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**SAP on Microsoft Azure**

**Cloud Adoption Framework Enablement Kit**

**Deployment Guide**

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**Version history**

|  |  |  |
| --- | --- | --- |
| Version | Changes | Date |
| 0.1 | Initial Release | June 2020 |

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We look forward to your feedback!

Thank you for your continued trust and partnership. The resources within this toolkit will be iteratively improved upon based on product releases as well as direct feedback from delivered engagements. We encourage you to provide feedback to help us improve our products and toolkits. Please use the feedback process available through following web site: <http://aka.ms/cafenablementkit>

# Introduction

The Microsoft Cloud Adoption Framework for Azure is proven guidance that is designed to help you create and implement the business and technology strategies necessary for your organization to succeed in the cloud. It provides best practices, documentation, and tools that cloud architects, IT professionals, and business decision makers need to successfully achieve short-term and long-term objectives.

## Document Purpose

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Description automatically generatedThis document is to provide partners and customers guidance to deploy and manage SAP in Azure in alignment with the Microsoft Cloud Adoption Framework for Azure (CAF). The considerations, decisions, and actions documented herein are broken into the six major CAF stages.

The goal of this document is to guide partners and customers though the CAF stages by identifying the most common considerations and decisions required to deploy SAP on Azure.

## Target Audience

This document is primarily intended for the following audiences:

* Azure and SAP Partners
* IT Infrastructure Managers
* Technical Directors, Managers, and Architects
* Decision Makers, Business Owners, and Directors

# Plan Phase

## Cloud Adoption Plan (SAP Implementation in Azure)

Partners and customers can choose the option of Mixed or Only Azure systems to be implemented. This can include the options of Non-Production systems on-premise and Production systems to Cloud or vice versa.

### Greenfield Implementation

Greenfield Implementation means to start a fresh deployment of SAP environment in Azure whether you have existing SAP workloads in on-premises. This is a new implementation of SAP (greenfield) for customers/partners who are migrating from a non-SAP legacy system or from an SAP ERP system and implementing a fresh system that requires an initial data load will be discussed in this scenario. Below are the two methods of most used in Cloud adoption plan.

* SAP On-Premise and Cloud Combination
  + Non-Production On-Premise
  + Production on Azure
* Azure Cloud Implementation
  + A screenshot of a cell phone

    Description automatically generatedNon-Production and Production are on Azure Cloud

### Brownfield Implementation

Brownfield implementation means you have existing SAP workloads and you would like to migrate from on-premises to Azure. In Brownfield migrations there are four main categories listed as below.

#### Homogeneous Migration

A Homogeneous migration is the easiest migration method to execute, as the operating system, database and hardware platform remain the same and no data conversion is required. To accomplish this, the simplest form of migration is a backup and restore method or DBMS replication to live replicate the database into Azure. For more information, [please refer Homogeneous Migration.](https://help.sap.com/viewer/6ffd9a3438944dc39dfe288d758a2ed5/CURRENT_VERSION/en-US/f1677053e4960150e10000000a44176d.html)

* **Lift and Shift to Cloud (Rehost):** In Lift and Shift, when the current operating system (OS) and Database Management System (DBMS) which are being used on-premises can be migrated to Azure without the need to change either. For more information, please refer [Rehost](https://docs.microsoft.com/en-us/azure/cloud-adoption-framework/migrate/azure-best-practices/contoso-migration-overview)
* **Migration Using Backup/Restore:** In homogenous migration method, we can use backup/restore method as a simplest method of migration. If the operating system and Database Management System are already running on an x86-based hardware platform, using either Intel or AMD x86 processors, then we can take a full database backup and restore it on the target virtual machine.
* **Migration using DBMS Replication:** In this method the database files can be shipped ahead of the time and enable DBMS replication between source and target environments. The records which are created or updated since the backup was taken, it will be transmitted and applied to the cloud using database-specific replication technologies. Example, SQL Server Always on Availability Groups or SAP HANA System Replication tool.
* **Migration using Azure Migrate:** Azure Migrate can assess and replicate the virtual machine or physical server to azure cloud. It is supported for VMware, Hyper-V Virtual Machines, Physical Servers. In this method, all the data and configurations of the operating system will be transferred to the cloud as-is.

#### Heterogenous Migration

Heterogenous Migration means, whenever there is a change to the operating system or DBMS software or hardware platform then the migration becomes heterogenous. In heterogenous migration, there are several types of methods which we can use for migration.

* Export/Import
* Database Migration Option (DMO) with System Move Option
* Near-Zero Downtime Migration with DMO
* Third Party Options
  + IBM DB2
  + Oracle Database

In **Export and Import** Migration below are the 3 Main phases:

**The three (3) phases of the System Export:**

* Generate the Data definition language (DDL) statements for non-standard database objects

Before migration, non-standard database objects should be scripted to SQL using the SMIGR\_CREATE\_DDL object

* Generate the structure files and compute the size of the database

Software Provisioning Manager is used to perform size calculation for tables and indexes. The output is written to the DBSIZE.XML file which can be run in advance of migration.

* Extract data to dump files

The data from the database is extracted to the filesystem which is based on provided configuration.

**The three (3) phases to the System Import:**

* Install Database software and create database

On first import step, it requires to install the DBMS software and provide connection details.

* Import data from the dump files

Data from the files is read and imported to the target database.

* Post-import checks

Software Provisioning Manager runs an additional check and the start the instance. This step will be performed after import.

**Lift and Migrate to Cloud (Re-Platforming)**

In Lift and Migrate method, if the current operating system and Database management system (DBMS) is not supported in Azure, then the migration becomes a heterogenous also known as replat forming. This is most used when the current operating system is not supported in Azure. In this method, we must change the operating system version as well as Database Management System (DBMS)

**Lift and Shift /Migrate to Cloud, Migrate part to HANA**

* Database Migration Option (DMO) with System Move Option

Now SAP has introduced the DMO option the Software Update Manager (SUM). Below are steps which includes in this migration.

* + System Upgrade
  + Unicode Conversion if required
  + Database Migration + Cloud Migration

DMO Performs an in-place migration to SAP HANA, which means that no switch of application server is possible, and cross data center migration is not supported. But SAP allow to use DMO for data center migration when it is used together with System Move Option.

DMO Can be performed with any source database and almost any target database. As of now when we use DMO with system move option, only SAP HANA or SAP ASE is supported as the target database.

**Note:** *DMO with System Move cannot be used for migration when the source system is already running on SAP HANA*

* **Near-Zero Downtime Migration with DMO:** Use Near-Zero Downtime Migration (nZDT) if you require the shortest possible business downtime. In this process selected large tables are transferred during the uptime phase. The SAP LT replication server is used to create database triggers and replicate the data to the target HANA database.

Also, nZDT can combine multiple activities such as database migration, system upgrade and Unicode conversion.

**Third Party Options**

If no options from above allow you to migrate SAP to Azure, then there are some additional third-party options that you can consider using. For more information contact relevant vendors.

IBM DB2 - Based on IBM, IBM Infosphere Changing Data Capture can be used to perform SAP heterogenous, migrating DB2 database between different operating system

**Oracle Database:** There are two solutions for migrating databases between different operating systems, which has developed by Oracle.

* + Oracle to Oracle - O2O

O2O solution require the database to be shut down for the duration of the migration.

* + Oracle to Oracle Online - Triple O

Triple O requires only very minimal downtime. It uses Oracle Golden Gate software for online Database Synchronization.

#### Vertical Migration Strategy

In Vertical Migration Strategy, it moves all the environments of SAP application at one time to Azure. This avoids any issues of compatibility between the development, A/Test and Production environments.

#### Classical Migration

In Classical Migration, all data stored in the database is exported to Flat files which can be copied further to target virtual machine in azure and re-create the database instance.

**Note:** SAP-Specific format is not bound to any particular database, it is possible to import the data even if the target platform runs on a different platform different database, different operating system, different hardware architecture.

### HANA Conversions

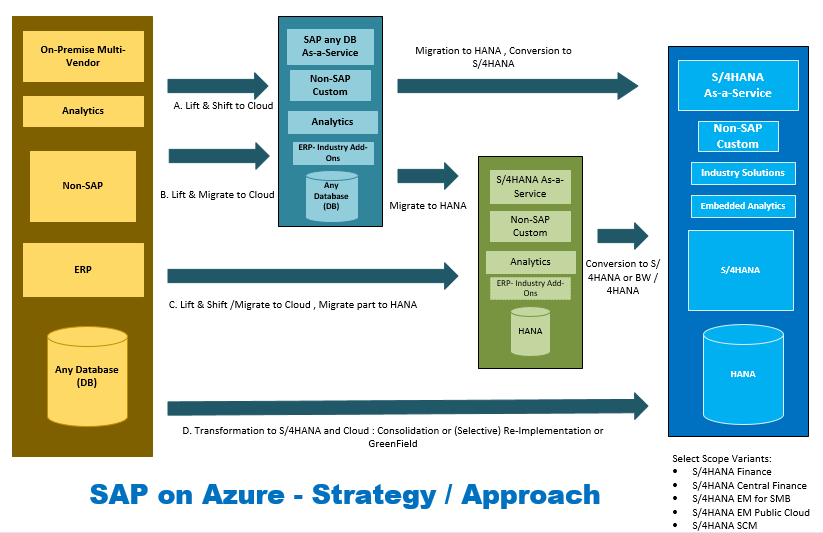
You have an existing ERP/SAP Business Suite system, and you want to leverage your previous investment in  
the business processes that you already have implemented your SAP. You want to bring them to the new world of SAP S/4HANA, B/4HANA and C/4HANA. Then HANA system conversion is perfect option for you. For more details [HANA Conversion](https://docs.microsoft.com/en-us/azure/virtual-machines/workloads/sap/hana-large-instance-virtual-machine-migration)

* For more information, please refer S4 HANA (**S4 HANA**)
* For more information, please refer B4 HANA Conversions ([**B4 HANA**](https://help.sap.com/doc/5560e71eb63b49ca9b6ec17fa5819690/1.0/en-US/SAP_BW4HANA_10_Conversion_Task_Lists.pdf))
* For more information, please refer C4 HANA Conversions ([**C4 HANA**](https://help.sap.com/viewer/product/SAP_C4HANA/Current/en-US?task=discover_task))

**Restrictions**

* The transition to SAP S/4HANA does not require the source system to be already on SAP HANA
* SAP S/4HANA Finance is the first offering under the SAP S/4HANA product family. The decision to go for SAP S/4HANA Finance oP should be based on the business benefits, but is not a mandatory prerequisite for any system conversion
* For older SAP Business Suite releases or systems on Non-Unicode an additional step to SAP ERP 6.0 EHP4 is required.
* System has to be an AS ABAP-only system. Dual-stack systems (AS ABAP and AS Java combined in one system) are not supported for the conversion. If your system is as dual-stack system, you have to split it before doing the conversion.

### Choosing the best Deployment Scenario

The following exercises will help establish the iterative processes to assess, migrate, optimize, secure, and manage those SAP workloads. Any enterprise-scale cloud adoption plan will include workloads that do not warrant significant investments in the creation of new business logic. Those workloads could be moved to the cloud through any number of approaches. Each of these approaches is considered a migration.

## SAP Workload on Azure - Supported scenarios

In Azure there are lot of different opportunities for various architectures and tools to get a scalable, efficient and highly available deployment. In this scenario, there are some restrictions when we consider operating system or Database Management System. This section will clear the supported scenarios for the SAP workload in Azure.

