensures minimal disruption and maintains the availability and reliability of services. In OCI, this can be implemented in multiple ways. A few of them are highlighted below:
 - **Automated response mechanisms:** When OCI detects a failure or degradation in service, it automatically initiates failover procedures. This might include redirecting traffic, starting backup instances, or shifting workloads to healthy components.
 - **Load balancers:** Traffic distribution across multiple instances is managed by load balancers in OCI. They ensure that the instances share the incoming traffic. If one of the instances goes down, the balancer detects the failure and redirects the traffic to the reachable instances. It is important to note that the load balancer's function is similar to that of an automatic failover or database failover and application failover.
 - **Database failover:** If the primary database becomes unusable, **Oracle Cloud Infrastructure (OCI)** automatically transitions database operations to a standby database using Oracle Data Guard. This translates to a smooth continuation of operations for a database user.
 - **Application failover:** In a web application which runs on several instances, if one instance goes down, the load balancer makes sure that traffic is still flowing to healthy instances. Users will not notice the instance failure at all.

- **Cross-region failover:** If an entire region goes down, a worldwide application can instantaneously switch over to another region where data and services are already in place, making sure that the application suffers no interruption in service.

An essential characteristic that ensures high availability and reliability within OCI is the automatic failover. It is a core mechanism that works to maintain the necessary uptime of services even when components fail. It is, therefore, very much part of the architecture's resiliency.

- **Geographic redundancy:** In this approach, resources and services are deployed in multiple geographic locations and regions. The main purpose of this approach is to achieve high availability, fault tolerance, and disaster recovery. This will ensure services remain operational and active even if one location is disrupted. This is like redundant components and is considered a good strategy in design of resilience. Geographic redundancy can be implemented in two models: multiple regions and cross-region. Both are discussed below:
 - With **multiple regions** and **availability domains** approach, infrastructure spreads across multiple geographic regions and availability domains. This will provide geographic redundancy. Whereas in the case of **cross-region replication**, instead of infrastructure, critical data and applications are replicated across regions. This will ensure backup is always there in other region for the users to access in the event of downtime.
- **Backup and recovery:** It is evident that cloud computing provides an unlimited pool of computing and storage resources, which comes at a much lower cost. In addition, it also offers benefits such as easy scalability. With this context, organizations are slowly but surely opting to migrate their workloads to the public cloud. Database backup and recovery is another requirement that is completely eased by the cloud. Particularly for organizations with multi-tiered storage architectures, cloud backup helps provide benefits such as keeping backup data separated geographically, which minimizes risk, and expanding the backup plan as a solution to support business continuity under all circumstances.
 - In this process, organizations will adopt ways to protect data and systems by taking backups. This will help organizations to have quick restoration in events such as data loss, data corruption, or any kind of failure in the system.

- This is very essential for business continuity and to make sure downtime is reduced significantly. We can implement regular backups by using Automated backup schedules and respective policies in align with compliance.
 - **Disaster recovery plans:** Every organization should ensure they have detailed **disaster recovery (DR)** plans. This should include regular disaster recovery drills. It is very critical to implement RPO and RTO threshold, which will have acceptable data loss and downtime in case any disaster occurs. In addition to performing automated regular backups, backups should also be encrypted. This will protect sensitive data from unauthorized access.
 - This guides backup and recovery strategies. Encrypt backups and store data to protect sensitive information from unauthorized access or tampering. Implement access controls and authentication mechanisms to ensure that only authorized personnel can initiate or manage backup and recovery processes. Configure instance DR in the architectural design. IDR is a feature that provides a disaster recovery solution for OCI compute instances. It allows you to create a standby instance in a different **availability domain (AD)** or region from your primary instance. If the primary instance becomes unavailable due to a disaster or outage, you can quickly failover to the standby instance to maintain business continuity. Instance DR helps ensure high availability and resilience for critical workloads running in OCI.
- **Security measures:** We need to adopt a resilience design to achieve architectures free from potential threats and vulnerabilities. Resilience design is important to protect data, systems, and various operations from security threats. These can be implemented by proper security measures. Security measures can be achieved by implementing IAM, network security, threat detection, and monitoring. IAM policies help prevent any kind of unauthorized access. It is mandatory to implement multi factor authentication and privileged access management with RBAC functionality. The second option is to implement security measures to have strong network security, which can be achieved by implementing firewalls, security groups and virtual cloud networks. Network security will protect resources from external threats since these are designed to be isolated.

Security measures can also be implemented by properly leveraging and integrating the threat detection and monitoring tools with security

information and event management tools. These solutions will help collect data and analyze any kind of security events, thereby enabling proactive threat detection. Configuring intrusion detection and prevention systems is another best approach to have security measures enabled. This will detect and block malicious activities such as unauthorized access attempts or malware infections in the system.

Disaster recovery in OCI can be accessed by clicking **Migration & Disaster Recovery** section. This covers all types of disaster recovery methods which OCI offers. Refer to *Figure 9.2*:

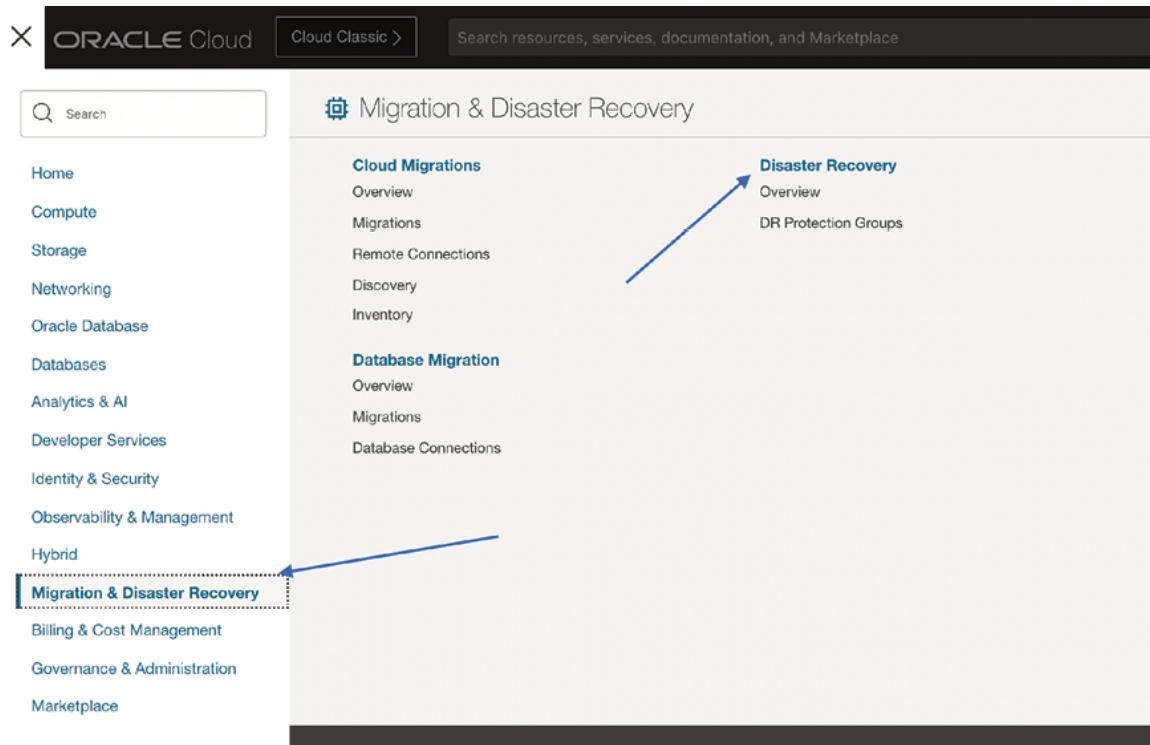


Figure 9.2: Screenshot of migration and disaster recovery

Governance

Cloud adoption governance incorporates the collection of policies, procedures, and regulatory measures put in place to direct and oversee the utilization of cloud computing assets within a company. The purpose of cloud governance is to ensure that cloud services are secure, compliant, and effectively utilized. One of the key objectives of cloud governance is to enforce a structured framework that enables organizations to adopt the advantages of cloud technology while preserving control, accountability, and compliance. Cloud governance provides a balance

between encouraging innovation and managing risks. The governance model will allow organizations to adopt security and compliance, which can be adjusted based on the needs of the organization. Developing a successful governance model involves making decisions regarding the provisioning, administration, stewardship, and decommissioning of cloud resources. Initially, a manual process can be utilized to set up the workflow. As the governance model evolves, automated workflows and infrastructure-as-code Terraform stacks can be configured to deploy the governance model seamlessly.

The governance model is cyclic and iterative, where we have steps like organize, govern, observe, and monitor. The diagram below illustrates the governance model involving the various steps:

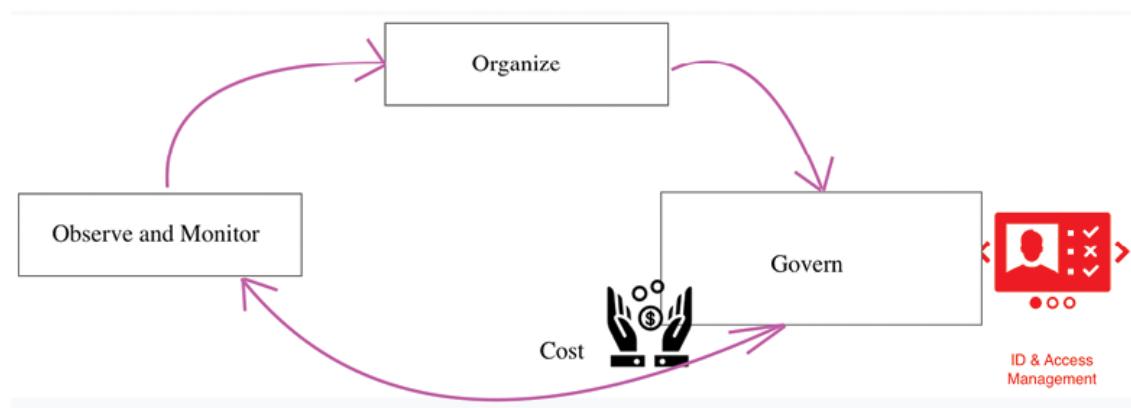


Figure 9.3: Screenshot of a diagram illustrating the steps in governance model

Here are a few foundational guidelines for implementing governance procedures:

- Strategize the layout of your tenancy and compartments prior to user and resource integration.
- Ensure your compartment arrangement aligns with the organizational department or project structure.
- Classify user roles and subsequently allocate users to groups with fitting permissions.
- Adhere to the principle of least privilege by initially granting minimal permissions and gradually increasing them as necessary.
- Enforce stringent password policies and implement regular password updates.

- Utilize instance principals and dynamic groups for invoking OCI services from compute instances.
- Maintain consistency by naming federated **identity provider (IdP)** groups in OCI with identical prefixes when mapping them.

Below are the key principles of efficient cloud governance:

- **Business objective alignment:** Cloud endeavors should directly align with strategic goals. Governance ensures that cloud integration supports business objectives and yields tangible benefits.
- **Risk management and security:** Security and risk mitigation take precedence. Governance institutes protocols to identify, evaluate, and alleviate risks related to data breaches, vulnerabilities, and unauthorized access.
- **Compliance and regulatory conformity:** Governance mandates adherence to industry regulations and legal stipulations. Cloud initiatives must comply with data protection laws, industry standards, and pertinent regulations.
- **Cost optimization and resource management:** Cloud governance emphasizes cost efficiency by judiciously allocating and utilizing resources. This principle prevents overspending, advocates economic practices, and aligns with budgetary constraints.
- **Operational excellence:** Governance fosters operational efficiency by defining standardized practices, guidelines, and procedures for cloud adoption, management, and ongoing operations.
- **Data protection and privacy:** Data security is paramount. Governance ensures organizations implement secure data handling through encryption, access controls, and compliance with data protection laws.
- **Performance metrics and KPIs:** Performance metrics and KPIs are key components used by *Governance* to evaluate the success of cloud programs. This indicator also supports continuous improvement. In a nutshell, cloud governance is essential as it guides organizations and provides the framework and tools needed to effectively manage their cloud resources, mitigate risks, and achieve their business objectives in a secure, compliant, and cost-effective manner.