### Supported Virtual Machines

* + Supported Scenario for SAP on Azure Virtual Machines please refer [supported scenario](https://docs.microsoft.com/en-us/azure/virtual-machines/workloads/sap/sap-planning-supported-configurations)
  + Supported Scenario for SAP work load on Azure, please refer [supported scenario](https://docs.microsoft.com/en-us/azure/virtual-machines/workloads/sap/get-started)
  + Supported Scenario for SAP on Azure, please refer: [Planning and Implementation](https://docs.microsoft.com/en-us/azure/virtual-machines/workloads/sap/planning-guide#:~:text=With%20Microsoft%20Azure%20Virtual%20Machine,Azure%20Virtual%20Machines%20(IaaS))

### SAP Software Supported on Azure

* + To Understand the supported SAP software in Azure, please refer [SAP Supported Software in Azure.](https://docs.microsoft.com/en-us/azure/virtual-machines/workloads/sap/sap-supported-product-on-azure)

### Virtual Machines certified for SAP on Azure

* + For more information about Certified Virtual Machines for SAP on Azure, please refer [Certified Virtual Machines for SAP](https://docs.microsoft.com/en-us/azure/virtual-machines/workloads/sap/sap-certifications)

## Migration Timeline

Planning the migration with a specific measurable estimated time will help the organization to make a broader view on migration activity. Below are the different migration scenarios. Among these, we need to identify the suitable scenario and estimate the timeline.

The different migration scenarios are below:

* **Greenfield Implementation:** In Greenfield Implementation, included pre-requirement, network deployment, greenfield implementation, post configuration activities to estimate the migration timeline.
* Consider below points to estimate migration timeline in different migration scenario as **Rehost Migration, SAP OS/DB Migration to Azure, HANA Conversion.**
  + Pre-Requirement
  + Migration DB to Azure
  + SAP to Azure (Lift and Shift)
  + Post Validation

## Key Assumptions and Risks

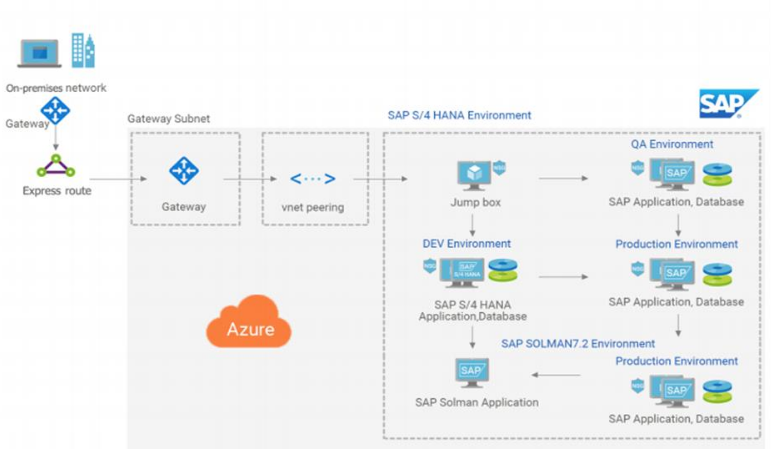
In this section, key assumptions and risks related to migration activity are documented. Assumptions are the first place to start identifying the risks involved in migration.

* **Example:** Bandwidth clog is one of the major examples of risk during migration. In this scenario you need to consider the latency, mode of connection from azure to on-premise to ensure the migration activity works in seamless manner.
* **Risks** – There are different risks associated with this deployment of which some of them are listed below:
  + Mobility Related risks
  + Columnar Database related risks
  + Availability of the given functionalities
  + Infrastructure related risks

# Ready Phase

In this cloud adoption journey, we are now on ready phase which states how to prepare the landing zone for SAP deployment or migration. In this section we will cover the points which illustrate the architecture design, SAP workload, best practices and first landing zone.

## High Level SAP Architecture Design

High level SAP architecture design provides the information of the components of existing SAP workload and about SAP 3-tier architecture layer, which are presentation layer, application layer & database layer.

* **List of Servers for single SAP environment** 
  + **Operating System with Specifications:** Ensure selected Operating System is compatible and certified from SAP to host the SAP workload. Also, we need to specific related to Virtual Machine Size SKUs in Azure which is recommended by Azure as appropriate specification to host SAP Workload. In this Reference Link : [SAP on Azure Certified Operating System](https://docs.microsoft.com/en-us/azure/virtual-machines/workloads/sap/sap-certifications) you will find more details about supported operating system and the VM Size SKUs supported by Azure to host SAP workload.
  + **Hostnames:** Identify the hostnames which used in current sap environment. This can be used as reference in new deployment or migration.
  + **Specifications:** Collect the information of hardware specification among the servers. This can be used as reference further.
* **Server Roles**
  + **DB Server, inc DB type and Version**: Database server in SAP environment is used to store the data in a standard format. Identify the current DB Server (Database server) specifications including the hardware, operating system, database type and its version. Database server play is a key important role in SAP workload.
    - **PAS server**: Presentation Servers works on presentation layer in SAP 3-tier architecture and known as client layer. This server is used as SAP-User interaction with GUI.
    - **Application Server**: Application server is the dispatcher distributes the workload to the different work processes to make the job done. It works on application layer which serves a purpose of a communicator between presentation and database layer
* **SAP Application / Product Version**
  + - List out the SAP application version, licensing, support pack from current existing SAP environment.
* **Any third-party System Details (only showing interaction points)**
* **Network Load Balancers:** We must use Application Gateway with WAF for Gateway level firewall and load-balancer which will work on OSI Layer 7 and internal load balancer which will be placed to balancer to request between application and database servers. Please refer [Azure Load Balancers](https://docs.microsoft.com/en-us/azure/load-balancer/load-balancer-overview) for more information.
* **End User Access Points/methods (high level):** End user access points for SAP application are desktop, mobile devices, laptop etc.

### Assessment & Capacity Planning

Assessment and capacity planning are an important step before moving further in deployment or migration the workload. Performing an assessment in environment provides a deeper understanding on the architecture, hardware specifications, operating system compatibility, dependencies, etc. The results are based on the data gathered during assessment. With the help of assessment results, we can perform capacity planning which defined as to provide appropriate IT resources for workload so they can perform efficiently with performance.

* **Infrastructure Assessment** 
  + Bandwidth Requirements between On-Premises vs Azure
  + Azure recommends using Express Route or Public Internet while migrating the workload as VPN will be limited for the bandwidth.
  + Express Route will provide a high-speed network bandwidth with resilience as it works on MPLS protocol.
* **Azure Migrate Tools- Azure Assets**
  + Azure Migrate will be used to discover, assess, and migrate the on-premises workload to Azure. Also, we can use to migrate physical servers and other public cloud servers to azure. It will work end to end.
  + Azure migrate will discover the assets from on-premises (physical and virtual environment) and perform a performance-based /usage-based assessment. Based on the assessment azure migrate will recommend the appropriate required VM sizes or we can choose as per our scope.
  + Determine Required [VM Sizes](https://docs.microsoft.com/en-us/azure/virtual-machines/workloads/sap/hana-vm-operations-storage)
    - **Like for Like**
      * Like for Like Migration from On-Premises to Azure environment which means allocating the exact amount of resources to the instances in azure based on On-premises servers resource allocation.
    - **Performance/Usage Based Sizing**
      * Performance or Usage Based sizing is mostly recommended sizing parameter when we are migrating the workloads from on-prem to azure environment. In this we get the recommendation of VM sizes from Azure Migrate Tool which are analyzed based on Performance or Usage based metrics. This will help to cost optimization.
  + **Rate of Change considerations**
* [**SAP Sizing Reports**](https://www.sap.com/about/benchmark/sizing.html#sizing-types)
  + **Execute Sizing Reports for each SAP system Being Migrated**
    - **For New Installation :** For New installation of SAP workload, we can use [SAP Quick Sizer](https://www.sap.com/about/benchmark/sizing.quick-sizer.html) and [SAP Sizing Guidelines](https://www.sap.com/about/benchmark/sizing.sizing-guidelines.html) to estimate the required CPU and Memory based on the number of users and /or transaction volumes.

This will include SAP Note 1928533 - SAP Applications on Azure: Supported Products and Azure VM types.

* + - **For Existing Workload Migration:** When migrating an existing workload from on-premise to azure, it is recommended to use reference sizing, using the capacity and utilization of the existing installed hardware to calculate the required resources in Azure.

Rather than moving with like-to-like basis approach, it is better to use performance-based approach, because Azure provides the way to scale-up and scale-down the VMs at any time based on requirement.

* + - **For Re-platforming we need below performance metrics**
      * **CPU**
      * Make and Model of Processor
      * Number of Cores
      * Processor Speed
      * Average utilization
      * Maximum utilization
      * **Memory**
      * Total available memory
      * Average memory consumed
      * Maximum memory consumed

\**We need to measure average and peak utilizations of compute resources.*

* + **Utilize results from above to determine correct Azure VM Size.**
    - Based on above results, we can determine the appropriate Azure VM size from Azure /SAP certified VM SKUs.
* **SAP HANA Sizing** 
  + **Execute Sizing Reports for each SAP system Being Migrated**

To ensure SAP HANA database systems to achieve optimum, we need to be more precise and specific for system sizing.

* + - CPU and Memory

SAP simply uses a fixed CPU to memory ratio for HANA or more accurately two ratios.

One Ratio for OLTP systems and second for OLAP systems, with the OLTP systems allowed twice the memory per CPU when compared with the OLAP systems.

* + **For new installation, you can use SAP Quick Sizer and SAP Sizing Guidelines. While using SAP Sizing Quick Sizer, there are two versions as below**.
    - **Classic**

Classic version is for sizing traditional Netweaver applications on AnyDB.

* + - **HANA Version**

HANA Version is for sizing applications on HANA

*\*Scale-Out deployment is only allowed for OLAP workloads.*

* **Storage Requirements for SAP HANA**
  + Based on recommendation, organization must use a storage which provides High IOPS. To achieve this goal, we need to use Premium SSD or Ultra SSD
    - **Premium SSD**: A solution based on high performance SSD, and the recommended storage for M Series and Mv2 series VMs when used for SAP HANA and combined with the write accelerator. Please refer [Azure Premium SSD](https://docs.microsoft.com/en-us/azure/virtual-machines/windows/premium-storage-performance) for more information.
* **Ultra-SSD:** A Solution based on ultra-performance SSD, which is only supported storage for Ev3 series VMs and gradually being supported on M Series and Mv2 series. Please refer [Azure Ultra SSD](https://docs.microsoft.com/en-us/azure/virtual-machines/linux/disks-enable-ultra-ssd) , for more information.
  + **Azure NetApp Files**: Azure NetApp Files helps to migrate and run complex, file-based applications with no code change. Azure NetApp Files is widely used as the underlying shared file-storage service in various scenarios. These include migration (lift and shift) of POSIX-compliant Linux and Windows applications, SAP HANA, databases, high-performance compute (HPC) infrastructure and apps, and enterprise web applications. Please refer [Azure NetApp Files](https://azure.microsoft.com/services/netapp/), for more information.
  + **Utilize results from above to determine correct** [OLAP/OLTP Azure VM Size](https://docs.microsoft.com/en-us/azure/virtual-machines/workloads/sap/hana-available-skus)
    - [OLAP](https://wiki.scn.sap.com/wiki/display/BI/OLAP+vs+OLTP) (Online Analytical Processing) these systems consist a set of software tools which analyze the data stored in a Database.
    - Online Transaction Processing ([OLTP](https://wiki.scn.sap.com/wiki/display/BI/OLAP+vs+OLTP)) this system supports transaction-oriented applications in a 3-tier architecture.

Based on above results organization has to determine the systems for OLAP /OLTP functionality with appropriate Azure VM sizes.

* + **SAP HANA:** Quick Sizer is a Web-based tool designed to make the sizing of SAP applications easier and faster. This tool provides the results for CPU, Memory and Disk Requirement based on filled Questionnaire. Please refer [Quick Sizer](https://www.sap.com/about/benchmark/sizing.quick-sizer.html#quick-sizer) for more information.
  + The [SAP HANA certified Azure storage](https://docs.microsoft.com/en-us/azure/virtual-machines/workloads/sap/hana-vm-operations-storage) types that can be considered for SAP HANA deployments list like:
* Azure premium storage is designed for high performance workload. In Azure premium storage it uses premium SSDs which deliver high-performance and low-latency disk support for virtual machines. For more details please refer [Azure premium SSD or premium storage](https://docs.microsoft.com/en-us/azure/virtual-machines/windows/disks-types#:~:text=Azure%20premium%20SSDs%20deliver%20high-performance%20and%20low-latency%20disk,Premium%20SSDs%20are%20suitable%20for%20mission-critical%20production%20applications.)
* Azure Ultra Disks offer High throughput with high IOPs and a consistent low latency disk storage for Azure IaaS virtual Machines VMs. For more details please refer to [Azure Ultra-disk](https://docs.microsoft.com/en-us/azure/virtual-machines/linux/disks-enable-ultra-ssd)
* Azure NetApp Files are used as the underlying shared file-storage service in various scenarios. It Supports both Linux and Windows file Workloads in Azure. For more details please refer [Azure NetApp Files](https://azure.microsoft.com/services/netapp/)
* **Different Sizing Methods & Approach Guidance**

Sizing methods is most important part when we plan to move the workload in cloud. Sizing of servers and other components directly integrated to cost, performance other functionalities. We have discussed important points which need to be considered during sizing.

* + **Consider Non-Production Systems Sizing Methods:** The sizing method which we can use for Non-Production system is to collect the resource consumption data from resources like CPU Usage, Storage Throughput and IOPS Data, Memory Usage, Network and storage latency. Collect this data from DBMS Layer Units and Application Layer Units.

*Ensure to use SAP Support requirements for Microsoft support agreements. SAP Support Note #2015553*

* + **Consider Production Systems Sizing Methods:** For Production SAP Workload there are different sizing methods. The Right Sizing means correct approach for what we need today and then scale up or down based on needs. Use of SAP Quick Sizer and SAP Sizing Guidelines to estimate the sizing. We can use User-based Sizing (Concurrent Users) from Quick Sizer or Transaction (Throughput) based sizing which is more realistic.
  + **Consider HANA and Non-HANA Systems:** SAP quick sizer can be used to calculate CPU and memory requirements of the implementation of SAP Software on top of HANA. For More details [refer SAP Note #1793345 - Sizing for SAP Suite on HANA](https://launchpad.support.sap.com/#/notes/1793345)
  + **Consider Windows / Linux Operating System:** For SAP Workload in Azure all major operating systems are supported Windows, SUSE Linux Enterprise, Red Hat Enterprise Linux, Oracle Linux. More information related to SAP Certified Iaas Platforms [SAP Documentation](https://www.sap.com/dmc/exp/2014-09-02-hana-hardware/enEN/iaas.html#categories=Microsoft%20Azure) and [Microsoft Azure Documentation](https://docs.microsoft.com/en-us/azure/virtual-machines/workloads/sap/sap-certifications)
    - **Supported databases running on Windows:**
      * Microsoft SQL Server 2008 R2 or higher
      * SAP ASE 16.0 SP02 or higher
      * IBM Db2 for Linux, Unix, and Windows 10.5 or higher (see SAP Note 2233094)
      * Oracle database: for versions and restrictions, see SAP Note 2039619
      * SAP MaxDB version 7.9
      * SAP liveCache as part of SAP SCM 7.0 EhP2 (or higher): Minimal version for

SAP liveCache: SAP LC/LCAPPS 10.0 SP 27 including liveCache 7.9.08.32 and LCA-Build 27, released for EhP 2 for SAP SCM 7.0 and higher

* + - **Supported databases running on Linux**
      * SAP HANA 1.0 SP12 and higher, SAP HANA 2.0:
      * On Microsoft Azure Large Instances
      * On Microsoft Azure Infrastructure as a Service IaaS (Azure Virtual Machines) SAP ASE 16.0 SP02 or higher
      * IBM Db2 for Linux, UNIX, and Windows 10.5 or higher
      * SAP MaxDB version 7.9.09.05 or higher
      * Oracle Database – only on Oracle Linux
      * SAP liveCache as part of SAP SCM 7.0 EhP4 (or higher):
      * Minimal version for SAP liveCache: SAP LC/LCAPPS 10.0 SP 34 including liveCache 7.9.09.05 and LCA-Build 34, released for EhP 4 for SAP SCM 7.0 and higher
* **Plan Update/Upgrade and Migration Requirements**
  + **Identify Business Applications that needs to be migrated:** Before migrating the workload to azure we need to identify the business applications which are in scope of migration. This will help us to understand the criticality and compatibility of business applications.
  + **Identify Technical Systems to be Migrated/Upgraded:** It is most important to identify technical systems properly which are in scope of migration or upgradation. This will provide details which can be used to plan the resources in cloud.
  + **Meeting the Operating System-Specific Requirements:** Ensure the selected operating system and the resources SKUs are supported by azure platform and application vendor. Best practices recommend using Azure/SAP certified Operating System/VMs SKUs which will provide the support with SLA.
  + **Third Party Application dependencies (SAP Supported):** Before starting the migration or upgradation ensure to gather all details about third party applications which are dependent on SAP applications. Migration can disrupt the dependencies which leads to production environment unfunctional.
  + **Assess with SAP Software Provisioning Manager** ([SWPM](https://wiki.scn.sap.com/wiki/display/SL/List+of+Important+SAP+Notes+and+KBAs)) : Software Provisioning Manger (SWPM) provides the execution of many system provisioning tasks and covers a wide range of platforms and products in both vertical ABAP and Java technology. We can perform Copy Operation on SAP NetWeaver System, Rename an SAP Business Suite System or Install a Standalone Engine (Such as SAP livCache).
  + **Assess with SAP Software Update Manager** ([SUM](https://wiki.scn.sap.com/wiki/pages/viewpage.action?pageId=421366825) )
    - Software Update Manager can be used for Software Maintenance, Database Migration, System Conversion, Customer Transport Integration and Correction of Installed Software Information (CISI)
    - We can perform major tasks by using Software Update Manager as below.
    - Apply Support Packages or Support Package Stacks
    - Implement Enhancement Packages
    - Apply a new release
    - Get more details about System Maintenance.
    - The Software Update Manager can be used with the option Database Migration Option (DMO) for a database migration, if the source system is ABAP based.
    - A System Conversion is the scenario to transfer an SAP ERP system into an SAP S/4HANA system.
    - The Customer Transport Integration (CTI) allows to integration of customer transports (custom development objects, or customer releases) into the maintenance procedure to reduce the business downtime.
    - The Correction of Installed Software Information (CISI) is the process of adapting the information in the SAP system about installed software instances. Inconsistencies in this information might cause errors during the regular maintenance process

### Understanding Non-Functional Requirements

In this section we need to understand the Non-Functional requirements in ready phase and the overview of resources system’s ability to recover from failures and continue to function. It’s not only about avoiding failures but also involves responding to failures in a way that minimizes downtime or data loss.

* **Resiliency:** Resiliency ensures the availability of the resources with an SLA aligned with shared responsibility model approach which ensures the reliable infrastructure for production environment. Below are the points which clarify the requirements to ensure the availability of production workload in azure.

There are 3 scenarios that cause downtime when running SAP in Azure.

[**Unplanned Hardware Maintenance Event:**](https://docs.microsoft.com/en-us/azure/virtual-machines/windows/manage-availability)Occurs when the Azure platform predicts that the hardware or any platform component associated to a physical machine is about to fail. In this case Azure uses [Live Migration](https://docs.microsoft.com/en-us/azure/virtual-machines/linux/maintenance-and-updates) to migrate the virtual machines from the failing hardware to a healthy physical machine. In cases where live migration cannot be used then the VM will experience unexpected downtime**.**

[**An Unexpected Downtime**](https://docs.microsoft.com/en-us/azure/virtual-machines/windows/manage-availability)When the hardware or the physical infrastructure for the virtual machine fails unexpectedly then VM will experience unexpected downtime. This can include local network failures, disk failures or other.

[**Planned Maintenance events.**](https://docs.microsoft.com/en-us/azure/virtual-machines/windows/planned-maintenance/)Periodic Updates made by Microsoft to the underlying Azure platform to improve reliability, performance, and security of the platform infrastructure. In rare case updates requires reboot of virtual machine to apply the updates to underlying infrastructure. In this case, we can perform azure planned maintenance with Maintenance-redeploy operation by initiating maintenance for VMs in suitable time window.

* + **HA requirements:** For SAP HANA High Availability, there must be minimum two virtual machines in Azure with SAP HANA Installed. Data replication can be performed by using HANA System Replication. For more details please refer [SAP HANA High Availability Overview and Configuration](https://docs.microsoft.com/en-us/azure/virtual-machines/workloads/sap/sap-hana-high-availability#:~:text=To%20achieve%20high%20availability%2C%20SAP,use%20a%20virtual%20IP%20address.)
  + **Acceptable downtime**
  + **Host Auto – Failover** ([**Failover Custer**](https://docs.microsoft.com/en-us/windows-server/failover-clustering/failover-clustering-overview))
    - **SAP HANA Scale-Out HA**
      * There are two options for HA in HANA Scale-Out.
        + HANA host auto-failover using a standby node
        + HANA system replication synchronous
    - **HANA Scale-Out HA with Host Auto-failover** 
      * HANA host auto-failover has been a native capability of SAP HANA and allows for a standby node to be created that can take over the work of any of the other nodes, either master or workers
      * Azure also supports SAP HANA host auto-failover on HLI, as HLI uses Azure NetApp Storage to provide the required storage for HANA. The NetApp volumes are mounted to the HLI servers using NFS, and the standby node can simply take over the volumes from a failed node
    - **Over Auto failover**
    - **Configuring Host Auto failover**

To Configure Host Auto-failover we must add one or more Virtual machine instances to the HANA system and configure them as standby nodes. When active node fails, a standby node automatically takes over. For more details about configuration refer the link [SAP HANA High Availability for Azure Virtual Machines](https://docs.microsoft.com/en-us/azure/virtual-machines/workloads/sap/sap-hana-availability-overview)

* + - **Any Consideration**
  + **Hana System Replication as HA**
    - **SAP HANA Scale-Up HA: To** provide HA for SAP HANA scale up, the recommended solution from SAP is to use HANA System Replication (HSR) in synchronous mode. This keeps two HANA instances in sync, with updates applied to the primary and the secondary at the same time. This solution is supported in Azure as it provides rapid failover of the service in the event of a failure of the primary node. HSR Deployment Options. *Refer to SAP Note: 1999880*
  + **HANA HA for VM Deployment**
    - **SAP HANA scale-out HA on VMs:** In SAP HANA Scale-out HA on Azure VMs, we can deploy it without a standby node. In this scenario we don’t always need a standby node, as Azure VM Auto-restart will restart a failed node. This will be not a fast recovery as using a standby node but does avoid the additional cost of the standby node.
    - When SAP HANA is configured with Azure Premium or Ultra SSD disk storage, a standby node cannot be configured as it needs to be able to take over the disks from the failed master or worker node, which is not possible with Azure premium or Ultra SSD disks.
    - There are 3 types of Solutions for HA in Azure VMs without ANF.
      * Rely on the Azure VM auto-restart feature to restart the failed node. This may be adequate for less critical systems.
      * Use HSR in the same way.
      * Use Azure HLI
  + **HANA HA for HLI Deployment**
    - **HA for SAP HANA HLI on Azure VMs can be done in 3 methods.**
      * **Storage Replication:** The Storage Systems ability to replicate all data to another HANA Large Instance stamp in another azure region. SAP HANA operates independently of this method. This method is also a default disaster recovery mechanism offered for HANA Large Instances.
      * **HANA System Replication:** In this method the replication of all data in SAP HANA to a separate SAP HANA System. Replication can be done in asynchronous, synchronous in-memory and synchronous mode as SAP HANA supports all of these modes.