Governance can be accessed in OCI by clicking the link for **Governance & Administration** as shown in *Figure 9.4*:

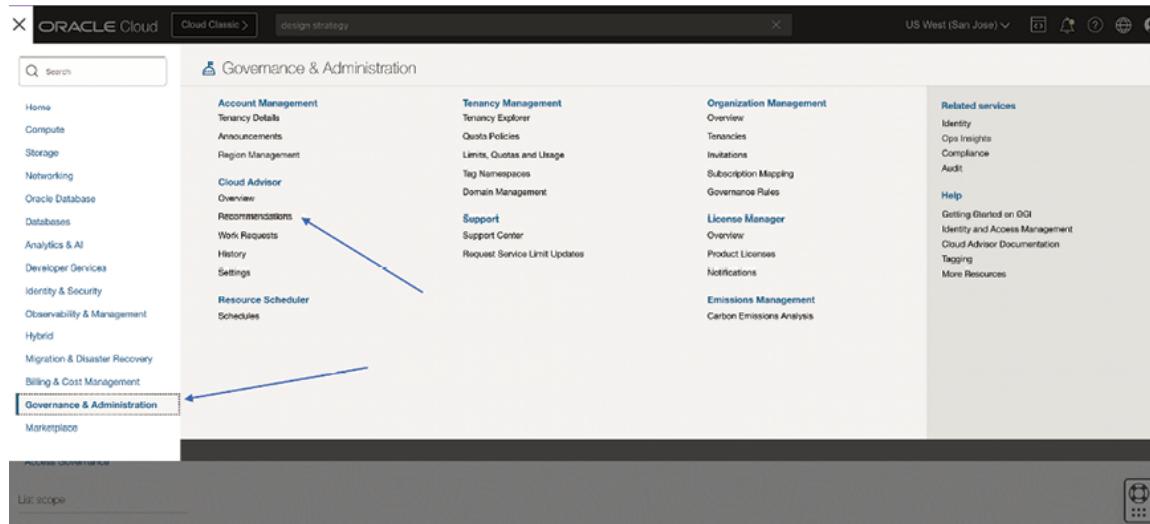


Figure 9.4: Screenshot of compliance documents

Incident detection and response

Incident detection and response (IDR) is a managed service in OCI that is designed to help organizations detect, investigate, and respond to security incidents in the cloud environment. This provides benefits such as continuous monitoring, advanced threat detection, and guided response actions, which facilitate OCI resources from security threats.

In order to monitor, prevent, and manage incidents, organizations are encouraged to follow below check list:

- Configure the systems with a security **information and event management (SIEM)** system.
- Define and configure **security operations center (SOC)** and an incident response team.
- Implement incident detection.
- Implement incident response.
- Implement incident reporting.
- Define an escalation path.
- Build a standard post-mortem and learning mechanism.

Threat monitoring and threat intelligence are essential to identify threats in advance, which is followed by taking steps for incident detection and response.

Threat monitoring and threat intelligence can be accessed from **Identity & Security** section in OCI, as shown in *Figure 9.5*:

The screenshot shows the Oracle Cloud Identity & Security interface. On the left, there's a navigation sidebar with various service links. The 'Identity & Security' link is highlighted with a dashed box and has a blue arrow pointing to it from the bottom-left. The main content area is titled 'Identity & Security' and contains several sections: 'Identity' (Overview, Domains, Network Sources, Policies, Compartments), 'Access Governance', 'Cloud Guard' (Overview, Recipes, Alerts, Configuration, Queries, Threat monitoring, Resources), 'Security Advisor' (Threat Intelligence, Threat Indicator Database, Firewalls, Network Firewalls, Network Firewall Policies), 'Web Application Firewall' (Policies, Network Address Lists, Edge Policy Resources), 'Certificates' (Overview, Certificates, Certificate Authorities, CA Bundles), and 'Security Zones' (Overview, Recipes). A blue arrow also points from the 'Threat monitoring' link in the Cloud Guard section towards the 'Threat Intelligence' link in the Security Advisor section.

Figure 9.5: Screen shot of threat monitoring and threat intelligence

Conclusion

To sum up, this chapter highlights the very important part that today's digital proactiveness in cybersecurity carries. It emphasizes what those rules and standards do and what they signify. It underlines why, in an era when compliance seems almost futile for the number of mandates one faces, these compliance measures should not only be followed but should also be seen as very good and very meaningful cybersecurity.

We discussed the basic and advanced concepts of compliance, various design strategies, best security and compliance practices, governance and governance framework, and cutting-edge network design principles. The best practices and recommendations suggested throughout this chapter are instrumental in elevating the security posture of your OCI network infrastructure to a more advanced and resilient state. This chapter discussed the advanced practices that not only offer a solid foundation for today's networks but also are leading-edge enough to meet tomorrow's emerging threats. It covered compliance with a renewed focus on how much of it can be handled automatically. It also covered a specific aspect of IDR

that has not been covered earlier: how to handle a suspicion—whether it originates from business analytics or IDS alerts. Finally, the chapter looked at vulnerability management practices as they might apply not just to last year's problems but also to issues that have not yet appeared on the threat horizon. In summary, the journey toward the cybersecurity domain is ongoing and requires continuous vigilance, adaptation, and collaboration across all levels of the organization. By prioritizing and ranking these pillars and adopting a culture of security, organizations can confidently navigate the complexities of the digital age and thrive in an environment of trust and resilience. In the next chapters, we will explore the future of OCI Security and best practices to be adopted to achieve secured architecture in OCI.

Multiple choice questions

- 1. In what environment do administrators exert the greatest level of control over the security of cloud applications?**
 - a. Software as a service (SaaS)
 - b. Platform as a service (PaaS)
 - c. Infrastructure as a service (IaaS)
 - d. Chief Information Security Officer (CISO)
- 2. What among the following is not categorized as a form of confidential computing?**
 - a. Implementing encryption methodologies
 - b. Trust execution environments
 - c. Zero Trust networks
 - d. Secure computation
- 3. In cloud security, which of the following is the zero-security approach?**
 - a. Moves the perimeter closer to protected areas.
 - b. Eliminates the perimeter.
 - c. Identity and access management
 - d. Security monitoring and logging

Answers

1. **b**

2. **c**

3. **a**

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CHAPTER 10

Future of OCI Security

Introduction

In this chapter, we will investigate the journey of cloud security, future, and emerging technologies, new threats and challenges in the security space, and future trends and considerations to be ready to handle the challenges in the cloud security space.

In the rapidly growing cloud adaption and in the world where cloud first approach, organizations are gearing towards cloud journey due to cost-effective and scalability and reliability, this allowed organizations to innovate faster and market the products quickly to take the competitive advantage.

Cloud revolutionized the organizations digital transformation journey, but this raised new challenges with security and compliance in the cloud world. This is not limited to cybersecurity attacks and breaches and more robust compliance and regulatory requirements. This requires effective monitoring and defense tools and techniques to keep the cloud resources safe and secure.

OCI is providing best in class security with advances suite of technologies and tools. OCI build upon fundamental concept the security and all the services and components are designed to keep security first approach and it provides industry leading security methods and tools which are efficient and

robust where organizations can trust with their mission critical services and data.

We will also cover the protection capabilities of the critical OCI components such as network firewalls, API Gateways, and defense mechanisms which allow robust securing on the gateway and network layers which helps organizations fortify and mitigate any security attaches and monitor and respond to incidents effectively.

As part of the future of the OCI security, we examine the latest trends and technologies in the cloud security realm such as zero-trust security architecture, **secure access service edge (SASE)** and modern identity management as we explore next generation of OCI cloud security.

Future of OCI security initiates the innovation, collaboration and resilience by using modern technologies in the cloud security world.

Structure

The chapter covers the following topics:

- Advanced security operations
- Threat intelligence and detection
- Automated incident response
- Benefits of automated incident response
- Security orchestration and automation
- Continuous compliance monitoring
- Oracle risk management and compliance
- Risk management cloud
- Oracle Cloud Guard
- Remediating security threats with Cloud Guard
- Automated user access management in OCI
- Continuously monitor user activity with AI
- Strategies for safeguarding API Gateways and network firewalls

Objectives

By the end of this chapter, we will learn about the **Oracle Risk Management and Compliance Service (RMCS)**, which provides organizations with the tools and technologies that are needed to navigate various regulatory requirements, identify and mitigate risks, and meet compliance requirements with confidence.

Advanced security operations

In the world of cloud computing, advanced security operations are required for companies to protect their user data and applications from growing cyber security threats.

OCI offers a large suite of advanced security operations with the latest technologies and best practices to protect organizational assets and meet compliance and regulatory requirements.

In the below section, we explore the key components of OCI's advanced security operations and how they help organizations to mitigate risks effectively and improve the security posture:

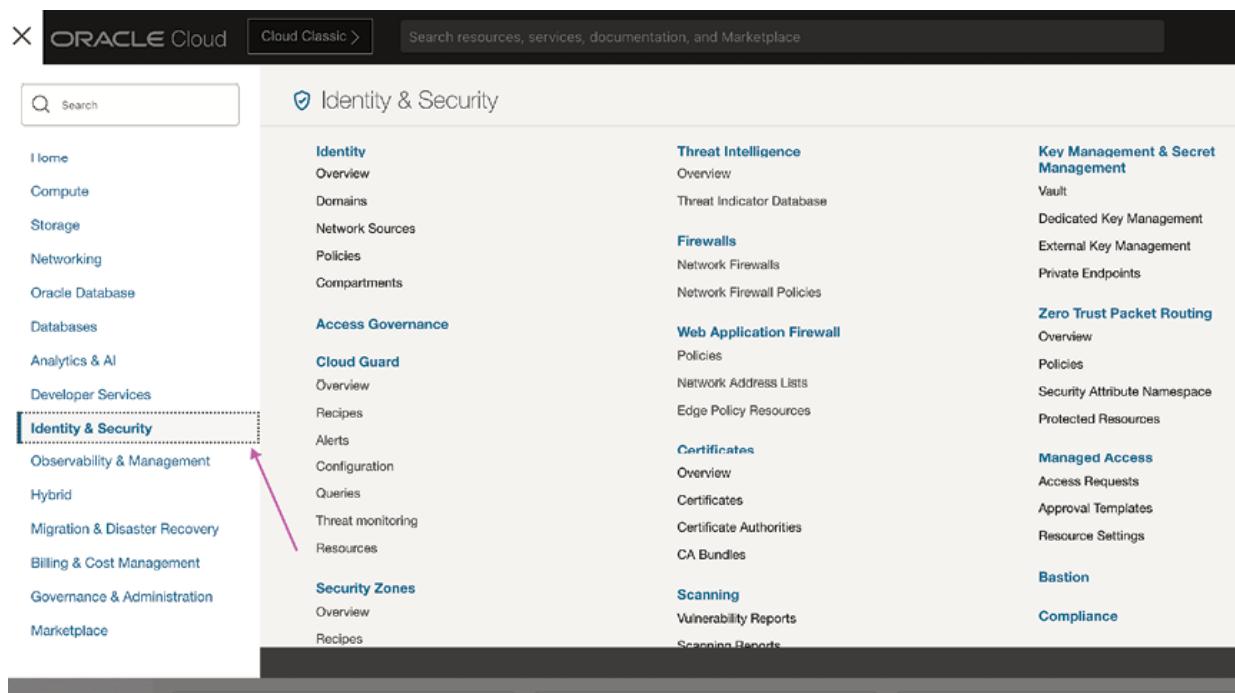


Figure 10.1: OCI Identity & Security interface

Threat intelligence and detection

The idea of advanced security operations is the ability to detect and respond to security threats in real-time and protect the resources. OCI provides its customers with advanced threat intelligence capabilities by using ML algorithms and AI-based analytics to detect suspicious activities and probable security breaches. Threat intelligence mechanism continuously monitors network traffic, system logs, and user activity; OCI can detect any changes in the behavior and signals of compromise, enabling organizations to respond quickly to emerging threats and mitigate them. *Figure 10.2* depicts the interface for threat intelligence in OCI:

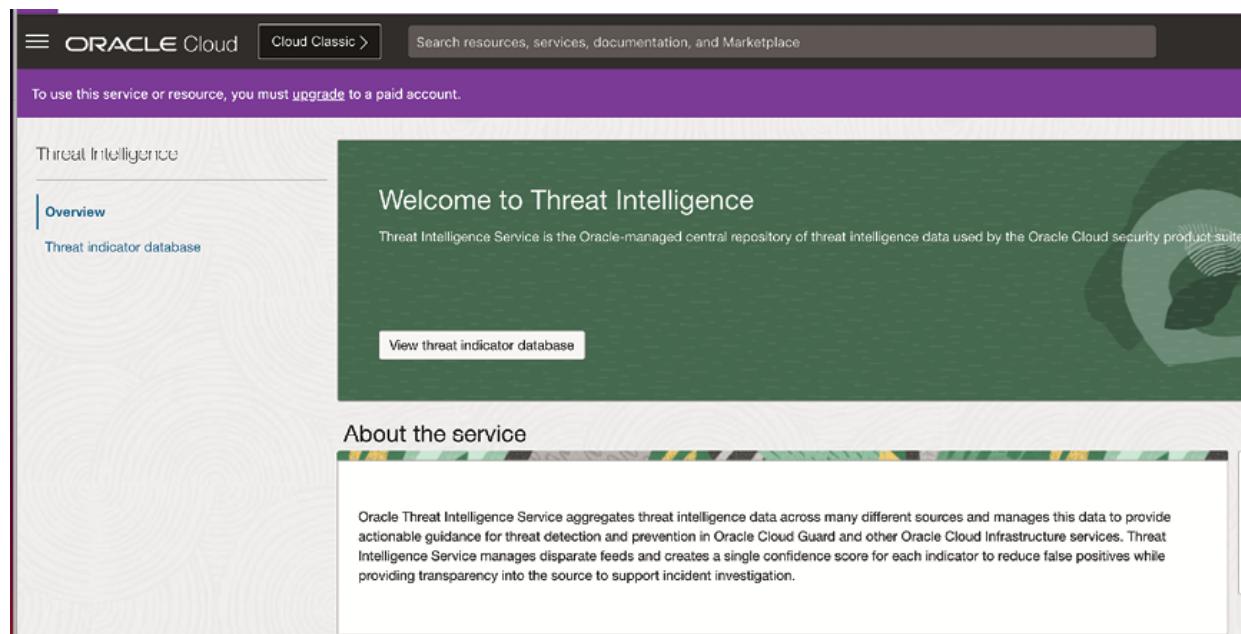


Figure 10.2: OCI Threat Intelligence interface

OCI Console offers real-time monitoring options that allow customers to continuously monitor their cloud infrastructure for security threats and vulnerabilities. Using the Security section of the OCI Console, organizations can check the dashboards and reports that provide details about security events, alerts, and incidents in their OCI environment. OCI cloud is integrated with external threat intelligence repositories, which provide up-to-date information on threats and attack patterns in the real world. This threat intelligence allows organizations to monitor, detect and respond to security incidents effectively.