*For more details please refer to link* [*SAP HANA Large Instances high availability*](https://docs.microsoft.com/en-us/azure/virtual-machines/workloads/sap/hana-overview-high-availability-disaster-recovery)

* + - * **Host Auto Failover:** A Local fault-recovery solution for SAP HANA that’s an alternative to HANA system replication. In this method master node becomes unavailable, as one or more standby SAP HANA nodes in scale-out mode are configured. Because of this SAP HANA automatically fails over to a standby node.
    - **HSR (HANA System Replication):** HANA System Replication (HSR) is a high availability and disaster recovery solution provided by SAP. HSR follows the “N+N” approach, where you configure the same number of nodes for both the primary and the secondary system. Each service in the primary system communicates with its counterpart in the secondary system to replicate the data.
    - **Intel Optane Memory for SAP HANA Large Instance:** Intel Optane Memory for SAP HANA Large Instance are Next Generation SAP HANA Large Instances which supports 3 TB to 9TB of memory with four socket 224vCPUs. Also, these new instances support both DRAM-only and DRAM plus Intel Optane Persistent memory combinations. For more details please [refer Intel Optane Memory for SAP HANA Large Instances.](https://azure.microsoft.com/en-us/blog/next-generation-sap-hana-large-instances-with-intel-optane-drive-lower-tco/#:~:text=Coupled%20with%20Intel%20Optane%2C%20the,a%20mode%20called%20app%20direct.)
  + **AnyDB HA Option**
    - **SQL Always-On Availability Groups HA Pair:** SQL Server Always on Availability groups provides High Availability capability to SQL Database with clustering as the base. For more details on Configuration part, please refer [SQL Server Always on HA in Azure VMs](https://docs.microsoft.com/en-us/azure/azure-sql/virtual-machines/windows/availability-group-manually-configure-prerequisites-tutorial)
    - **SQL Managed Instance:** Azure SQL Managed Instance is a fully managed platform as a service provided by Azure. which has intelligence, easy to scale, always operate on the latest version of SQL, fully isolated and secure. For more details please refer to [Azure SQL Managed Instance overview.](https://docs.microsoft.com/en-us/azure/azure-sql/azure-sql-iaas-vs-paas-what-is-overview)
    - **Oracle Data Guard:** Oracle Data Guard provides high availability, data protection and disaster recovery for databases. It also provides a comprehensive set of services that create, maintain, and monitor one or more standby databases to enable production oracle databases in case of Disaster or Data corruptions. For more details please refer [Oracle DataGaurd Overview.](https://docs.oracle.com/cd/B19306_01/server.102/b14239/concepts.htm#g1049956)
* **Performance**

Performance means end-to-end response time and throughput. The end user performance is corelated to End-to-End response time. Please refer for more details [End User Performance](https://blogs.sap.com/2020/07/23/sap-s-4hana-end-to-end-performance/).

* + **End user experience expectations:** From the perspective of end user, the application performance should not be a sluggish and must be low latency which will increase the productivity with consistency.
* **Security**
  + **Network and Access Points**
    - Implement Network Access Control which control and limit the connectivity to and from specific devices or subnets within a virtual network.
    - Also, organization can achieve the goal of network security by limiting the access to virtual machines and services to approved users and devices.
    - Network Security Groups (NSGs), Network Security Group (NSGs) is a software level firewall which works on IP address and TCP or UDP Protocols. It is stateful, packet filtering firewall which enables to control access based on a 5-tupple Hash mechanism. For more details please refer [Network Security Groups](https://docs.microsoft.com/en-us/azure/virtual-network/security-overview)
    - Azure security center Just in time VM access, Azure Security center can manage the NSGs on VMs and lock access to the VM until a user with appropriate RBAC permission request access. Based on Authorization, Azure security center will modify the NSGs to allow access to selected ports for the specific time. When time expires the NSGs are restored to their previous secured state. For more details please refer [ASC JIT Access](https://docs.microsoft.com/en-us/azure/security-center/security-center-just-in-time?tabs=jit-config-asc%2Cjit-request-asc)
    - Service Endpoints are another way to apply control over the network traffic. We can limit communication with supported services to just specified VNET over a direct connection. Traffic from specified VNET to the specified Azure service remains on the Microsoft backbone network. For more details please refer [Service Endpoints](https://docs.microsoft.com/en-us/azure/virtual-network/virtual-network-service-endpoints-overview#secure-azure-services-to-virtual-networks)
  + **Azure Firewall:** Azure firewall is a managed, cloud-based network security service. Which protects Azure Virtual Network resources from unwanted traffic and attacks. It is fully stateful firewall as a service with built-in-high availability and unrestricted cloud scalability. For more details please refer [Azure firewall.](https://docs.microsoft.com/en-us/azure/firewall/overview)
* **Management and Monitoring**
  + **Monitoring Tools being used:** Azure monitor will be used to monitor the azure resources and collection of logs. Apart from this Network Performance Monitor and Network Watcher will be used to monitor and use to troubleshoot the network related and NSG related issues.

### SAP Supported for Azure: Certification & VMs

SAP provides the SAP HANA Hardware and Cloud Measurement tools (HCMTs) to vendors to validate their platform meets the required key performance indicators (KPIs). Microsoft Azure has successfully certified a wide range of virtual machines and bare-metal servers to run SAP HANA. Which ensures all hardware components are compatible and offer the required performance.

* **Identify SAP Systems for Cloud Migration**
  + SAP workload on Azure virtual machine [supported scenarios](https://docs.microsoft.com/en-us/azure/virtual-machines/workloads/sap/sap-planning-supported-configurations)
  + Checking the Source and Target Operating System/Database SAP Release Dependencies
    - Product Availability Matrix ([PAM](https://apps.support.sap.com/sap(bD1lbiZjPTAwMQ==)/support/pam/pam.html#ts=0)) (Requires SAP S-User ID)
  + DB Upgrade / Migration ([DMO Options/Sidecar Approach](https://azure.microsoft.com/en-us/blog/best-practices-in-migrating-sap-applications-to-azure-part-2/))
  + [HANA Large Instance](https://docs.microsoft.com/en-us/azure/virtual-machines/workloads/sap/hana-overview-architecture?toc=/azure/virtual-machines/linux/toc.json)Dedicated bare-metal hardware to run large workloads
  + HANA Larger Instance for higher performance and higher memory to processor ratio
    - [Intel Optane Memory for SAP](https://azure.microsoft.com/en-us/blog/next-generation-sap-hana-large-instances-with-intel-optane-drive-lower-tco/)
  + Finalizing VM selection based on SAP Notes and Certification
  + Supported VMs, Products, DB and OS versions
    - Identify the VM Skus which are certified and supported by SAP in Azure platform. Also ensure the SAP application and related products, database type and version, operation system supportability by SAP vendor. For more details please refer Link [Supportability to Azure by SAP](https://docs.microsoft.com/en-us/azure/virtual-machines/workloads/sap/sap-supported-product-on-azure)
  + **SAP NetWeaver & AnyDB Certification for Azure**
    - To ensure the SAP NetWeaver & any DB certification for Azure, please refer to reference link [SAP NetWeaver certifications](https://docs.microsoft.com/en-us/azure/virtual-machines/workloads/sap/sap-certifications)
* **SAP S/4HANA Azure Cloud**
  + **Single Tenant (**[**Single Tenant**](https://docs.microsoft.com/en-us/azure/virtual-machines/workloads/sap/sap-hana-scale-out-standby-netapp-files-suse)**)** : SAP S/4 HANA Single Tenant edition is provisioned to a single customer in a dedicated landscape, which offers the full scope of S/4 HANA. For more details please refer on [SAP S/4 HANA Single Instance.](https://blogs.sap.com/2018/11/26/sap-s4hana-cloud-single-tenant-edition-ste/)
    - Maximum privacy
    - Costs Involved
  + Multi-Tenant ([Multi-Tenant](https://docs.microsoft.com/en-us/azure/app-service/manage-scale-up))
    - **HANA Multitenant Database Containers (MDC):** Multitenant Database Containers provides much greater isolation between the individual databases which makes more secure and robust structure. MDC is SAP Preferred solution for virtualizing HANA and Azure Preference has generally been to use bare-metal-certified appliances. In MDC, all databases share one set of binaries, so all the databases run on common release. In case of patch and upgrade restart of HANA instance will cause downtime for all containers.
    - Hardware and Power Economy
    - Effort to Upgrade
    - Backups and Redundancy
  + **Scale Up (**[**Scale up**](https://docs.microsoft.com/en-us/azure/virtual-machines/workloads/sap/sap-hana-scale-out-standby-netapp-files-suse)**):** In scale-up, the whole HANA instance must fit into a single HANA node, and as the database grows we will need to scale-up the host, be it a VM or a physical bare-metal server.
  + **Scale Out (Scale out):**In scale-out theory, you can scale the size of the HANA instance as the database grows, by adding extra nodes
* **Unsupported Scenarios:** Not Supported means SAP and Microsoft will not be able to support these configurations and need to defer to an eventual involved third-party that provided software to establish such architectures. In this there are two categories as below.
  + **Storage Soft Appliances**: In Azure some vendors offer own documentation on how to use these storage soft appliances on azure related to SAP software. In these scenarios the specific vendor must support for configuration or deployment. Please refer [SAP Support note#2015553](https://launchpad.support.sap.com/#/notes/2015553)
  + **High Availability Frameworks:** In Azure only pacemaker and windows server failover cluster are supported for High Availability to SAP workload. In case of any other clustering solution used for SAP workload then involve the specific vendor for support, configuration, or deployment.

*Please refer the link for more details related to* [*Unsupported Scenario*](https://docs.microsoft.com/en-us/azure/virtual-machines/workloads/sap/sap-planning-supported-configurations)

### Decide Azure Region

Azure regions are global datacenters where Azure computes, networking and storage resources are located. This is key factor to be specific while choosing the Azure regions as all regions does not have all range of Azure products and services. Please refer [Azure Regions](https://docs.microsoft.com/en-us/azure/virtual-machines/regions) for more details

* **Proximity of DC & Users:** Azure Proximity placement groups improve the overall performance by reducing network latency among virtual machines. When we configure the Virtual Machines in Proximity Group, then it enforces to all the resources to follow each other and land in the same data center for best latency.
* **Product Availability in Region:** In Azure all products are not available in all regions due to compliance and other limitation concerns. There are some global services which are available to all datacenter like Azure AD, Azure DNS etc., but for other products we need to identify the availability of product in specific region. To ensure the product availability please use the [link](https://azure.microsoft.com/en-us/global-infrastructure/services/) and ensure the product is available before starting the migration/implementation activity.
* **Paired Region for DR check:** Paired Region is a set of data centers deployed within a latency-defined perimeter and connected through a dedicated low-latency network. A regional pair consists of two regions within the same geography. This azure Paired region are useful during configuration of Business Continuity and Disaster Recovery planning. For more details please refer to link [Azure Paired Region for BCDR](https://docs.microsoft.com/en-us/azure/best-practices-availability-paired-regions)
* **SAP VMs availability per region :** To ensure SAP VMs availability based on region we recommend to refer link [SAP VMs Availability Per Region](https://azure.microsoft.com/en-us/global-infrastructure/services/?products=sap-hana-large). This will provide appropriate details about certified SAP VMs SKUs.
* **Azure Supported VMs for SAP:** For best and reliable infrastructure in azure cloud SAP has provided some recommended and certified VMs SKUs. Which must be used for SAP deployment to avoid any unexpected issues in production environment. For more details please refer Supported Azure SAP VMs SKUs Pre-Existing Azure Infrastructure

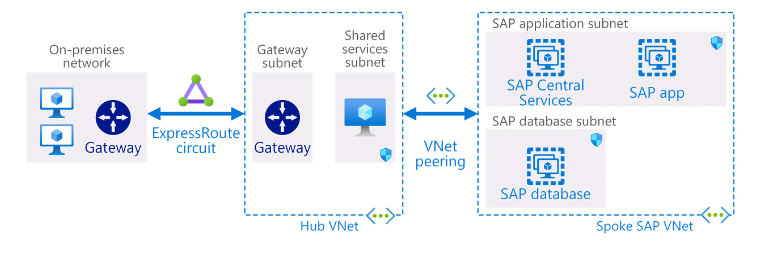
## Designing SAP Workload on Azure

In this section we will go through the components which are required for Designing SAP workload on Azure infrastructure. Understanding the components deeply will help to design the workload more efficiently and robust on Azure.

### Design Network, Compute, Storage

#### Design Network

In Designing the SAP workload on Azure, Network will be a first component which has to setup in Azure Infrastructure with appropriate network strategy. Below is the Hub-and-Spoke network model which is recommended as a best network design to host SAP workload.

**HUB and Spoke Network Diagram**

\**Diagram Reference#* [*https://docs.microsoft.com/en-us/azure/architecture/reference-architectures/sap/sap-overview*](https://docs.microsoft.com/en-us/azure/architecture/reference-architectures/sap/sap-overview)

* **Network address spaces & subnets:** A Network address specifies as identifying a network node or device in a network and used to communicate with each other. A subnet enables you to segment the virtual network address space into one or more sub-networks and allocate a portion of the virtual network address space to each subnet.
* **Multi Network- Vnet Peering consideration:** VNet peering is a mechanism that connects two separate virtual networks (VNets) in the same region or other region through the Azure backbone network. Once peered, the two virtual networks appear as one for all connectivity purposes. We can associate multiple NICs on a VM to multiple subnets, but those subnets must all reside in the same virtual network (vNet). *For more details about VNet Peering, please refer* [*VNet Peering*](https://docs.microsoft.com/en-us/azure/virtual-network/virtual-network-peering-overview)
* **Single Network Vs. Multi Network Consideration:** A network interface enables an Azure Virtual Machine to communicate with internet, Azure, and on-premises resources. Virtual machines (VMs) in Azure can have multiple virtual network interface cards (NICs) attached to them. We can associate multiple NICs on a VM to multiple subnets, but those subnets must all reside in the same virtual network (vNet).
* **Azure Network Load balancer:** Azure Load Balancer operates at layer four of the Open Systems Interconnection (OSI) model. It's the single point of contact for clients. Load Balancer distributes inbound flows that arrive at the load balancer's front end to backend pool instances. These flows are according to configured load balancing rules and health probes. The backend pool instances can be Azure Virtual Machines or instances in a virtual machine scale set. For more details about Azure Network Load Balancer, please refer [Azure Network Load Balancer](https://docs.microsoft.com/en-us/azure/load-balancer/load-balancer-overview#:~:text=Key%20scenarios%20that%20you%20can%20accomplish%20using%20Standard,probes%20to%20monitor%20load-balanced%20resources.%20More%20items...%20)
* **Hybrid Network Consideration:** Communicate between applications that exist on-site and in Azure (Azure SQL/PaaS, IIS front end to back end, and legacy applications) Create security zones on-site and through Azure (DMZ in Azure, and development networks)
  + - * + **Best Practice - Azure Network**
  + **Azure Accelerator Networking:** Accelerated Networking enables single root I/O virtualization (SR-IOV) to a VM, which improves its networking performance. This high-performance path bypasses the host from the Datapath, reducing latency, jitter and CPU utilization. For more details about Accelerated Networking, please refer [Azure Accelerator Networking.](https://docs.microsoft.com/en-us/azure/virtual-network/create-vm-accelerated-networking-powershell)
  + **Standard Load Balancer (LB) Recommendation:** In Azure, load balancer operates at layer 4 of the Operating Systems Interconnection (OSI) model. Load Balancer distributes inbound flows that arrive at the load balancer's front end to backend pool instances. This works on based of load balancing rules and health probes. For more details about Azure Load Balancer, please refer [Standard Load Balancer in Azure](https://docs.microsoft.com/en-us/azure/load-balancer/load-balancer-overview)
  + **Consider Proximity Placement Group for DB latency:** A Proximity placement group is a logical grouping used to ensure that Azure Compute Resources are physically located close to each other. This will help to achieve the requirement of low latency. For more details about Proximity Placement Group, please refer [Proximity Placement Group](https://docs.microsoft.com/en-us/azure/virtual-machines/windows/proximity-placement-groups-portal).
  + For Hybrid Network Speed & Security: Consider Express Route (ER): In Azure, Express Route extend your on-premises networks to Azure Cloud with a private connection which facilitated by a connectivity provider. Basically, it works on MPLS (Multi-Protocol Label Switching) Protocol. Express Route Offers more reliability, faster speeds, consistent latencies, and higher security that typical connections over the internet. For more details about Express Route and Recommendation please refer, [Express Route.](https://docs.microsoft.com/en-us/azure/expressroute/expressroute-introduction) For Architecture Details, please refer [Express Route Architecture.](https://docs.microsoft.com/en-us/azure/architecture/reference-architectures/dmz/secure-vnet-dmz)
  + **Enable ExpresRoute Fast Path Feature**: Express Route Fast Path is designed to improve the data path performance between your on-premises network and virtual network. When Fast Path is enabled, it sends network traffic directly to virtual machines in the virtual network bypassing the gateway. For more details about Express Route Fast Path, please refer [Express Route Fast Path.](https://docs.microsoft.com/en-us/azure/expressroute/about-fastpath)
    - * + **DR Scenario - Consider**
  + **VNet Peering :** Virtual network peering enables you to seamlessly connect networks in [Azure Virtual Network](https://docs.microsoft.com/en-us/azure/virtual-network/virtual-networks-overview). The virtual networks appear as one for connectivity purposes. The traffic between virtual machines uses the Microsoft backbone infrastructure. Like traffic between virtual machines in the same network, traffic is routed through Microsoft's *private* network only.  For more details about VNet Peering, please refer [VNet Peering.](https://docs.microsoft.com/en-us/azure/virtual-network/virtual-network-peering-overview)
  + **Express Route (ER) Global Reach:** ExpressRoute is a private and resilient way to connect your on-premises networks to Microsoft Cloud. You can access many Microsoft cloud services such as Azure, and Office 365 from your private data center or your corporate network. For example, you may have a branch office in San Francisco with an ExpressRoute circuit in Silicon Valley and another branch office in London with an ExpressRoute circuit in the same city. Both branch offices can have high speed connectivity to Azure resources in US West and UK South. For more details about Global Reach, please refer [Express Route Global Reach.](https://docs.microsoft.com/en-us/azure/expressroute/expressroute-global-reach#:~:text=ExpressRoute%20Global%20Reach%20is%20designed%20to%20complement%20your,and%20connect%20your%20branch%20offices%20across%20the%20world.)
    - * + **ER can be shared across subscription: Cost Optimization:** ER (Express Route) can be shared across subscription in Azure which will reduce the cost and help to optimize it appropriately. Please refer for more details [Express Route for Multiple Subscriptions.](https://azure.microsoft.com/en-us/blog/enable-multiple-subscription-expressroute/)
        + **Multiple NIC Consideration:** In SAP HANA, SAP distinguish three network zones.
  + **Client Zone:** Client applications which connects to database and execute SQL or MDX queries.
  + **Internal Zone:** Internal Communication between SAP HANA instances.
  + **Storage Zone:** The storage zone is used to access data and log files that are stored on storage account tiers.

*So, there must be multiple NIC for VMs to avoid latency issues and get rapid performance over the network****.***

* + - * + **HANA Network Design Best practices:** While design for migration the most important and critical step is to design and implementation of Azure Networking. The best practices are based on the Azure platform and service features available. Please refer for more details [Best Azure Networking Practices.](https://docs.microsoft.com/en-us/azure/cloud-adoption-framework/migrate/azure-best-practices/migrate-best-practices-networking)

#### Design Compute

Compute is a core component for building the infrastructure or migration in cloud platform. Based on specific and appropriate compute resource SAP workload can run seamlessly on azure. To achieve this objective, design the compute considering each aspect listed below.

* + - * + **Finalizing VM SKU Mapping:** Finalize the VM SKU considering the certified VM SKUs provided by SAP and Azure.
  + **SAP Notes & Azure VM Sizing Guidance :**Before finalize the VM SKU sizing please refer to [Sizing Guidelines](https://www.sap.com/about/benchmark/sizing.sizing-guidelines.html) and [Certified VM SKUs.](https://www.sap.com/dmc/exp/2014-09-02-hana-hardware/enEN/iaas.html#categories=Microsoft%20Azure)
    - * + **Best Practices - Azure Compute** :Please refer the reference link for Best Practices -[Azure Compute](https://azure.microsoft.com/en-gb/blog/best-practices-in-migrating-sap-applications-to-azure-part-1/)

We can use max disks limit allow per VM and total Throughput/ IOPS allow per VM. Ensure Secure transfer and secure storage are enabled.

#### Design Storage

After designing the compute section, it’s time to design the storage for SAP workload. SAP workload required High Performance with low latency storage, so the workload runs with effective performance. Consider below components while designing the storage for SAP workload.