In the security world, threat detection and response alerting and notification are very important. OCI allows organizations to customize alert configurations based on their preferences and criteria. Notification preferences and thresholds can be adjusted and can be sent via email, SMS or other communication methods. OCI Cloud uses behavioral analytics and anomaly detection to identify patterns and network activity that indicate security threats. This method analyzes system logs, user activities, and network activity to detect behavioral changes, flag anomalies and raise alerts for quick incident identification and response.

OCI provides tools and technologies to investigate threats and analyze security compromises to understand root causes and impacts. This capability is supported by advanced search and query features, which help companies respond to incidents and breaches effectively. OCI Cloud also offers automated response and remediation features, these features enable organizations to identify and respond to incidents as they happen, using advanced technologies to isolate malicious files and block suspicious network activity and thereby mitigating potential risks or compromises in the system. Let us explain what **threat event** is. In OCI, a threat event refers to any occurrence that poses a potential risk to the security, integrity, or availability of cloud resources and services. The *National Institute of Standards and Technology* defines a threat event as an event or situation that has the potential for causing undesirable consequences or impact. By recognizing and managing threat events, organizations can enhance their security posture, minimize risks, and protect their OCI resources effectively. These events can indicate malicious actions, system vulnerabilities, or unauthorized access attempts. In summary, threat events in OCI encompass a wide range of activities that can compromise the security and integrity of cloud resources. By proactively identifying and managing these events through various OCI tools and services, organizations can enhance their security posture, safeguard sensitive data, and ensure compliance with regulatory requirements. Understanding threat events is essential for maintaining a secure and resilient cloud environment.

The screenshot shows the OCI Threat indicator database search interface. At the top, there's a navigation bar with 'Threat Intelligence' and 'Threat indicator database' selected. Below the navigation is a search section with a dropdown menu labeled 'Search for' containing 'Please select an option'. There are two filter dropdowns: 'Date last reported' set to 'Last 30 days' and 'Confidence score' set to 'Higher than 50'. Below these are 'Search' and 'Reset' buttons. A table below the filters has columns: Indicator, Type, Threat type, Overall confidence, First reported, and Last reported. A message at the bottom of the table says 'No items found.'

Figure 10.3: OCI Threat indicator database

Automated incident response

OCI offers automated incident response capabilities that enable organizations to respond to security incidents rapidly and effectively. Automated incident response, which is modern cybersecurity option, allowing organizations to detect, analyze and respond to the security incidents effectively.

OCI can work with **security orchestration, automation and response (SOAR)** platforms to automatically carry out pre-defined incident response processes. This includes actions like isolating affected systems, quarantining harmful files, and blocking suspicious network traffic. By automating these procedures, OCI helps organizations respond faster, minimize the impact of security incidents, and reduce risks.

Working of automated incident response

Automated incident response systems constantly monitor network traffic, system logs, and security events for signs of potential security events. When a security event is detected, the OCI system automatically sends an alert and starts the **incident response process (IR)**.

After detecting a security incident, automated systems analyze the event data to determine its severity and impact. The system then prioritizes the incident based on predefined criteria. By correlating multiple security events and using threat intelligence feeds, the system can assess the likelihood and

potential impact of the incident. These systems then execute predefined actions and response playbooks to mitigate the impact of security incidents.

Usually, actions include separating the compromised system component, such as blocking malicious network activity, separating suspicious files or revoking user access privileges. Automated systems orchestrate and automate response workflows and playbooks, ensuring consistent and efficient incident response. This can also be done by defining the custom workflows for detection, analysis, containment, eradication, and recovery, organizations can streamline their incident response and reduce manual intervention.

These systems integrate well with other security tools and technologies, such as **intrusion detection systems (IDS)**, **security information and event management (SIEM)** platforms, and endpoint protection solutions which are available widely in the OCI cloud. Using various security tools, organizations can help improve their ability to detect and respond to security threats effectively. Automated systems continuously learn from security incidents and feedback from security analysts to improve detection algorithms, response playbooks, and decision-making capabilities and analyzing the historical incident data and identifying patterns of malicious behavior, the system can refine its response strategies and adapt to evolving threats over time.

Benefits of automated incident response

Automated incident response helps companies detect and respond to security incidents in as they happen and helps to reduce the time to respond to the incidents in fast paced manner. This reduces the risk of cyberattacks by automating the most frequent tasks, such as event management, analysis, and remediation.

Security resources can focus on more important tasks that are important to organizations, while automated incident response ensures consistent and accurate response actions using the playbooks and workflows defined by the security team; it works as an automated bot that executes based on the set of workflows and instructions the security team has set. This minimizes the risk of human error and ensures best practices are always followed.

Automated incident response systems can process large volumes of security events and incidents, allowing companies to respond properly and standardize the incident response processes. This reduces operational costs associated with managing security incidents, improving security standards, reducing response times for the incidents, and mitigating risks.

Security orchestration and automation

OCI provides its customers advanced security options which are helpful for its customers to automate and improve the security process and organizational workflows. This is provided by OCI using the tools and frameworks which are useful for orchestrating security tasks and routine security operational work. OCI provides tools for integrating the security controls in the cloud infrastructure of the complete OCI cloud. This helps to create automations for policy enforcements, vulnerability management like scaling and meeting the compliance and auditing requirements, which helps to improve the operational health of organizations and reduce the workload, and improve the security state of the organizations.

Key components of security orchestration and automation

The following are the key components of security orchestration and automation:

- **Workflow orchestration:** Orchestration helps organizations to build workflows on the security process using various tools and technologies; it helps organizations to build standard operations processes for security management such as incident response, threat detection, and vulnerability management since this is workflow-driven; this process is consistent and follows the orchestration defined.
- **Automation of repetitive tasks:** Automation mainly focuses on the reducing the human interaction and workload reduction, automating regular time-consuming tasks in the security domain helps the security experts to save the time in log analysis, training the issues. Automation also can help in reducing the response time to incidents which can save time consuming and error prone when humans are involved.

- **Integration with security tools:** In security world, many different tools and technologies are used for threat detection and response. Integration with security tools is key for **intrusion detection and response (IDR)**. Security orchestration and automation platforms integrate with different tools in the market. Integrating with large set of tools in the organizations helps to detect and respond to incidents in faster and efficient manner.
- **Incident response automation:** Incident response is key in the security realm, which is time-critical and essential for protecting the critical organization's resources and data. Security orchestration and automation help organizations to setup automatic response to analysis, detection and response using the workflows and playbooks which help to handle the incidents effectively.
- **Threat hunting and investigation:** Threat investigation is critical to analyze and identify the potential threats, security orchestration and automation help analysis with automation of the log analysis, data pattern analysis and collection and other logs and events from other security tools and provide information for effective investigation of threats.
- **Compliance and policy enforcement:** Implementing compliance and enforcing security policies is critical for organizations security. Security orchestration and automation help organizations enforce security policies and regulatory compliance requirements by automating policy enforcement and audit processes; this can be done by integrating the compliance process and security controls across the organizations and applying them to all the systems with a standardized approach.

Benefits of security orchestration and automation

The following are the benefits of security orchestration and automation:

- **Improved efficiency:** The efficiency of organizations can be improved by removing manual dependencies, automating tasks and implementing workflows and orchestrating security operations.

Security orchestration and automation can help detect, analyze, and perform real-time remediation and respond quickly and effectively.

- **Enhanced scalability:** Security orchestration and automation platforms can handle large volume of events and, assess the threats and respond/remediate them without the need for human intervention and it can scale to handle any volumes which is key benefit with automation and tooling.
- **Reduced risk of human error:** Automation of repeated tasks helps to improve efficiency and reduce human error when processing large volumes requires continuous monitoring and response with accuracy; using the security orchestration and automation platforms helps scale and minimize human error.
- **Cost savings:** Efficiency and cost savings are important factors organizations and having cost optimizations helps organizations benefit most from the OCI Cloud. Using the security orchestration and automation platforms help automate and improve the efficiency with respond with low cost as most of the tasks are automated and requires minimal human intervention.

Security orchestration and automation platforms are essential part of the cybersecurity strategies which enable organizations to automate and improve the security operations, threat detection, investigations and auto remediation of the repetitive tasks. This allows organizations to implement standardization with compliance and security for improved security and minimizing the risk for the organization.

Continuous compliance monitoring

Meeting the security and compliance requirements is essential for the organizations; it is important function of the compliance organizations to ensure all the security best practices are implemented, meeting the local and international compliance requirements. Implementing the standard procedure and policies on security and implementing the continuous compliance monitoring to ensure the defined policies and procedures are in place to mitigate the security risks and meet the compliance requirements.

Key components of continuous compliance monitoring

The following are the key components of continuous compliance monitoring:

- **Automated checks:** Automated compliance checks help to ensure organizations meet all the regulatory and compliance requirements using the automated checks; this is a continuous process, and any deviation from the standard will be alerted; this helps organizations to set up the one-time compliance standards and maintain them with continued checks and alerting.
- **Real-time compliance monitoring reporting:** In audit compliance requires reporting of the security events to ensure all the compliance checks are meeting. Continuous compliance monitoring gives real-time visibility into an organization security. This makes it easy to monitor and provide reports for auditing in a real-time manner, which helps organizations to ensure the compliance checks are always maintained and monitored using real-time dashboards.
- **Integration with security controls for compliance:** Compliance monitoring should work seamlessly with security controls like IAM, data encryption, network segmentation and IDS. This integration ensures security policies are properly applied and enforced across the organization. OCI offers the integration which helps to achieve this.
- **Automated fixes and compliance enforcement:** Monitoring allows organizations to automate fixes and enforce security policies to address compliance gaps and vulnerabilities. Automated checks and remediations can apply patches, adjust configurations and help to implement security controls to reduce risks and maintain compliance.
- **Scalable, reliable and flexible:** Solutions should scale and adapt to changing IT environments. OCI security tools can handle changes in infrastructure, applications and compliance requirements, helping organizations stay compliant during growth, expansion, and technological changes.
- **Support and improvement:** For compliance tools supports ongoing improvement of security controls and processes. By analyzing

compliance data and performance metrics, organizations can identify areas for improvement, implement corrective actions and optimize their security posture over time.

Benefits of continuous compliance monitoring

The following are the benefits of continuous compliance monitoring:

- **Risks management:** Compliance checks and monitoring help organizations to identify and fix security risks proactively and reduce the chances of data breaches and compliance issues.
- **Better monitoring and security:** Security events monitoring and constantly improving the security controls, organizations can strengthen their defenses, fix vulnerabilities and become better at detecting and responding to threats.
- **Reporting compliance:** Compliance checks and monitoring provide proof that organizations are meeting the highest regulatory requirements and standards and improving the standards of audit compliance.
- **Operational efficiency:** Compliance checks automation and fixes, makes managing compliance easier, reduces manual work, and improves efficiency, which allows security teams to focus on high-priority issues and day-to-day priorities in the organizations.
- **Cost saving:** Monitoring compliance check automation helps to reduce the risks and manual efforts, and remediation helps organizations save money by reducing the cost of compliance management and minimizing the risk of fines, legal expenses, and penalties.

Oracle risk management and compliance

Risk and compliance management for cloud adoption incorporates a series of policies, procedures, and practices designed to identify, assess, and mitigate the risks linked to cloud-based technology solutions. This process includes recognizing the potential risks of adopting cloud services, establishing risk management frameworks, and implementing controls to reduce your

organization's risk exposure. Risk and compliance management involves ensuring that cloud-based technology solutions adhere to regulatory requirements as well as internal policies and standards. The responsibility for risk and compliance usually spans multiple roles that contribute to shaping processes during cloud adoption. Few of the roles are managed by *Cloud Governance Team, Cloud Security Team, Legal and Compliance Teams* and *Risk Management Team*.