* + - * + **Azure Disks Support for SAP**
* **Azure Premium SSD:** Azure premium SSD are the mainstay storage for SAP on Azure VMs. This disk type offers high performance in Azure and provides resilience in single VM with SLA. For more details about Azure Premium SSD Disks, Please refer to [Azure Premium SSD.](https://docs.microsoft.com/en-us/azure/virtual-machines/windows/premium-storage-performance)
* **Ultra-Disk:** Ultra-Disks are newest addition and provides lowest latency and highest IOPS with throughput. Also provides the ability to adjust the IOPS and throughput independent of the capacity. As of now this are supported as data disks. For more details about Ultra-Disks, please refer to [Azure Ultra Disks.](https://docs.microsoft.com/en-us/azure/virtual-machines/windows/disks-enable-ultra-ssd)
* **Azure NetApp Files:** Azure NetApp Files (ANF) which is fully managed and integrated cloud service in Azure. ANF brings all the features of the NetApp ONTAP Storage OS into Azure. ANF uses dedicated NetApp storage hardware deployed inside Azure Data Centers. For more details about Azure NetApp Files, please refer [Azure NetApp Files](https://docs.microsoft.com/en-us/azure/azure-netapp-files/).
  + - * + **Best Practices - Azure Storage**
  + Managed disks preferred will be preferred over unmanaged disks.
  + Review new updates in SAP Note # 2015553 for “No-Support" for Azure HDD and Standard SSD in Azure.
  + Premium SSD, Ultra SSD and Azure NetApp Files (ANF) to cover single VM SLA
  + Disk Caching for data and other drive (Non-Log file drive)
  + Min. Premium SSD with write accelerator
  + local temp D: Drive for page file /swap file OR Temp DB
  + HANA Storage Best Practices
    - SAP HANA Redo log storage latency requirements
    - Premium SSD & Write Accelerator
    - Ultra-SSD
    - Azure NetApp Files for HANA database: ANF as Database files
  + SAP HANA [Storage requirements](https://www.sap.com/documents/2015/03/74cdb554-5a7c-0010-82c7-eda71af511fa.html)
    - Azure NetApp Files for HANA database: ANF as Database files

### Design SAP Application Architecture

Consider the below high-level decision-making points in choosing right Azure VM for your deployments:

* + - * + For SAP Workload Migrations Prepare a details design document from the Existing SAP Architecture diagram to represent cloud systems and connections along with access points.
        + For Greenfield implementations prepare a detailed architecture diagram from the scratch.
  + Azure Regions Selected
  + OS and DB Hosts Details
  + Application Details
  + Connecting Systems including Third Part systems
  + Access Points in Terms of Servers and users

### Design Business Continuity: HA, DR & Backup

**High Availability**

* **Azure High Availability capabilities** 
  + Azure Resiliency & SLAs
  + Availability Sets & Availability Zones
  + PPG with AZ architecture
* **Design HA for SAP Application**
  + SAP Architecture Components & HA requirements
  + SAP ASCS/SCS Clustering HA requirements & NW 7.4+ changes
  + SAP HANA Deployment Options: ([FAQ On Migration](https://archive.sap.com/documents/docs/DOC-62664))
* **Operating System level High Availability**
  + SUSE OS level clustering is supported

**ASCS HA Options**

* **Windows: Using file share: Scale Out File Share (Windows 2016 SOFS + S2D):** In this windows cluster we can use server internal storage as a shared stored and create failover cluster. Also, file share can be used instead of cluster disk. For more details please refer [Windows 2016 SOFS + S2D SAP](https://blogs.sap.com/2018/03/07/your-sap-on-azure-part-5-ascs-high-availability-with-storage-spaces-direct/)
* **Windows: Using Azure Net App File (SMB) with WSFC:** In this Windows Server Failover Clustering we can use Azure NetApp File with SMB protocol to build the cluster. We can hos SAP Global Host files on the Shares. For more information , please refer [Windows Server Failover Cluster with NetApp + SMB](https://docs.microsoft.com/en-us/azure/virtual-machines/workloads/sap/high-availability-guide-windows-netapp-files-smb)
* **Windows: Using clustered shared disks (WSFC + SIOS DataKeeper Shared Disk):** In this cluster SIOS Data keeper will provide 'sapmnt' and 'trans' individual/separate file share for multiple SAP environments in the system landscape. For more details please refer [SIOS Data Keeper HA](https://blogs.sap.com/2020/08/04/sap-on-azure-highly-available-file-share-cluster-for-multiple-sap-environments-in-windows-using-sios-datakeeper/)
* **Linux: Clustering by using the SLES cluster framework (With NFS Cluster OR ANF):** In Linux Clustering by using the SLES cluster framework, a highly available NFS server is installed to store the shared data of a highly available SAP system. For more information , please refer to [Linux Clustering using SLES with NFS.](https://docs.microsoft.com/en-us/azure/virtual-machines/workloads/sap/high-availability-guide-suse-nfs)
* **Linux: Clustering by using RHEL GlusterFS framework (With GlusterFS OR ANF):** In Linux Clustering by using RHEL GlusterFS framework, a GlusterFS Cluster is installed and used to store the shared data of a highly available SAP system. For more information please refer [to Linux Clustering by using RHEL with GlusterFS](https://docs.microsoft.com/en-us/azure/virtual-machines/workloads/sap/high-availability-guide-rhel-glusterfs)
* **New Option – Coming Soon: Azure Shared Disks with WSFS & Linux Cluster support for ASCS VMs**: In Azure Shared Disks with WSFS & Linux Cluster support for ASCS VMs, any application that currently leverages SCSI Persistent Reservations (PR) can use this well-known set of commands to register nodes in the cluster to the disk. The application can then choose from a range of supported access modes for one or more nodes to read or write to the disk. These applications can deploy in highly available configurations while also leveraging Azure Disk durability guarantees. For more information , [please refer Azure Shared Disk with WSFS & Linux Clusters.](https://azure.microsoft.com/en-us/blog/announcing-the-preview-of-azure-shared-disks-for-clustered-applications/)
  + **HANA HA for VM Deployment**
    - **Host Auto – Failover**
      * Over Auto failover
      * Configuring Host Auto failover
      * Any additional Consideration
    - **Hana System Replication as HA**
      * HSR Deployment Options: with/without Data Pre-load
* **HANA HA for HLI Deployment**
  + Host Auto Failover
  + HSR
* **AnyDB HA Option**
  + SQL AlwaysOn Availability Groups HA pair
    - * + Oracle DataGard HA Pair For details see [SAP support note #1778431](https://launchpad.support.sap.com/#/notes/1778431)
        + IBM Db2. Find details in the article [Multiple instances (Linux, UNIX)](https://www.ibm.com/support/knowledgecenter/en/SSEPGG_10.5.0/com.ibm.db2.luw.admin.dbobj.doc/doc/c0004904.html)

**Disaster Recovery**

* **Design Business Continuity: HA, DR & Backup**
  + Azure High Availability capabilities
  + Azure Resiliency & SLAs
  + Availability Sets & Availability Zones
* **App Server DR**
* For App Server, use Azure Site Recovery for Disaster Recovery which will replicate the entire VM to secondary region.
* The SMLG transaction manages login groups for ABAP application servers.
* It uses the load-balancing function within the message server of the Central Services to distribute workload
* **AnyDB DR**
* Data Transmission Service to implement data migration and real-time synchronization between various databases, laying a solid foundation for database disaster recovery.
* Hybrid Backup Recovery (HBR) is a simple and cost-effective Backup as a Service (BaaS) solution
* **Database replication technology for DB DR (like SQL Always On, Oracle Data-guard)**

For Database Servers Disaster Recovery for DB like SQL, Oracle, use their native tool provided by vendor which ensures the transaction integrity with primary and secondary server. For SQL server configure SQL Always on and for Oracle replicate the database by using Oracle Data-guard.

* + HANA VM DR Approach
  + Hana System Replication as DR
  + Backup to local NFS mount point (Using NFS VM Cluster) and Move old backup files to Azure blob storage (AzCopy)
  + Backup to local NFS mount point (Using ANF) and Move old backup files to Azure blob storage (AzCopy)
    - Cleanup Old Backups ([Backup Retention](https://docs.microsoft.com/en-us/azure/backup/backup-azure-security-feature-cloud))
    - HANA backup based on storage snapshots manually
    - For VM with Premium Data Disks: using the Azure Disk Blob snapshot
    - For VM with ANF Data Disks: Using ANF Snapshot feature (recommended)
    - For HLI: Using Perl script from GitHub for NFS LUN level
* **Network Requirement**
  + Express route is required
* **Cost Considerations**
  + Express route cost
  + ASR
  + Download cost
  + VPN Gateway and Express router gateway cost
  + Storage cost
* **HANA HLI DR Approach**
  + HSR as DR
  + Storage Replication HLI

**Backup**

Backup is essential component for SAP workload environment. It will ensure the data back in place in case of any data corruption or accidental deletion incidence occurs. In Azure, leverage the benefit of Azure Backup which backup entire VM or files and folders easily and store in recovery service vault in encrypted format.

* **Backup options for SAP Application Servers** 
  + **Azure Managed Disks Snapshots: A** Snapshot is a full, read-only copy of a virtual hard drive (VHD). Snapshot is available for Operating System (OS) Disks and Data Disks as a backup. Please refer [Azure Managed Disks snapshots](https://azure.microsoft.com/en-us/updates/azure-managed-disks-incremental-snapshots-are-now-available/) for more details.
  + **Azure IaaS VM Backup:** Azure VM Backup provides independent and isolated backups to guard against unintended destruction of the data on VMs. This Backups are stored in a Recovery Services vault. Please refer [Azure VM Backup](https://docs.microsoft.com/en-us/azure/backup/backup-azure-vms-introduction) for more details.
  + **3rd Party Solutions**
    - Consider Backup Storage Locations
    - Consider Cost/Performance impact on S2S or ER when backing up to On-Prem
* **Any DB Backup - SQL**
  + **Manual Backup- Backup to URL :** In Azure Manual Backup -Backup/Restore to URL refers to Backup to Microsoft Azure Blob Storage Service. Please refer [Manual Backup to URL](https://docs.microsoft.com/en-us/sql/relational-databases/backup-restore/sql-server-backup-to-url?view=sql-server-ver15) for more details.
  + **MS Data Protection Manager based backup: Microsoft** Data Protection Manager is a backup tool which can be used to Backup and Restore the Virtual machines, File & Folders, Databases and bare-metal servers. Please refer [Microsoft Data Protection Manager](https://docs.microsoft.com/en-us/system-center/dpm/dpm-overview?view=sc-dpm-2019) for more details.
  + **Azure Managed SQL Backup (Azure Backup for SQL VMs) :**SQL Server Database Backup in Azure VMs can be performed by using Azure Backup Service. Please refer [SQL Server Database Backup in Azure VMs](https://docs.microsoft.com/en-us/azure/backup/backup-sql-server-database-azure-vms) for more details.
  + **Third party Backup Solutions:** In Azure Marketplace there are options of third-party backup solutions which can be used to back up the databases. Please refer [Backups Options Available in Azure Marketplace](https://azuremarketplace.microsoft.com/en-us/marketplace/apps/category/storage?page=1&subcategories=backup-and-recovery) for more details.
* **HANA Backup Options in Azure** 
  + **Azure VM Backup HANA Backint Support (Azure Native HANA backup)**

SAP HANA Databases are mission critical workloads which require a low recovery point objective and fast recovery time objective. Please refer for [SAP HANA Database Backup Solution](https://docs.microsoft.com/en-us/azure/backup/sap-hana-db-about) for More details.