Risk Management Cloud

In the modern, highly innovation business world, managing risks is crucial for organizations to handle uncertainties, protect their assets, and parallelly reach their goals. Oracle understands the importance of risk management in helping organizations find, assess and reduce risks in their operations. Oracle's Risk Management Cloud is a comprehensive platform that helps organizations effectively manage risk management and make informed decisions to improve their ability to handle risks in the organizations.

Identifying risks

Oracle's **Risk Management Cloud (RMCS)** provides organizations a central place to do thorough risk assessments across all business areas. RMCS also provides advanced analytics and automation. Organizations can identify, and rank risks based on their occurrence and criticality, which helps them to allocate resource.

Risks prevention

Oracle's Risk Management Cloud helps to assess risks but also helps organizations take preventive steps to reduce the chance and impact of potential risks. This can be achieved by integrating with Oracle's security and compliance solutions; organizations can choose to automate risk reduction processes and enforce security controls as preventive measures. Oracle's predictive analytics can help to anticipate and address emerging risks in the modern business landscape.

Compliance management

Managing compliance is challenging in the ever-changing regulatory world, keeping up with industry regulations and standards is critical for all organizations in the world with local and internal regulations. RMCS helps organizations to ensure compliance with various regulatory requirements like GDPR, HIPAA, SOX, and PCI-DSS is met by using the pre-built compliance frameworks, control libraries, and automated checks; Oracle makes it easier for organizations to meet regulations and demonstrate compliance.

Monitoring and reporting

RMCS provides continuous monitoring and reporting, which helps organizations to track changes in their risk environment in real-time using real-time monitoring and reporting. This is implemented by automated data collection and analysis, generating real-time reports and offering insights into risk scope for immediate decision-making in real-time. Custom reporting templates and dashboards are available for organizations to help organizations to reach based on the trends based on the unique requirements they have.

Flexible and scalable solution

RMCS is designed to meet with organizations of any size and industry. It is critical for RMCS to meet a single risk assessment for an organization or conducting enterprise-wide initiatives, Oracle offers scalable solutions to meet unique requirements for every customer across the industries. RMCS also provides integration with third-party risk management tools, ensuring organizations that they can build a comprehensive risk management program that helps to analyze their specific needs and goals.

Oracle Cloud Guard

Oracle Cloud Guard (OCG) is a cutting-edge security service offered by OCI that provides real-time threat detection, automated remediation, and continuous monitoring capabilities to protect customer cloud environments against security risks, threats, and vulnerabilities in the cloud world, which are considered high-risk deployments. As organizations across the world are leaning towards migrating their workloads to the cloud, ensuring the security

of their cloud infrastructure becomes paramount, and OCG emerges as a critical solution to address these challenges effectively in the cloud world.

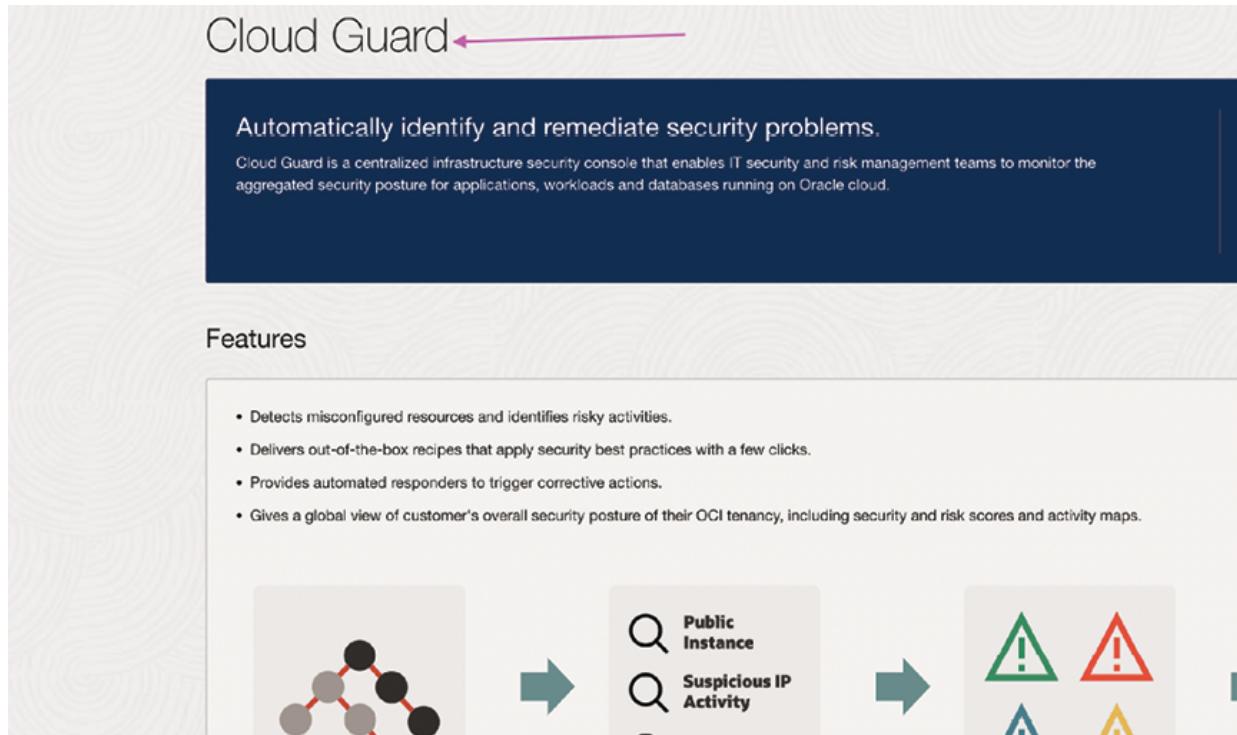


Figure 10.4: OCI Oracle Cloud Guard interface

Key features and benefits of Oracle Cloud Guard

The following are the key features and benefits of Oracle Cloud Guard:

- **Real time detection:** Oracle Cloud Guard monitors the entire OCI cloud environment, including compute systems, networking components, database and storage resources and other services. To detect security threats and vulnerabilities in real time. Using advanced artificial intelligence and machine learning technologies. Cloud Guard analyzes data, system logs, and user activity to identify indicators of compromise or suspicious behavior and reports them as needed.
- **Remediation automated:** One of the key features of OCG is its capability to automatically detect and respond to security issues without any security personnel involvement. To explain more about the process when a security threat is detected, Cloud Guard can start a set of defined actions to mitigate the risk and restore the security

posture of the environment. Response can be different based on the threat detections, it may include adjusting security configurations, applying patches and updates, or disabling or deleting compromised resources.

- **Monitoring:** OCG provides organizations with continuous monitoring capabilities that enable them to maintain visibility into their cloud environment and identify security risks and vulnerabilities as they occur. Using continuously monitoring systems for security threats and compliance violations, Cloud Guard helps organizations address security issues before they become major incidents and cause damage to organizations.
- **Security operations:** OCG offers a centralized operations platform for managing security operations across the entire OCI environment. Using a unified dashboard, companies can view security alerts, monitor compliance status, and track response and remediation activities as they occur. These centralized security operations helps to streamline incident response, improve collaboration between security teams across the organization, and enables companies to maintain a strong security standard.
- **Oracle security services integration:** OCG seamlessly integrates with other security services offered by OCI cloud, such as IAM, network security, and data security. Using these integrated security services, organizations can implement different layered security approach that can protect their cloud environment from multiple angles and ensures robust security coverage in all areas.

Remediating security threats with Cloud Guard

Cloud Guard is a top-of-the-line solution for organizations to handle security threats in their cloud systems. It provides automated fixes, which means it quickly and efficiently deals with security problems, reducing the harm from possible attacks. This method ensures that security concerns are handled promptly and effectively.

Remediation

Oracle Cloud Guard can automatically initiate predefined remediation actions when identified with security threats to mitigate the risk and restore the security posture of the environment.

These remediation actions may include:

- **Changing security configurations:** Cloud Guard can adjust security configurations, such as updating firewall rules or modifying access control policies, to address security vulnerabilities and prevent unauthorized access.
- **Applying patches and updates:** Cloud Guard can apply patches and updates to vulnerable systems and software components to eliminate known security vulnerabilities and reduce the risk of vulnerabilities.
- **Quarantining compromised resources:** Cloud Guard can identify and flag potentially compromised resources or systems from the rest of the environment to prevent further damage like privilege escalation and reduce the surface areas to contain the impact of the incident.

Threat detection

OCG continuously monitors the entire OCI environment, analyzing telemetry data, system logs, and user activity to detect security threats as they happen. Using artificial intelligence and ML tools, Cloud Guard identifies indicators of compromise and suspicious behavior, triggering alerts for potential security issues.

Enhancements

OGG continuously learns from security incidents and responses from users and other partners, which helps to improve its detection and remediation capabilities. Using historical data and identifying patterns of security incidents, Cloud Guard can improve its algorithms and heuristics to better detect the latest threats and prevent future incidents.

Customizable playbooks

OGG allows organizations to define customizable playbooks that specify set of actions to be taken in response to security events. These playbooks can be

defined as a set of instructions to meet the unique security requirements and compliance requirements of each organization, making sure that response actions align with their security policies and procedures.

Monitoring and control of user access

Managing user access and permissions is critical to ensuring the security of organizational data and infrastructure resources. OCI offers advanced IAM capabilities that help companies to manage users and access controls with robust monitoring and user access controls effectively to ensure the right set of access is provisioned for the right users.

Automated user access management in OCI

Automation of user lifecycle management for both cloud and on-premises environments is achieved by streamlining the process of determining which applications users can access and what roles or entitlements they should receive. Manage access to OCI resources, including networking, compute, and storage can be easily implemented by utilizing a flexible and easy-to-understand policy syntax. Let us understand how user automated access management in OCI can be accomplished as explained below:

- **Access control policies:** OCI enables organizations to define fine grained access controls, policies and permissions using Oracle IAM policies. This set of policies helps organizations to define and understand who can access which resources and under what conditions, allowing companies to set the lowest privilege principles and ensure that users have access only to the data and infrastructure they need to perform their job functions.
- **Role-based access control (RBAC):** OCI supports RBAC for user access and identity; RBAC is a modern and advanced security process that allows companies to define user roles with common sets of permissions and assign these roles to users or groups. Mapping users to roles based on their job functions, organizations can streamline access management and ensure consistency and compliance across the organization.

- **Centralized IAM:** OCI provides customers with a centralized platform for managing user identities, access policies, and permissions across their entire cloud infrastructure. Using the OCI Console or APIs, organizations can create and manage user accounts, groups, and roles, improve the process of creation and termination of the user access.
- **Automated IAM:** OCI has automation capabilities that help companies to automate the creation and termination of user access based on set off workflows and business rules. Oracle Cloud IAM policies, customers can automate the process of user creation, granting and revoking user access to data and resources, ensuring that access rights are grants with user roles and responsibilities.
- **Integration with identity providers:** OCI integrates seamlessly with IdPs such as **Oracle Identity Cloud Service (IDCS)**, **Active Directory (AD)**, and others IdP providers, enabling customers to use existing identity management systems in the organizations and extend their user access controls to the cloud without any change in the user experience or existing identity providers. Customers can centralize user authentication and authorization processes and enforce consistent access policies across hybrid environments.

Monitoring and auditing

OCI provides customers with monitoring and auditing capabilities that enable them to track user access and activity, detect unauthorized access attempts, and maintain visibility into their access controls. Using audit logs of Oracle cloud and monitoring tools, customers can monitor user access in real time and identify any changes in the behavior of users and systems to take assess and take actions to mitigate security risks.

OCI helps organizations to automate the monitoring and control of user access effectively, to ensure only authorized users have access to resources and data. Using identity management, implementing based on access controls, automating provisioning and de-provisioning workflows, and integrating with identity providers, OCI enables organizations to enhance security, standardize access management processes, and maintain compliance with regulatory requirements.

Continuously monitor user activity with AI

In the modern cloud computing world, where the threat landscape is completely different from traditional methods, it is essential to have a modern approach to deal with the threats and have tools and technologies which can help detect and respond as they happen to protect the organizations' resources. In order to protect the sensitive resources of the organizations, Oracle Cloud uses advanced tools and technologies which help to implement robust security policies by customers to protect the data. These tools are developed using artificial intelligence which monitors the user activity. Based on the patterns and use behaviors, they identify the security risk and raise alerts or respond to incidents to protect the resources.

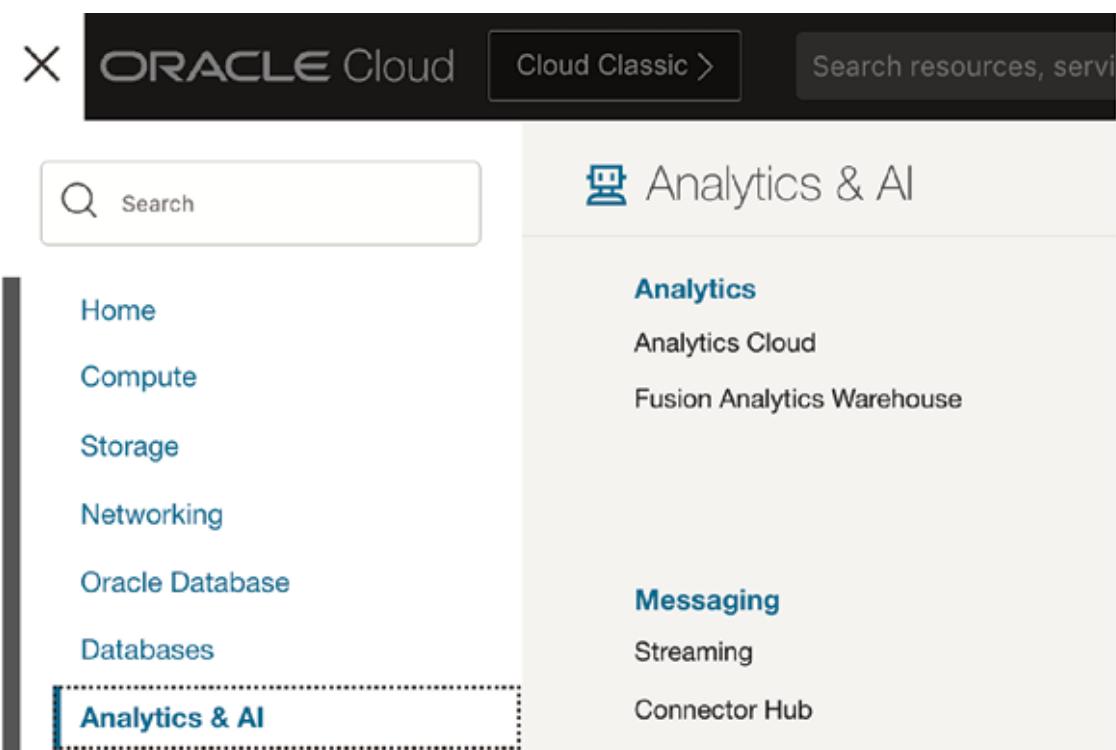


Figure 10.5: Screenshot OCI analytics and AI

OCI-AI integration to enhance user activity monitoring

OCI Generative AI is a fully managed service on Oracle Cloud Infrastructure that offers a suite of advanced, customizable **large language models (LLMs)** designed for various use cases, such as chat, text generation,

summarization, and the creation of text embeddings. Let us understand a few of the components of AI and its benefits below:

- **User behavior:** OCI uses advanced AI to study how users normally behave and establish what is typical for each user. By watching for unusual behavior, OCI can spot potential security threats like unauthorized access, suspicious data transfers or strange resource usage.
- **Context awareness:** OCI looks at user activity in the whole context of what was being done; OCI does this by considering factors like the user's role, location, access time, and the sensitivity of the accessed resources. This helps OCI to differentiate between normal actions and potential threats, reducing false alarms and improving threat detection accuracy.
- **Anomalies detection:** OCI employs machine learning to detect odd patterns in user activity, like unexpected spikes in login attempts or unusual file access. By analyzing user logs, activity and data, OCI can send alert to security teams of a possible security breach in real-time.
- **Automatic response:** OCI can automatically respond to security threats by carrying out predefined actions like revoking access, isolating compromised resources, or blocking suspicious network traffic. This automation helps organizations react quickly and reduce the impact of security breaches.
- **Risk ranking:** OCI assigns risk scores to user activities based on how serious and likely the threats are. By focusing on high-risk activities, OCI helps security teams concentrate on the most critical issues and manage risks better.
- **Improving:** OCI continuously learns from user data and security analyst feedback to improve its detection algorithms. By studying past data and identifying malicious patterns, OCI enhances its ability to detect new threats and adapt to changing attack methods over time.

Safeguarding API Gateways and network firewalls

Safeguarding API Gateways and network firewalls refers to the strategies and practices used to secure the API Gateways and network firewalls within OCI. This consists of a range of security measures designed to protect applications and data from unauthorized access, attacks, and vulnerabilities. Few of the key components for safeguarding are access control, data protection, monitor logging, regular audit and traffic management. Let us explain in the below sections the methods to safeguard API Gateways and network firewalls.

API Gateways

API Gateways serve as the entry point for interactions between clients and backend services, making them critical components in ensuring the security of organizations' digital ecosystems.

Figure 10.6 shows the interface to create API Gateways in OCI:

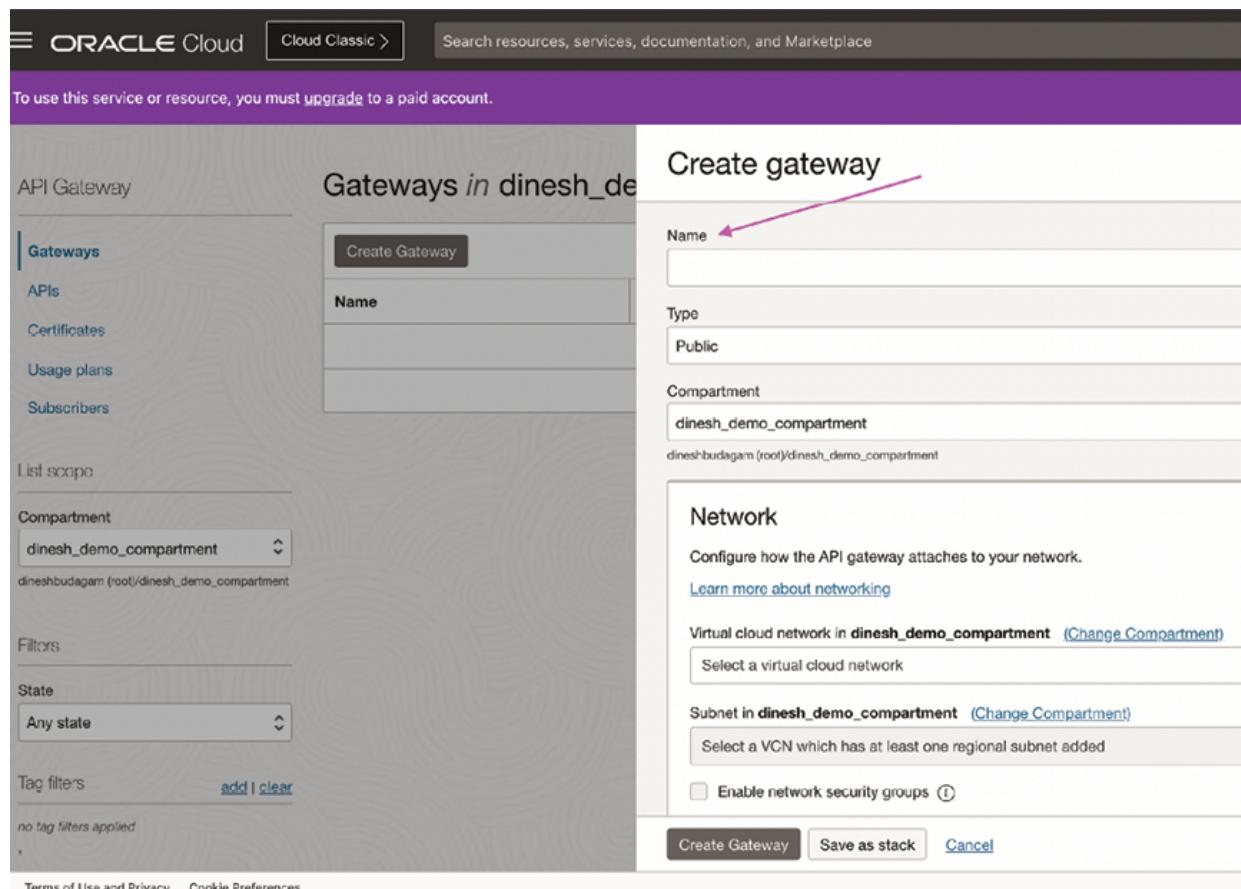


Figure 10.6: Screenshot OCI create gateways

Strategies for safeguarding API Gateways and network firewalls

The following are the strategies for safeguarding API Gateways:

- **API access controls:** Implement strong authentication and authorization mechanisms to control access to APIs. This can be achieved by using standard authentication protocols such as OAuth 2.0 or OpenID Connect to authenticate users and services and enable access controls based on user roles and permissions to ensure that only authorized entities can access sensitive resources. This helps to protect the API usage and controlling who can use and access the data.
- **Coding practices:** Ensure that APIs are developed using the highest standard of coding practices to mitigate common vulnerabilities such as injection attacks, broken authentication, and insecure direct object references. This can be achieved by adopting a security first approach when writing the code and conducting regular code reviews and security assessments using standard tooling to identify and remediate security gaps in API development and implementation.
- **Data encryption:** Data encryption is critical for security the data transmissions in transfer and storage. For transfer utilize **Transport Layer Security (TLS)** to encrypt data transmitted between clients and API Gateways to prevent attacks during the data transmissions attacks. Along with encryption in transit, encrypt sensitive data stored in API Gateways and backend database systems to protect against data breaches and unauthorized access to storage media where sensitive data is being stored.
- **API activity logging:** Implement robust logging and monitoring capabilities on the API layer to capture the API activity and detect any behavior indicative of security threats. Monitor API traffic for suspicious patterns, access such as unusually high request volumes, unexpected error rates, different payload or unauthorized access attempts, and generate alerts based on the log pattern to identify the potential threats and investigation.
- **Rate limiting and throttling:** Rate limiting on public API is critical for the availability of the service; implement rate limiting and other

mechanisms to mitigate the risk of API abuse and **denial-of-service (DoS)** attacks, which can be fatal for mission-critical services. Setup API Gateways to implement usage quotas, rate limits on the API, and concurrency limits to avoid excessive API requests from DDoS attacks from unknown actors.

- **Adding API Gateway Backends:** Let us explore how to integrate various types of backends into API Gateways using the API Gateway service. This can be achieved by following any of these approaches: Adding an HTTP or HTTPS URL as an API Gateway Backend, adding a function in OCI functions, Adding Stack responses as an API Gateway Backend, or Adding logout as an API Gateway Backend. Let us discuss at high level for each of these approaches.
- **Adding an HTTP or HTTPS URL as an API Gateway Backend:** It is common to need an API that connects to the HTTP or HTTPS URL of a back-end service, with an API Gateway offering frontend access to that back-end URL. After creating an API Gateway using the API Gateway service, you can set up an API deployment to access these HTTP or HTTPS URLs. Here are the steps to implement: create an API Gateway, Create an API deployment, define the route, and set authentication.
- **Adding a function in OCI functions as an API Gateway Backend:** In this approach, we can build an API using server-less functions as the backend, with an API Gateway offering front-end access to those functions. We can create server-less functions using OCI functions. These are built as Docker images and pushed to a specified Docker registry. Each function's definition is stored as metadata within the OCI Functions service. When a function is invoked for the first time, OCI Functions retrieves its Docker image from the designated Docker registry, runs it as a Docker container, and executes the function. For subsequent requests to the same function, OCI Functions routes them to the existing running container. If the container remains idle for a period, it is automatically stopped. After creating an API Gateway using the API Gateway service, you can set up an API deployment that triggers serverless functions defined in OCI Functions. Here are the steps to implement, create, and deploy functions in OCI functions,

create an API Gateway, create an API deployment, define the route, and set authentication.

- **Adding stack responses as an API Gateway Backend:** Using the API Gateway service, users can define a path to a stock response back end that always returns the same HTTP status code, HTTP header fields (name-value pairs) and content in the body of the response. Similarly, you can add stock response back ends to an API deployment specification by using the console or by editing a JSON file. Using stack responses as an API Gateway Backend enhances automation, security, scalability, and monitoring for managing OCI infrastructure resources. This method of using stack responses as an API Gateway Backend can be applied in scenarios such as production deployments, where you need a call to a specific path to always return a predefined HTTP status code in the response.
- **Adding logout as an API Gateway Backend:** A typical requirement for APIs is to allow clients to log out cleanly by revoking access tokens and potentially calling additional URLs for further post-logout tasks. The API Gateway facilitates this by enabling the definition of logout back ends, particularly when implementing an OAuth 2.0 token authentication policy for an API deployment. Requests made to the logout back end can optionally include a query parameter named **postLogoutUrl**, which specifies the URL to redirect to after logout. In nutshell, implementing a logout functionality through the API Gateway not only enhances security by revoking access tokens but also allows for the execution of additional post-logout tasks. By utilizing OAuth 2.0, it ensures a seamless integration of authentication policies, while the option for a **postLogoutUrl** provides a smooth transition for users after they log out. This approach ultimately leads to a more secure, user-friendly, and manageable API environment.