* + **HANA backup to the file system in an Azure Linux Virtual Machine/ HLI.** Please refer [HANA Backup in Azure](https://docs.microsoft.com/en-us/azure/virtual-machines/workloads/sap/sap-hana-backup-guide) for more details.
    - Backup to local backup drive and then only backup that drive files to Azure Backup Recovery Service Vault.
    - Backup to local drive and Move old backup files to Azure blob storage (AzCopy)
    - Backup to local NFS mount point (Using NFS VM Cluster) and Move old backup files to Azure blob storage (AzCopy)
    - Backup to local NFS mount point (Using ANF ) and Move old backup files to Azure blob storage (AzCopy)
* **HANA backup based on storage snapshots manually** 
  + **For Virtual Machine (VM):** 
    - **For VM with Premium Data Disks: using the Azure Disk Blob snapshot:** In Azure, Azure Storage provides the capability to take snapshots of blobs. Snapshot capture the blob state at that point in time which later point can be used as Backup. Please refer [Azure Blob Snapshot as Backup](https://docs.microsoft.com/en-us/azure/storage/blobs/snapshots-overview) for more details.
    - For VM with Azure NetApp FilesANF Data Disks: Using ANF Snapshot feature (recommended): In Azure, Azure NetApp files provides a powerful enterprise-grade NFS and SMB file service to SAP environment. In Azure NetApp files a script is used to back up the SAP HANA which create a snapshot copy. Please refer [Azure NetApp Files Backup](https://blog.netapp.com/azure-netapp-files-sap-hana-backup-in-seconds/) for more details.
  + **For HLI: Using Perl script from GitHub for NFS LUN level:** In Azure, you can leverage the benefit of pearl script with GitHub to back up the HANA Database. Please refer [Backup with Pearl Script and GitHub](https://github.com/msjuergent/hana-large-instances-self-service-scripts) for more details.
  + **Third Party Backup tools:** In Azure Marketplace, there are third party backup solutions available which requires additional license. Enterprise Backup products can have additional capabilities compared to native azure backup. Below are the advantages including in third party backup products.
    - * Support for Various databases, including SAP HANA Scale-Out
      * Support for SAP HANA snapshot backup.
      * Data reduction through advanced compression and deduplication that decrease backup storage costs.
      * Customize backup policies.

### Design Security

* **Azure Storage Account:** In Azure, Storage Account contains all of Azure Storage data objects, Blobs, Files, Queues, tables and disks. Data in your Azure Storage account is durable and highly available, secure and scalable. Please refer [Azure Storage Account](https://docs.microsoft.com/en-us/azure/storage/common/storage-account-overview) for more details.
* **Azure SQL Services (Database and Server):** Azure SQL is a family of managed, secure and intelligent products that use the SQL server database engine in the Azure Cloud. Azure SQL Supports modern cloud applications. SQL Server on Azure Virtua Machines enable to use full version of SQL Server in the Cloud without having to manage any on-premise hardware. It also simplifies licensing costs and runs in many different geographic regions around the world. Please refer [Azure SQL](https://docs.microsoft.com/en-us/azure/azure-sql/virtual-machines/windows/sql-server-on-azure-vm-iaas-what-is-overview#:~:text=SQL%20Server%20on%20Azure%20Virtual%20Machines%20enables%20you%20to%20use,geographic%20regions%20around%20the%20world.) for more details.
* **Azure Security Overview**
  + **Security Landscape & Value:** Azure Security Center provides a wide range of tools and capabilities. These tools and capabilities help make it possible to create secure solutions on the Azure platform. Microsoft Azure provides confidentiality, integrity, and availability of customer data with transparent accountability. Please refer [Azure Security Center](https://docs.microsoft.com/en-us/azure/security/fundamentals/overview) for more details.
  + A screenshot of a cell phone

    Description automatically generated **Microsoft Shared responsibility model:** In Azure, Shared Responsibility Model provides the details about the responsibility of cloud service provider and customer. The workload responsibilities vary depending on whether the workload is hosted on Software-as-a-Service, Platform as-a-Service, Infrastructure-as-a-Service or On-Premise Datacenter. Please refer [Shared Responsibility Model](https://docs.microsoft.com/en-us/azure/security/fundamentals/shared-responsibility) for more details.

*Reference:* [*https://docs.microsoft.com/en-us/azure/security/fundamentals/shared-responsibility*](https://docs.microsoft.com/en-us/azure/security/fundamentals/shared-responsibility)

* **Azure Data Center Level Security**
  + Physical Security
  + Hardware & System Security
  + Multi-tenancy Layer Security
* **Designing Secure Identity and Access Management**
  + **Cloud identity Design Practice: Azure AD**
    - Integrating on-prem AD with Azure (Architecture Options -total 4 design options)
    - AP SSO Scenarios with Azure
    - SAP SSO with Azure AD: NW & HANA
  + Overview of Azure Active Directory Domain Services & SAP Limitation
* **Least Privilege Design Practice:** Lock down inbound traffic to your Azure Virtual Machines with Azure Security Center's just-in-time (JIT) virtual machine (VM) access feature. This reduces exposure to attacks while providing easy access when you need to connect to a VM.
* **Enable JIT on your VMs** - You can enable JIT with your own custom options for one or more VMs using Security Center, PowerShell, or the REST API. Alternatively, you can enable JIT with default, hard-coded parameters, from Azure virtual machines. When enabled, JIT locks down inbound traffic to your Azure VMs by creating a rule in your network security group.
* **Request access to a VM that has JIT enabled** - The goal of JIT is to ensure that even though your inbound traffic is locked down, Security Center still provides easy access to connect to VMs when needed. You can request access to a JIT-enabled VM from Security Center, Azure virtual machines, PowerShell, or the REST API.
* **Audit the activity** - To ensure your VMs are secured appropriately, review the accesses to your JIT-enabled VMs as part of your regular security checks.
* **Additional Identity Protection:** Privileged Identity Management provides time-based and approval-based role activation to mitigate the risks of excessive, unnecessary, or misused access permissions on resources that you care about.
* **Designing Secure Network & Communication**
  + **Planning Network Security**
  + Pattern # 1: Securing access from/to internet
    - Azure DDos Protection
    - Azure Managed Firewall
    - Azure Web Application Firewall
    - Azure Network Security Groups & UDRs
    - Azure Network Virtual Appliances
  + Pattern # 2: Securing access from/to Azure PaaS
  + Pattern # 3: Securing hybrid /on-prem traffic
* **Securing Your VM Access**
  + Essential practice for VM security
  + Secure VM Access with Azure Bastion
* **Designing Security for Data**
  + Data Protection
    - Data Encryption at Rest and in motion
    - Key Management: Azure Key Vault
* **Plan Security Monitoring & Management**
  + Azure Security Center
  + Azure Sentinel

#### Architecture Level

* Hub and Spoke Design

#### Network security

* Network Security Groups
  + Host level
  + Subnet Level

#### Security Monitoring

* Azure Threat Protection
* Logging and Monitoring
* Azure Security Center

#### Data Security

* Disk level Encryption
* Blog storage is encrypted

#### Identity and access controls

* Enable SSO for SAP
  + <https://docs.microsoft.com/en-us/azure/active-directory/saas-apps/sap-hana-cloud-platform-identity-authentication-tutorial>
* Enable MFA for SAP Applications
* Identity Access Management
* Azure Key vault

### Design Monitoring & Governance Controls

* **Monitoring**
  + Azure Enhanced Monitoring for SAP NetWeaver (SAP Note:1409604)
  + Use Existing Tools
  + Solution Manger Monitoring
* **Governance Controls**
  + Design Authority and Governance Owner
  + Azure Cloud Governance
  + Continue to leverage best practice SAP controls
    - Master Data Governance

### Define DevOps, Automation & Management Approach

* **DevOps**

Combination of cultural philosophies, practices, and tools that increases an organization’s ability to deliver applications and services at high velocity: evolving and improving products at a faster pace than organizations.

* **Automation**

A pipeline in a Software Engineering team is a set of automated processes that allow Developers and DevOps professionals to reliably and efficiently compile, build and deploy their code to their production compute platforms.

* **Management Approach**

This approach views management as an activity based on certain unique management functions. Management is regarded as a process for getting things done through the functions of planning, organizing, staffing, leading and controlling.

### Storage Considerations

* Blob Storage
* Disk
* Azure Premium SSD
* Ultra-Disk
* Azure NetApp Files
* Hot, Cold and Archive
* Redundancy
  + Local redundancy (LRS)
  + Zone redundancy (ZRS)
  + Geo Redundancy (GRS)
  + HANA VM Operations Storage and Recommendation

## Establish Best practice guidance

Temporarily beefing up the infrastructure to accelerate your SAP migration throughput and reduce the downtime. We recommend you leverage virtual machine accelerators for your SAP application and database layers. Enable Accelerated Networking on your virtual machines to accelerate network performance

Prepare best practices available for SAP Generic scenario

* PPG with AZ (Proximity Placement Group) : [PPG (Proximity Placement Group)](https://docs.microsoft.com/en-us/azure/virtual-machines/workloads/sap/sap-proximity-placement-scenarios) in Azure used for optimal network latency with SAP applications. SAP Applications based on the SAP NetWeaver or SAP S/4HANA architecture are sensitive to network latency between the SAP application tier and SAP database tier. To provide optimal latency and avoid the latency issues, azure offers Proximity placement groups.

Azure Proximity Placement Groups is a logical construct which is bound to an azure region and an azure resource group. When VMs are deployed, all subsequent VMs gets deployed in the same datacenter as the first virtual machine as close to each other.

* **Limitation**: Only Windows SOFS Clusters supported with ASR DR (as of Feb 2020), not Linux Cluster. For Linux workaround like RA-GRS Blob Storage custom job.

## Conduct Governance baseline discussion

Organization's development and IT departments to be agile by making it easy to create, read, update, and delete resources as needed. However, while giving unrestricted resource access to developers can make them very agile, it can also lead to unintended cost consequences. The solution to this problem is resource access governance—the ongoing process of managing, monitoring, and auditing the use of Azure resources to meet the goals and requirements of your organization

* **Business risks:** Identifying and understanding corporate risks.
* **Policy and compliance:** Converting risks into policy statements that support any compliance requirements.
* **Processes:** Ensuring adherence to the stated policies.

## First landing Zone

Before adoption can begin, you must create a landing zone to host the workloads that you plan to build in the cloud or migrate to the cloud. This section of the framework guides you through the creation of a landing zone.

### Organize Azure Resources

* Create Management groups
* Create Subscription: Use subscriptions to manage costs and resources that are created by users, teams, or projects.
* Configure Azure Policy
* Create User as Contributor
* Tagging Each Resource
* Choosing an Azure Region
  + Region pairs
  + Supported services/features
  + Data Sovereignty
  + Network Distance
  + Availability Zones
* Create Resource groups: A resource group is a logical container into which Azure resources like web apps, databases, and storage accounts are deployed and managed.

### Network Setup

This section describes the different options to setup a network

* **Virtual Network / Subnet** 
  + Dev Environment Subnet
  + QA Environment Subnet
  + Production Environment Subnet
* **Network Security Group** 
  + SAP Application Network Security Group
  + SAP Database Network Security Group
* **Azure Firewalls**
* **Configure the Diagnostics Settings**

### Hybrid Network setup

This is an optional setup for organizations who wants to connect their on-premises network to Azure cloud. Here are the available options to connect to Azure cloud:

* **Express Routes: Provide connection between on-premises network and the Microsoft cloud in three different ways.** 
  + Cloud Exchange Co-location.
  + Point-to-point Ethernet Connection.
  + Any-to-any (IPVPN) Connection
* **Hub-n-spoke: Azure supports two types of hub and spoke design.** It supports communication, shared resources, and centralized security, or a design based on Azure Virtual WAN for large-scale branch-to-branch and branch-to-Azure communications.
* **Forced Tunnelling:** There are two options to configure Azure Forced Tunnelling,
  + Using a VPN Gateway.
  + Forced tunnelling via Azure Firewall.