Network firewalls

Network firewalls act as the first line of protection in ensuring customers' networks are protected from unauthorized access and malicious activity. This is foremost to have a proper strategy and understanding of implementing the

network firewalls in cloud computing as all the resources are hosted or deployed behind the firewalls. *Figure 10.7* shows the interface to create network firewalls in OCI:

The screenshot shows the 'Create network firewall' interface in the OCI console. It includes the following fields:

- Name:** firewall-20241012-1025
- Create in compartment:** dinesh_demo_compartment (dineshbudagam /root/dinesh_demo_compartment)
- Network firewall policy in dinesh_demo_compartment:** (Change compartment)
- Select policy:** (dropdown menu)
- Enforcement point:** Select a VCN and subnet for network traffic routing.
- Virtual cloud network in dinesh_demo_compartment:** (Change compartment)
- Select a VCN:** Dinesh_Demo_VCN_LB
- Create network firewall** (button)
- Note:** Please note that after creating a firewall with an upgraded policy, you will not be able to use older policies in this firewall.

Figure 10.7: OCI—create network firewall interface

Strategies for safeguarding network firewalls effectively

The following are the strategies for safeguarding network firewalls effectively:

- Firewall configurations:** Firewall configuration acts as first level defense, configuring the network firewalls to implement strict access controls and filter inbound and outbound traffic based on set of security policies of organizations. Having right set of firewall rules to allow the required traffic to enter or exit the network boundaries and block unauthorized access attempts. This helps to detect, and block known bad actor IP addresses and domains.
- Intrusion detection:** The IDPS, also called IDR, is critical for every organization's data and resources protection. Implanting IDPS alongside network firewalls to monitor network traffic for signs of suspicious activity helps organizations identify and respond faster. It is also important to automatically detect and block malicious traffic

based on the detection and attacks. Setup IDPS to detect and prevent common network attacks, such as port scanning, malware propagation, and DDoS attacks.

- **Segment network traffic:** Segment network traffic into separate zones or subnets based on trust levels and security requirements based on the sensitivity of the systems deployed, i.e. High, Medium, and Low. Implement firewall rules to restrict communication between different network segments and enforce network separation policies to prevent movement within the network by attackers in the event of a security incident.
- **Update and patch:** Updating firmware and software to the latest versions is critical in addressing the known vulnerabilities. Always ensure network firewalls up to date with the latest security patches. It is good practice to review different vendor security advisories and apply patches regularly to minimize the risk of exploitation by cyber attackers.
- **Regular security audits:** Periodic security audits are best way to ensure all the best practices are implemented, define policies to conduct regular security audits and penetration tests to identify security vulnerabilities in network firewalls. Engage security experts, vendors to perform periodic security assessments and implement the effective controls and measures to prevent security attacks.

For better network security by implementing the above strategies, organizations can improve the security posture of their network firewalls, mitigate risks effectively, and protect their networks from cyber threats.

Conclusion

In the world of cloud computing, security domain a top priority for organizations is to protecting data and resources and maintain trust with customers and partners. OCI stands key cloud security provider who is known for security the resources by offering suite of advanced security operations, tools, and technologies developed to protect against advanced cyber security threats in the cloud world.

In this chapter, we have learned the key components of OCI's advanced security operations, including Oracle Risk Management and Compliance, Oracle Cloud Guard, automated remediation capabilities, automated monitoring and control of user access, and continuous monitoring of user activity with AI. These latest technologies and best practices help companies to improve their security standards, mitigate risks properly, and meet compliance with different regulatory requirements globally.

Using a centralized risk assessment platforms, which helps in monitoring the risks and proactive in risk mitigation, Oracle OCI helps organizations to protect their assets and maintain trust with customers and partners.

Oracle Cloud Guard revolutionizes the way organizations respond to security threats in their cloud environments by providing advanced threat detection, automated remediation, and continuous monitoring capabilities. Using Cloud Guard, companies can detect and respond to security incidents very fast and effectively, minimizing the impact of potential security breaches and maintaining a good security posture.

Automation tooling helps in mitigating security issues; organizations can minimize security risks by using automation, which can improve the operational standards, time taken to respond, and security personnel time in handling large volumes of events and incidents. Automation also reduces the human beings' errors and improves the overall security standards.

We have also learned the importance of cloud security in the modern world, where cloud systems have a lot of threats globally. This will only continue to grow as organizations focus on cloud migration, which helps them to take advantage of cloud cost minimization, scalability and flexibility, and time to market. This is driving customers heavily on cloud infrastructure and services. OCI, using advanced technologies such as AI and ML technologies, provides a very innovative modern approach to security; organizations can build a secure and resilient cloud environment that enables innovation, drives growth, and ensures business continuity.

OCI offers organizations the tools, technologies, and expertise required to manage and implement complex security policies for robust security. Using OCI's advanced security operations, organizations can protect their data, applications, and infrastructure against cyber threats, mitigate risks

effectively, and embrace the full potential of cloud computing with peace of mind.

Multiple choice questions

1. What is the primary goal of threat intelligence in OCI?

- a. To reduce data storage costs
- b. To enhance application performance
- c. To identify and mitigate potential security threats
- d. To improve user experience

2. How does threat detection contribute to OCI security?

- a. By encrypting data
- b. By monitoring and identifying suspicious activities
- c. By compressing network traffic
- d. By optimizing database queries

3. What is the benefit of automated incident response in OCI?

- a. Reducing manual intervention in handling security incidents
- b. Increasing data redundancy
- c. Enhancing data compression
- d. Simplifying user management

4. Which of the following best describes automated incident response?

- a. Automatically backing up data
- b. Automatically identifying and responding to security threats
- c. Automatically compressing data

- d. Automatically managing user accounts

5. What does security orchestration and automation aim to achieve?

- a. To streamline and automate security workflows and processes
- b. To improve application performance
- c. To enhance data encryption
- d. To reduce storage requirements

6. Why is security orchestration important for OCI security?

- a. It simplifies data compression.
- b. It enables coordinated response to security incidents.
- c. It increases network speed.
- d. It enhances data availability.

7. What is the purpose of continuous compliance monitoring in OCI?

- a. To ensure applications run faster
- b. To maintain adherence to regulatory and security standards
- c. To reduce the cost of cloud services
- d. To simplify user authentication

8. Which of the following is benefit of monitoring continuous compliance?

- a. Enhanced data compression
- b. Improved regulatory compliance
- c. Reduced data redundancy
- d. Increased storage capacity

9. What is the role of Oracle Risk Management and Compliance in OCI?

- a. To manage data storage
- b. To identify, assess, and mitigate risks
- c. To enhance network performance
- d. To simplify user management

10. How does Oracle Risk Management and Compliance help organizations?

- a. By reducing data size
- b. By increasing application speed
- c. By providing tools to manage and mitigate risks
- d. By optimizing database queries

11. What is the primary function of Risk Management Cloud?

- a. Data encryption
- b. Risk assessment and mitigation
- c. Network optimization
- d. User account management

12. Which of the following is a feature of Risk Management Cloud?

- a. Data compression
- b. Automated risk detection and reporting
- c. Application performance tuning
- d. Data redundancy management

13. What does Oracle Cloud Guard provide for OCI?

- a. Improved data storage

- b. Increased application speed
- c. Enhanced security posture management
- d. Simplified user authentication

14. Which capability is included in Oracle Cloud Guard?

- a. Data compression
- b. Continuous monitoring and remediation of security issues
- c. Network speed enhancement
- d. User account optimization

15. What is the benefit of automating the monitoring and control of user access?

- a. Reducing data redundancy
- b. Enhancing network speed
- c. Increasing data compression rates
- d. Ensuring that only authorized users have access to resources

16. How does automated user access control improve security?

- a. By optimizing application performance
- b. By providing real-time monitoring and control of user permissions
- c. By reducing storage costs
- d. By increasing data availability

17. Why is it important to safeguard API Gateways and network firewalls?

- a. To reduce data size
- b. To protect against unauthorized access and attacks

- c. To enhance data compression
- d. To increase network speed

18. Which strategy is effective for securing API Gateways?

- a. Data compression
- b. Reducing storage costs
- c. Increasing application performance
- d. Implementing strict access control and monitoring

Answers

- 1. c
- 2. b
- 3. a
- 4. b
- 5. a
- 6. b
- 7. b
- 8. b
- 9. b
- 10. c
- 11. b
- 12. b
- 13. c
- 14. b
- 15. d
- 16. b

17. b

18. d

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CHAPTER 11

Best Practices for OCI Security

Introduction

In this chapter, we will discuss the best practices for implementing **Oracle Cloud Infrastructure (OCI)**. We will learn the best practices to secure API Gateways, securing Bastion, Object Storage, securing OCI controller center, and firewall. In today's quickly changing digital landscape, organizations are increasingly turning to cloud solutions to drive innovation, scalability, and efficiency. In the last chapters, we discussed how OCI offers a comprehensive suite of cloud services which are designed to meet the demands of modern businesses, from startups to large enterprises.

Nevertheless, we examined the distinct challenges involved in migrating to the cloud and optimizing cloud environments. Without proper guidance and adherence to best practices, organizations may face problems like security vulnerabilities, performance slowdowns, and inefficient use of resources.

To resolve these challenges and maximize the benefits of OCI, it is essential to follow established best practices tailored to the platform. These best practices encompass a wide range of considerations, including security, performance optimization, cost management, and operational efficiency.

In this chapter, we will explore some of the key best practices for implementing OCI across various aspects of cloud deployment and management. By adhering to these guidelines, organizations can enhance

the reliability, security, and efficiency of their OCI environments while maximizing their return on investment.

Whether you are initiating a new OCI deployment or needing to optimize an existing environment, the insights provided in this guide will empower you to leverage OCI effectively and achieve your business objectives in the cloud. Let us explore the best practices that will help you unlock the full potential of OCI.

Structure

This chapter covers the following topics:

- Technical requirements
- Securing API Gateways
- Securing Bastion
- Securing object storage
- Securing OCI control center
- Securing firewalls
- Best recommendations and considerations

Objectives

The core objective of this chapter is to provide comprehensive and best practices for implementing OCI. By adhering to these goals and adopting customized best practices, organizations can efficiently utilize OCI to reach their business objectives, minimizing risks and optimizing the advantages of cloud computing.

This chapter offers practical guidance and best recommendations adhering to OCI standards for implementing each best practice, tailored to the unique requirements and use cases of organizations leveraging OCI. By the end of the chapter, readers will understand the concepts of securing API Gateways, Bastions, Object Storage and firewalls and emphasize the benefits of adhering to best practices in OCI, including enhanced reliability, scalability,

agility, and cost-effectiveness, as well as mitigating risks associated with cloud deployment.

Technical requirements

In order to actively participate and understand the contents of the chapter *Best Practices for OCI Security*, readers should be equipped with the understanding of computer systems, concepts in networking and basic knowledge in information technology.

In addition to the above technical requirements, readers are advised to have an understanding of the below specifications for technical needs:

- **Internet access:** To utilize online resources, references, and examples related to cloud computing, readers need a stable internet connection.
- **Computing device:** Additionally computing device such as a desktop computer, laptop equipped with a modern web browser is essential for reading the chapter content and accessing any online materials.
- **Web browser:** It is recommended to have the latest version of web browsers, which ensures compatibility and optimal and best viewing experience of web-based resources and interactive content. Here are a few web browsers recommended: *Google Chrome*, *Mozilla Firefox*, *Microsoft Edge*, or *Safari*.
- **Familiarity with basic security and cloud services:** Having knowledge with any of cloud services and their basic functionalities will enhance the understanding of the chapter.
- **Networking concepts:** Knowledge of fundamental networking concepts such as IP addressing, subnets, routing, and firewall principles.
- **OCI Identity and Access Management (IAM):** Familiarity with OCI IAM for managing users, groups, and policies to control access to OCI resources.
- **Logging and monitoring:** Familiarity with OCI logging and monitoring services to capture and analyze network activity and

security events. Understanding the data security, Security principles and security concepts and knowledge in compliance standards.

Securing API Gateways

There are different ways to secure API Gateways. In this section, let us define API Gateway and understand different ways to secure API Gateways in OCI.

An API Gateway functions as a vital part of the application delivery infrastructure, positioned between clients and services to offer centralized management of API communication. Additionally, it ensures security, enforces policies, and provides monitoring and visibility across on-premises, multi-cloud, and hybrid environments.

An API Gateway generally receives requests, particularly API calls, from a client and directs them to the respective backend applications or microservices. By securing and facilitating essential traffic between backend services and API consumers, it minimizes the likelihood of breaches, downtime, and slower performance.

API Gateways has benefits such as it authenticates the requesters who makes API calls by verifying if the requester is authorized to make the respective request, acts as router in routing the requests to relevant backends, applies rate limits to mitigate DDoS attacks and prevents overloading of systems and handles errors and improves SSL/TLS traffic to improve performance.

Now, let us understand the overview of API Gateway. The API Gateway service provides a platform to publish APIs, allowing to define private endpoints that can be accessed exclusively within network infrastructure. These private endpoints provide a highly secured way to manage and control access to APIs, ensuring that they are only available to authorized users or systems within your organization's internal network. In addition, if we need to make APIs accessible to external clients over the internet, the API Gateway service offers the flexibility to expose these endpoints with public IP addresses. By Implementing in this way, we can extend the reach of APIs beyond internal network boundaries, enabling clients from anywhere on the internet to interact with your services. Furthermore, the

API endpoints facilitated by the API Gateway service come equipped and inbuilt with a wide range of features to enhance functionality and security. These features include:

- **API validation:** The API Gateway validates incoming requests that follow a set of predetermined norms and patterns, thereby ensuring that data remains integral and unchanged.
- **Request and response transformation:** In this mechanism, the gateway changes the incoming request and outgoing response forms to adapt the different data formats, structure, or content to be compatible to both client and backend service's needs.
- **Cross-origin resource sharing (CORS):** This is specifically one of the major features in API.CORS support is a critical feature that allows you to determine which domains should be allowed access to your APIs helping in preventing unauthorized cross origin requests and aiding legitimate interactions across various domains.
- **Authentication and authorization:** We discussed different IAM policies in *Chapter 2, Mastering Identity and Access Management*. API Gateway can be trusted for user authentication and authorization before accessing protected APIs provided by it. In this respect, this kind of service helps enforce security policies for instance only authenticated users can access any information that comes out of it thus securing all sensitive information from unauthorized entities.
- **Request limiting:** By doing these configurations on API Gateway, users can restrict clients from making too many requests within a certain period. When implemented, this helps prevent misuse/abuses of your APIs, hence lowering risks of overloading backend systems, leading to fairness.

The purpose of this section is to provide a comprehensive solution for managing and protecting your APIs, whether they are going to be used within your network or exposed to external clients through the Internet. If appropriately leveraged, it will enable you to effectively regulate access rights, observe security protocols, and enhance the performance of API infrastructure. Now, let us explain how to secure API Gateways in OCI.

Securing API Gateways in OCI involves implementing various best practices and leveraging OCI's security features. This post extensively goes over securing API Gateways in OCI. We covered a few of the concepts in prior chapters:

- **Authentication and authorization:** Authentication and Authorization will allow you to control the system by managing IAM policies. You can use the appropriate IAM policies to decide who can or cannot access the API Gateway resources. Determine which end-users are allowed to call the API and which ones are only authorized to view deployed APIs using IAM policies.
- **SSL/TLS encryption:** Ensure the enabling and configuring the SSL/TSL encryption. This will make sure the data transmitted between clients and the API Gateway is always secured. OCI API Gateway facilitates SSL/TLS termination, allowing you to upload your SSL/TLS certificates to secure communications. Additionally, OCI allows the configuration of custom domains and TLS certificates.
- **Setting up custom domain and TLS certs with API Gateway:** Setting up custom domain and TLS certs is one of the approaches to secure API Gateway. This feature allows API development teams to select the certificate the gateway uses to secure traffic. This enables teams to make their APIs accessible through their own hostname and domain, rather than the default hostname generated during the gateway's creation. API Gateways created using the API Gateway service are secured with TLS certificates issued by a certificate authority. There are two ways of acquiring TLS certificates. This can be achieved by letting the API Gateway service acquire a default TLS certificate for you or obtain a custom one from a certificate authority. To assign a specific custom domain name to an API Gateway, you need to provide a custom TLS certificate rather than depending on the default certificate provided by the API Gateway service.

Note: Oracle recommends using custom TLS certificates for public or production systems. For Private or non-production systems such as Development and QA, Oracle recommends only using default TLS certificates obtained by the API Gateway service. For API Gateway limits, refer to the link as shared here:

<https://docs.oracle.com/en-us/iaas/Content/APIGateway/Reference/apigatewaylimits.htm>

- **Web application firewall (WAF):** It is important to consider the integration of OCI WAF with your API Gateway. Through this integration, SQL injection, **cross-site scripting (XSS)**, amongst other common web vulnerabilities can also be guarded against. Here we define WAF policies which inspect and filter incoming traffic into the API Gateway to give an extra layer of security against malicious attacks.
- **API key management:** Ensure API key authentication takes place for clients accessing your APIs. OCI API Gateway supports built-in API key authentication. By managing the API keys securely and rotating them periodically mitigate the risk of unauthorized access.
- **Rate limiting:** Rate limiting should be implemented to prevent misuse of APIs. Based on different criteria such as the number of requests per second, minute, or hour, OCI API Gateway permits you to define the rate limits. Rate limiting can be implemented by Configuring the defined rate limiting rules according to your use cases, business needs application's requirements and expected traffic patterns.
- **Logging and monitoring:** Enforce logging for API Gateway traffic to capture details such as request and response metadata, errors, and anomalies. Utilize OCI Logging service to centralize and analyze logs generated by the API Gateway for security monitoring and troubleshooting purposes. We covered detailed concepts of logging and monitoring in *Chapter 5, Database Fortification in OCI*.
- **Distributed denial of service (DDoS) protection:** Leverage OCI DDoS protection to safeguard your API Gateway against DDoS attacks. Configure DDoS protection policies to detect and mitigate volumetric attacks targeting your API endpoints.
- **Data protection:** Employ appropriate data protection measures to safeguard sensitive data transmitted through the API Gateway. Utilize

encryption mechanisms such as client-side encryption for protecting data at rest and in transit.

- **API Gateway policies:** Configure API Gateway policies to enforce additional security measures such as request/response transformation, content validation, and traffic routing rules. Implement security policies to sanitize input data, validate payloads, and enforce security headers. Incorporate CORS functionality into API deployments. Add **Mutual TLS (mTLS)** support to API deployments.
- **Regular security audits and reviews:** Conduct regular security audits and reviews of your API Gateway configuration, IAM policies, and access controls. Stay informed about the latest security best practices and updates from OCI and apply them to enhance the security posture of your API Gateway.

By following these best practices and leveraging OCI's security features, you can effectively secure your API Gateways in OCI.

Securing Bastion

In this section, we will discuss an overview of bastions and different ways to secure bastions.

OCI Bastion is a feature designed to enhance security by providing controlled and temporary access to specific resources within a network that do not have publicly accessible endpoints. This is particularly useful for instances or resources that are not directly reachable from the internet due to security reasons.

Authorized users are able to establish connections to these protected resources through the OCI Bastion using **Secure Shell (SSH)** sessions. Access is restricted to users from predefined IP addresses, adding an additional layer of security by limiting connections to trusted sources.

Once connected via SSH, users have the ability to interact with the target resource using any software or protocol supported by SSH. For instance, they can utilize **Remote Desktop Protocol (RDP)** to connect to Windows hosts or Oracle Net Services to establish connections to databases.

In summary, OCI Bastion acts as a secure gateway, allowing authorized users to securely access specific resources within the OCI environment, even if those resources do not have direct public endpoints, thereby mitigating potential security risks associated with open internet access.

Bastions play a crucial role in tenancies imposing stringent resource controls. For instance, you might utilize a bastion for accessing compute instances within compartments linked to a security zone, where instances lack public endpoints.

By integrating with OCI IAM, you achieve control over access to both bastions and sessions, determining which users can access them and specifying their permissible actions with these resources.

We need to have knowledge of security and compliance requirements to implement security in bastion. We discussed in *Chapter 1, Introduction to Oracle Cloud Infrastructure* responsibilities of Oracle and customers.

Oracle is responsible for physical security of OCI. Customers are responsible for network security, host security and access control.

Securing a bastion host in OCI involves implementing several best practices to ensure that only authorized users can access it and that the bastion itself is protected from potential threats. Here are some key steps to discuss in securing a bastion in OCI:

- **Network security:** Ensure the bastion host is placed within a private subnet, ideally within a **Virtual Cloud Network (VCN)** with strict security rules. Enforce security lists and network security groups to control inbound and outbound traffic to the bastion, allowing access only from trusted IP addresses. When setting up a bastion, best recommendation is to use a CIDR block allow list to define one or more IP address ranges in CIDR notation which are permitted to connect to sessions hosted by the bastion. Restricting the address range improves security.
- **SSH hardening:** Securely Configure SSH access to the bastion. Disable root login, enforce strong password policies and consider using SSH keys for authentication instead of using passwords. Regularly update SSH configurations and apply patches to mitigate known vulnerabilities.

- **Identity and access management (IAM):** Use OCI IAM to manage access to the bastion host. Assign respective IAM policies to control which users or groups have permission to access the bastion and limit their actions to only what is necessary. Implement IAM features like temporary credentials or session tokens to enforce time-limited access.
- **Multi-Factor Authentication (MFA):** Enforce MFA for accessing the bastion host. Require users to authenticate using multiple factors such as passwords and one-time codes generated by authenticator apps or hardware tokens, adding an extra layer of security.

Implement the concept of **Pluggable Authentication Modules (PAM)**. PAM feature is an authentication mechanism which allows users to configure how applications use authentication to verify the identity of a user. This approach allows users to integrate target Linux instances with IAM to perform end-user authentication with first and second factor authentication. In these cases, it will facilitate the end users to log in to a Linux server using SSH and user their IAM credentials to authenticate.

- **Monitoring and logging using Cloud Guard:** Logging and monitoring solutions need to be implemented to track activities on the bastion host. Enable OCI Audit logs to capture all management activities related to the bastion, including login attempts and configuration changes. Use OCI Monitoring and Alerts to set up notifications for suspicious activities. By enabling Cloud Guard in your tenancy, it allows to report any user activities which are potential security concerns. Cloud Guard suggests corrective recommended actions to be adopted once problems or security threats are detected. Cloud Guard can also be configured to automatically take certain actions. Cloud Guard can detect patterns of activity that indicate possible malicious attempts to gain access to resources in your environment and use them for corrupt purposes. One of the core functionalities which Cloud Guard provides is Processing problems. These involves steps like Prioritizing problems which are tagged with highest risks, evaluating details of problem, and resolving each of the

problem. Instance Security in Cloud Guard uses the OCI Logging service to record activity.

Note: Enable logging for the regions you want to monitor.

- **Regular updates and patching:** Keep the bastion host up to date with the latest security patches and software updates. Ensure regular checks for security advisories and apply patches promptly to mitigate potential vulnerabilities.
- **Backup and recovery:** Implement regular backups of the bastion host configuration and data. In the event of a security incident or failure, having backups ensures that you can quickly restore the bastion to a known secure state.
- **Security best practices:** Follow OCI security best practices and guidelines provided by *Oracle*. Stay informed about security threats and implement appropriate security measures to mitigate risks effectively.

By following these steps, you can enhance the security of your Bastion host in OCI and ensure that it serves as a secure gateway for accessing resources within your environment.

Securing object storage

In this section, we will discuss in detail the insight of object storage and how to make it secure. OCI provides a service known as object storage, which is a highly resilient, robust, and efficient platform for modern data storage requirements. It unconventionally delivers advanced storage capabilities while providing reliability and cost-effectiveness, thus making it an excellent choice for various storage needs. One of the major highlights of OCI's Object Storage is its exceptional data durability. It is built in such a way that your information can still be recovered even after many years have lapsed and even when there has been hardware failure or some other unexpected phenomena. This makes it important for business organizations that use vital and important information to operate because it minimizes the chances of data loss, thereby ensuring continuous access to critical data. Another good thing about OCI Object Storage is its scalability and

flexibility. The fact that Object Storage can handle any amount of unstructured data regardless of their content type distinguishes it from other forms of database management systems like RDBMSs. In any form, such as analytic big data, multimedia files like photos and videos, or others, OCI Object Storage will ensure that you get what you want by providing unlimited space.

Further, OCI Object Storage is integrated seamlessly with other OCI applications and services, thus giving in detailed and comprehensive storage mechanism for cloud infrastructure. This integration will enable you to deal with data easily for different purposes such as application development, data analysis or content delivery.

In a nutshell, OCI Object Storage is a robust storage platform that brings together high performance, reliability, and cost-effectiveness qualities. This feature makes it possible for companies to safely keep their data assets irrespective of its size or content type besides having the openness and adaptability necessary to adhere to shifting storage demands over time.

Let us now discuss how to secure the object storage in OCI. There are different ways to secure Object Storage in OCI to achieve confidentiality, integrity, and availability of the stored data. Here are several methods to secure Object Storage in OCI:

- **Access control policies:** Define granular access control policies using IAM. The granular access control regulates who can access Object Storage resources and what actions they can perform.
- **Authentication:** Use IAM authentication mechanisms such as user credentials, API keys, and or instance principals to authenticate access to Object Storage resources.
- **Encryption:** We have different encryption methods in general. Encrypt data at rest using Oracle-managed keys or customer-managed keys **Bring Your Own Key (BYOK)** to protect against unauthorized access to stored data.
- **Network security:** Leverage VCNs and security lists (ACLs) to control network traffic to and from Object Storage. Additionally, you can use service gateway or private endpoints to restrict access to

specific networks or compartments. The transmission of data between customer clients such as SDKs and CLIs and Object Storage public endpoints is encrypted using TLS 1.2 as the default security protocol. We can establish secure access to Object Storage for on-premises systems through the private network. Public Internet dependency can be removed. This process can be achieved by Fast Connect Public Peering.

- **Access control lists (ACLs):** In this use case, we can implement ACLs at the bucket level. This will specify who can access the data within the bucket and what level of access and permissions the users will have, such as read, write, and delete.
- **Object versioning:** Accidental deletion or modification of objects can be prevented by ensuring the enabling of object versioning. In this case, the previous versions of objects are retained. To achieve the minimization of the risk of loss in data resulting from accidental or malicious deletions by authorized users, OCI strongly recommends having an approach such as implementing object versioning to automatically create a new version of an object when a new object is uploaded, an existing one is overwritten or an old one is deleted. OCI recommends having regular backups of Object Storage. Implement the concept of **write once, read many (WORM)**. This compliance requires that objects cannot be deleted or modified. Use retention rules to achieve WORM compliance.
- **Audit logging:** Enable logging to OCI Audit service to monitor and track access to Object Storage resources. Logging includes metrics such as successful and failed access attempts. This will help users to identify, detect, respond, and prevent security incidents to occur.
- **Data management policies:** Implementing data lifecycle management policies to automatically move and delete objects based on pre-defined criteria. This implementation significantly reduces the risk of any unauthorized access to obsolete data.
- **Integration with Oracle Cloud Guard:** Integrate Oracle Object Storage with Oracle Cloud Guard in order to achieve the continuous

monitoring of security threats, and compliance violations for proactive detection and remediation purposes.

- **Third-party security tools:** Configure the third-party security tools for vulnerability checking. Third-party security tools integrated in OCI are used for enhancing its posture in issues related to vulnerability checkers, intrusion tracing systems, as well as data leaking prevention solutions.

Organizations should proactively implement the above discussed security measures. This implementation will effectively safeguard the data stored in Object Storage. By employing these security measures, organizations can effectively protect their data stored in Object Storage.

Securing OCI Control Center

OCI Control Center (OCC) allows users to oversee cloud consumption at the region level and access capacity data for specific regions where OCC functionality is accessible. Utilize OCC to verify resource availability and manage capacity requests effectively.

OCC has two features below: Metrics monitoring and capacity requests. Let us explore these key concepts in OCI:

- **Metrics monitoring:** OCC facilitates the monitoring of cloud consumption and capacity at the region level. Users can export this data for more in-depth analysis and reporting purposes. Additionally, metrics can be retrieved programmatically as JSON data via API, offering flexibility in data retrieval and processing.
- **Capacity management:** Within OCI, users can request additional physical resources through OCC. This capability allows users to manage capacity efficiently. Key tasks related to capacity management, such as listing and exporting the latest versions of availability catalogs, creating new capacity requests, and tracking the lifecycle of these requests, can be performed seamlessly through both the OCI Console and SDKs/CLI. This integrated approach streamlines the process of acquiring and managing resources,

enhancing the overall efficiency of resource utilization within OCI environments.

OCC console can be accessed through supported browsers like *Google Chrome* 69 or later (preferred browser), *Firefox* 62 or later, or *Safari* 12.1 or later. OCC can also be accessed using OCI CLI or REST API's by setting up the environment or using OCI Cloud Shell.

Securing OCC involves implementing various measures to safeguard the platform, its data, and access. All the security implementations discussed in the above sections are valid and are good for securing the OCI control center. Here are several steps to secure OCI Control Center:

1. **Identity and access management (IAM):** In addition to IAM policies discussed, implement **multi-factor authentication (MFA)** for user accounts accessing OCC to add an extra layer of security.
2. **Network security:** Configure network security groups or security lists to restrict access to OCC endpoints to only necessary IP addresses or CIDR blocks and utilize private endpoints or VPN connections to access OCC securely over private networks instead of the public internet.
3. **Data encryption:** In addition to enabling encryption for data in transit by using TLS/SSL protocols to encrypt communication between client applications and OCC endpoints, implementing encryption for data at rest by leveraging OCI KMS to manage encryption keys and encrypting sensitive data stored within OCC is highly recommended.

Securing firewalls

In this section, we will discuss the concept of firewall and different ways to secure the firewalls in OCI. A firewall is a specialized network security tool or software application designed to manage and regulate both incoming and outgoing network traffic according to defined security protocols. In nutshell, it serves as a protective shield separating internal private networks from external entities, such as the broader internet. Moreover, functioning as a cybersecurity measure, a firewall effectively screens network data,

shielding users by preventing malicious software from reaching the internet via compromised devices.

OCI Network Firewall on other hand is a cloud-native, managed firewall service that incorporates machine learning-powered firewall capabilities to safeguard your OCI workloads. It provides ease of consumption and leverages Palo Alto Networks' **next-generation firewall technology (NGFW)**.

As an OCI native firewall-as-a-service solution, OCI Network Firewall enables users to benefit from firewall functionalities without the need for configuring and managing additional security infrastructure. The Network Firewall instance is highly scalable and comes with built-in high availability. Users can deploy it within a VCN and subnet of their preference. This firewall inspects each and every request passing through it, including TLS encrypted traffic, and enforces actions such as allow, reject, drop, intrusion detection, or prevention based on user-configured firewall policy rules. These concepts are covered in detail in *Chapter 3, Navigating Network Security in OCI*.

For securing the firewalls, we need to follow all the methods discussed in the sections for (Securing Bastion, API Gateways, Object Storage and OCI Control Center). In addition, below are a few such as the concept of network security groups, use of network security services, creation and use of security zones, use of the Vault service for the management and rotation of secret credentials utilized in conjunction with the Network Firewall. A vault serves as a secure repository that houses encryption keys and confidential information known as secrets, which are pivotal in safeguarding data and establishing secure connections to protected resources. Secrets within a vault are encrypted using master encryption keys, thereby ensuring that sensitive credentials such as passwords, certificates, SSH keys, or authentication tokens remain protected from any kind of unauthorized access.

To effectively use the secrets, it is essential to first establish a vault and, if necessary, create a master encryption key if one does not already exist. This basic and foundational setup provides the framework for securely managing and accessing sensitive information within the vault, thereby facilitating enhanced security measures across your infrastructure and applications.

Every secret is automatically provisioned with a secret version. When you initiate a rotation of a secret, you generate a fresh secret version by having new secret contents in the Vault service. Regularly rotating secret contents mitigates the consequences in the event of a secret exposure.

In addition to Vault, we can have Audit, logging and IAM policies enforced to secure the Network Firewall.

Best recommendations and considerations

In this section, we will discuss some of the best practices and guide you with recommendations, advice, or suggestions to help you design, architect, and build network infrastructure in OCI:

- Ensure that you allocate sufficient time and resources at the outset of your project plan to execute a thorough OCI Network Design. Make sure your OCI Network Design incorporates the layout topology, has proper sizing of the VCNs and Subnets, has domain name Service, and any external network connectivity to on-premises. In summary, it is always advisable and recommended as a best practice to perform your proper OCI network design at an early stage properly sizing the VCNs and subnets appropriately during your design will not only assist you to accommodate the needs for future growth and expansion, but it also streamlines your IP allocation by using utilizing connected and condensable IP addressing space.
- Incorporate DNS into your initial network design and engage with your DNS administrators from the outset.
- For the majority of OCI deployments, Oracle recommends adhering to best practices by implementing a **multi-Virtual Cloud Network (VCN) design** within a **hub-and-spoke topology**, utilizing the **Dynamic Routing Gateway (DRG)** for connectivity. This has benefits such as isolation and segmentation of different environments.
- Using the default options such as OCI provided default route table and a security list when provisioning subnets is ideal for a basic deployment or to get you started but not an advisable approach for designing production codes that includes various subnets.

Maintaining dedicated VCN route tables and security lists for each subnet enables precise control over routing and security settings for individual subnets, avoiding the need for shared resources.

- Prior to creation of VCN, assess the necessary number and size of CIDR blocks based on the anticipated deployment of resources and subnets within the VCN.
- While planning your subnets, take into account or consider your traffic patterns and security needs. As discussed, always assign all resources belonging to allocate a particular tier or role to the same subnet.
- After creating each subnet, enable VCN flow logs and consider establishing a distinct log group specifically for VCN flow logs. Ensure that VCN flow logs are integrated as an important component within the broader architecture and design of your OCI Logging strategy.
- Oracle recommends using NSGs and gives precedence to it over security lists for implementing any kind of enhancements needed in future and also suggests adopting NSGs for components that all have the identical security posture.
- This can be achieved by creating NSGs for specific groups of resources that share the similar and identical traffic flow requirements such as NSG for each tier of an application.
- Adopt a whitelist strategy for both security list and NSG rules, permitting only the necessary protocols, sources and ports required by application or workload.
- It is recommended to use OCI Bastion Service compared to configuring Bastion Host in Public Subnet.
- Establish policies to restrict access to specific individual network resources by enforcing IAM policies. Detailed IAM policies are discussed in [*Chapter 2, Mastering Identity and Access Management*](#).
- Implement the hub-and-spoke VCN design, placing the firewall(s) within a hub VCN and leveraging the DRG to direct traffic through

the firewalls. A hub-and-spoke network, usually referred to as a star network which has a centralized component that is connected to multiple different networks around it. Setting up this kind of topology in the traditional on-premises data center is very expensive but can be easily implemented in the cloud with minimal or no extra expenses. The DRG, on other hand, is a virtual router which provides a route for private network traffic between a VCN and a network outside the region including a VCN in another OCI region, an on-premises network, or a network from another cloud provider.

- Secure the load balancers by enabling end-to-end TLS connections between a client's applications and a customer's virtual cloud network by using load balancers. Define IAM policies to restrict load balancer management permissions to a minimal subset of users and groups.
- Leverage the maximum security. Zones service which helps you minimize the risk of inappropriately low security policies and secure DNS zones and records by defining the IAM policies to restrict the users authorized to make changes to DNS zones and record.
- Enhance the availability of applications on OCI by incorporating redundant compute nodes across various availability domains. This ensures failover capability and optimally utilizes fault domains. This is one of the best recommendations to achieve system resilience and hence high availability. It is also recommended to have all VM instances in the indicated compartment to be clustered in a single fault domain. This will improve the availability of your VMs across all fault domains. This approach is also referred to as fault tolerance.
- Enabling **Object Versioning** is one of the recommendations as it provides protection of data against accidental or malicious object updating, overwriting, or deletion. This needs to be enabled at Bucket level.
- Similar to Object Versioning. It is advisable to enable **Object Replication**. This will provide protection from regional outages and helps in disaster recovery efforts and addresses compliance requirements. In this mechanism of Object Versioning, we usually

maintain multiple copies of data in regional locations closer to user access. This will also reduce latency.

Conclusion

In conclusion, this chapter has provided a comprehensive and in detail exploration of best practices and recommendations for securing API Gateways, Bastion, Object Storage and firewalls within OCI. We begin on a journey from foundational principles to sophisticated strategies, aiming to empower readers with a deep understanding of the intricacies involved in securing their network environments.

We delved into advanced securing network and services methodologies, various access control mechanisms, and cutting-edge network design principles. The best practices and recommendations suggested throughout this chapter are instrumental in elevating the security posture of your OCI network infrastructure to a more advanced and resilient state. By understanding the advanced practices covered in this chapter, readers are well-prepared to implement robust defenses against emerging threats, ensuring the continued integrity and availability of their network resources in the dynamic landscape of OCI.

As organizations continue to innovate and transform their businesses in the cloud, adherence to best practices in OCI will be very important and critical. By following the guidance provided in this chapter and continually evolving their approach to cloud deployment and management, organizations can position themselves for success in today's digital economy.

In summary, the implementation of best practices in OCI enables the organizations to achieve their business objectives with confidence, driving innovation, scalability, and efficiency in the cloud.

By adhering to these best practices, organizations can achieve several key benefits such as enhanced security, improved performance operational excellence, cost efficiency and scalability and flexibility.

Multiple choice questions

1. In the below choices, select the option which is a challenge in cloud security.

- a. disaster recovery is not implemented.
- b. Data is not encrypted sufficiently.
- c. cloud costs are too expensive.
- d. Inadequate scalability in implementing cloud solutions.

2. How are external threats protected by implementing network security in cloud computing?

- a. Implementing encryption methodologies
- b. By providing the IAM controlling access to cloud resources
- c. Monitor and filter network traffic both inflow and outflow
- d. update regularly the patching in cloud software

3. Mention the component in cloud security that involves defining who can access specific cloud resources and what actions they can perform?

- a. Network security controls
- b. Data Guard
- c. Identity and access management
- d. Security monitoring and logging

Answers

- 1. b
- 2. c
- 3. c

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