**Note**: *For information about the deployment models, see Understanding deployment models. If you are new to Azure, we recommend that you use the Resource Manager deployment model.*

### Domain Controller setup

If using AD on-Prem, extend AD into Azure VNet for reduced auth latency, added resilience, etc and follow below steps:

* Deploy a new Windows Server VM to the appropriate VNet.
* Create availability sets in each location for the VM. Availability sets ensure that the Azure fabric separates the VMs into different infrastructures in the Azure region and allows Contoso to be eligible for the 99.95-percent SLA for VMs in Azure.
* They attach a new data disk to the VM. This disk contains the Active Directory database and the SYSVOL share.
  + The size of the disk will determine the number of IOPS that it supports.
  + Over time the disk size might need to increase as the environment grows.
  + The drive shouldn't be set to read/write for host caching. Active Directory databases don't support this.
* Enable ADDS and configured as a DC

# Adopt Phase

Adopt phase provides the implementation steps for migration, innovation and testing. Whether looking to migrate existing workloads to the cloud or innovating something new, this phase is where the technology implementation takes place to deliver on the business expectations and align to the cloud adoption plan

## SAP Deployment Summarization

### Proof of Concept (POC)

You can run a pilot before or during project planning and preparation. We assume you've already identified a system that you want to migrate to Azure for the pilot ([Deployment Guide](https://docs.microsoft.com/en-us/azure/virtual-machines/workloads/sap/deployment-guide)). Below are the key points to consider:

* **Mange Bandwidth to Azure from On-Premise data transfers**
* **Consider Cleaning up Data from the Database in on premises before moving it to cloud**
  + Review the SAP article for Data Volume Management ([DVM](https://help.sap.com/viewer/c3c5ec585ee248228ddb6c3f08073ea9/7.2.04/en-US/c6f56656a6d7d054e10000000a441470.html))
* **Build Azure VMS and Validate**
* **Access**
  + For Windows Virtual Machines we need to use RDP with 3389 Port enabled in Network Security Group
    - Use Credentials which are provided during VM creation
  + For Linux Virtual Machines we need to use SSH with 22 port enabled in Network Security Group
* **VM types**
  + Use Azure VMs certified for SAP HANA SKU sizes. [Certified SKUs](https://www.sap.com/dmc/exp/2014-09-02-hana-hardware/enEN/iaas.html#categories=Microsoft%20Azure)
* **OS Settings or Patches**
  + Azure Update Management
    - It assesses the environment across subscription for updates (Windows and Linux SAP VMs) from central location
      * Provide Classifications for Update
      * Critical Updates
      * Security Updates
      * Feature Packs
      * Service Packs
    - Log Analytics Agent for OS
  + Use Premium SSD or Ultra SSD for Operating System and Data Storage and Azure NETAPP files.
* **Network**
  + Connect the vNIC to subnet in defined VNET
  + Ensure the On-Premise connectivity to cloud (Express Route or VPN Site-2-Site Connection)
* **Plan Migration and Decide on the Approach** 
  + Decide on the SAP Tools being used by running all the available options (SWPM, DMO or SUM) And create a run book and finalize on the approach for the next systems migration in SAP Landscape
* **For Greenfield Implementation use SWPM Tool**
  + Software Provisioning Manager offers the execution of many system provisioning tasks and covers a broad range of platforms and products.
  + Supports both on the ABAP and the Java technology.
  + The task can be to copy an SAP NetWeaver system, rename an SAP Business Suite system, or install a standalone engine (such as SAP liveCache), all tasks can be handled with Software Provisioning Manager.
* **For OS/DB and Application Migration use SUM**
* **For HANA Migration / Conversions use SUM with DMO** 
  + Use for existing SAP ABAP system to the SAP HANA database
  + Use the database migration option (DMO) of the Software Update Manager (SUM) it combines SAP upgrade and database migration to SAP HANA in One tool.
  + **Use Automate your Azure Migration (**[**Automated Deployments**](https://azure.microsoft.com/en-gb/blog/automating-sap-deployments-in-microsoft-azure-using-terraform-and-ansible/)**)**
  + Use tools to automate the deployment process
  + Azure ARM Templates
  + Terraform
  + Ansible Playbook
    - **Azure Data Copy (**[**Azure Data Factory**](https://docs.microsoft.com/en-us/azure/data-factory/quickstart-create-data-factory-copy-data-tool)**)**
  + Cloud-based ETL and data integration service that allows you to create data-driven workflows for orchestrating data movement and transforming data at scale.
  + **Archive and compress data and check**
  + Come up with strategy for Archive data that are either retained for internal or regulatory compliance
  + Move the Archive data to Archive Tier in Azure Blob Storage for long term retention.
* **Test your backup/restore sequence**
  + Configure Azure Backup in same region where resources deployed with schedule backup policy and retention policy.
  + Use Application Crash Consistent Backup
* **Test your high availability and disaster recovery procedures**
  + Use Availability Sets (99.95% SLA) or Availability Zones (99.99 % SLA) for VM
  + Configure Azure Site Recovery for Disaster Recovery Environment
  + \*We need to change license in ASR Failover
* **Security checks**
* **SAP Pen Tests**
  + **Whitebox Testing:** White-box testing is a method of software testing that tests internal structures or workings of an application, as opposed to its functionality.
  + **Blackbox Testing:** Black Box Testing is a software testing method in which the internal structure/ design/ implementation of the item being tested is not known to the tester.
  + **Gray box Testing:** Gray box testing is a technique to test the software product or application with partial knowledge of the internal workings of an application. This testing will identify the defects due to improper code structure or improper functioning usage of an application.
  + **Red Team / Blue Team Testing:** A **Red team** is a group that helps organizations to improve themselves by providing opposition to the point of view of the organization that they are helping. They are often effective in helping organizations overcome cultural bias and broaden their problem-solving capabilities. A **Blue team** who perform an analysis of information systems to ensure security, identify security flaws, verify the effectiveness of each security measure, and to make certain all security measures will continue to be effective after implementation.
* **Performance testing**
  + Use Benchmark tool to test the performance as below
  + IOMETER /FIO – To Test Storage Performance
  + NIPING – (Tool Delivered by SAP) - This tool is used by SAP support to check on the network connectivity and more important latency and throughput on the network
* **Monitoring Setup**
  + Configure Azure Monitor to monitor the key resources like CPU Usage, Disk Metrics, Network Usage.
  + Azure Monitor can be used to set alerts during incident or high resource usage.
* **Export ARM Templates and store in Azure Template Library:** To Rebuild the Instance in case of redeployment, ARM templates can be used as a QuickStart.

### Non-production phase

In the production phase, we start to deploy non-production SAP systems into Azure following a successful POC, leveraging all the testing and validation tasks. Additional steps you need to consider during that phase include:

* + **Migrate in waves (**[**White Paper on Azure**](https://azure.microsoft.com/en-us/resources/migration-methodologies-for-sap-on-azure/)**)**

### Production preparation phase

* Work through necessary SAP release upgrades of your production systems before moving into Azure.
* Agree with the business owners on the functional and business tests that need to be conducted after the migration of the production system.
* Test production migration process into Azure. In cases where you are not moving all production systems to Azure within the same timeframe, identify groups of production systems that need to reside in the same hosting location.

### Go-live phase

Don't accept last-minute changes in configurations and process. In addition, apply the following measures:

* Verify that monitoring is operational. Recommended monitoring approach includes Azure portal, Azure Monitor as well as Perfmon for Windows and SAR for Linux. Monitor the following counters:
* **Avoid Last Minutes Requests**
  + Avoid changes to migrated workload apart from plan and strategy
* **Verify Monitoring Tools**
  + Verify the statistics of CPU, RAM, Disk and Network Latency
  + Perform ABAP Meter Test after migration to ensure application and database performance benchmarks are up to the mark.
* **Test Scanning and Printing**
  + Plan to execute printing test and ensure scanning time are in defined SLA
  + Check whether Interfaces are functioning, and other applications are communicating with newly deployed application systems.
  + Execute a Smoke-test with aligned resources.
  + Check transport and management systems using SDMS.
* **Check Backups and Replication**
  + Verify the VM and Database Backups and replication to ensure roll-back /crash-recovery plan.
  + After migration check database replication

### Post Go live

**Azure-specific tasks include:**

* Monitoring and analyzing Azure resource billing
* Optimizing price/performance ratio of Azure compute and storage resources.
  + Use Azure Advisor to optimize and recommendation
* Minimizing cost by stopping/deallocating Azure VMs, which aren't actively used.

## Implementation Guidance

In this section we will be discussing on the special considerations for each scenario to be followed/considered to come up with right decisions.

### Greenfield Implementation

This is a new implementation of SAP (greenfield) for customers/partners who are migrating from a non-SAP legacy system or from an SAP ERP system and implementing a fresh system that requires an initial data load. The new implementation process will be discussed in this scenario.

* **SAP On-Premises and Cloud Combination**
  + **Non-Production On-Premises**
    - Non-Production Environment can be created on physical & virtual servers.
    - Identify the Hardware requirements based on SAP recommendation
    - Configure the Storage and Storage Fabric for Servers
    - Configure the Network for Servers and Firewall Rules (On-Server and Network)
    - Deploy and Configure base Operating System
    - Install Required Security Patches released by OEM Vendors and SAP Software
    - Validate the installation and prepare for testing
  + **Production on Azure**
    - Create an Azure AD Use and Assign Contributor Role to Subscription
    - Create Resource Group in specified region
    - Establish Hybrid Connectivity with Express Route from On-Prem to Azure or Site-to-Site VPN
    - Create a Log Analytics Workspace (Diagnostics and Monitor Metrics)
    - Create Virtual Network (VNET) and define specific subnets for below resources
      * Jump Box
      * Production Application Workload
      * Production Database Workload
    - Create and Configure Application Gateway (Load Balancer and WAF)
    - Create and configure internal load-balancer between Application, Database intra-communication and NSG and Apply on Subnet Level as Best Practices.
    - Create Storage Account with General Purpose V2 Kind, Specify Redundancy as per requirement.
    - Create Virtual Machines (Application and Database)
      * Select the VM Size SKUs from SAP Certified VM SKUs List
      * Use Managed Disks for Operating System/Data
      * Use Premium SSD Disks (Standard SSD, Ultra SSD)
      * Use Availability Zone (For Datacenter Redundancy) or Availability Set (For Planned or Unplanned maintenance Failure)
    - Configure Virtual Machines and Update with Latest Security updates.
    - Create Virtual Network Interface Resource and attach to specific VMs
    - Enable Boot and Diagnostics Logs
    - Disable the Public IP requirement for the VM
    - Enable the Diagnostics Logs for all resources and Azure Monitor
    - Enable Port 3389 for RDP (Windows) and 22 Port for SSH (Linux) for remote management.
    - Enable Azure Backup for Application and Database VM
    - Apply Tags for all deployed resources
    - Export ARM templates from all resources and store it into Azure Template Gallery
    - For VMs destined to run SAP HANA, Microsoft uses a storage configuration that is known to pass the SAP HANA Hardware

Configuration Check Tool (HWCCT) for SAP HANA Platform 1.0 and SAP HANA Hardware and Cloud Measurement Tools for SAP HANA Platform 2.0 or newer.

* + **Azure Cloud Implementation**
    - High Level Design Document
    - Current vs Target Inventory
    - High Level Solution Architecture
    - Services available per Azure Region
    - Block Diagram of Solution
    - Sizing of Compute and Storage
    - OS, DB and Kernel Details
    - Business Continuity and DR
    - Inventory of SAP Interfaces/ NON-SAP Interfaces
    - Foundational Services (AD, DNS, NTP)
    - Naming Conventions (Azure Resources)
    - Build Automation to save significantly manual effort
    - Production Migration Planning
    - Agree with business on timings
    - Consider production dependency
    - Adjust operational scripts

### Test before actual migration Rehost Scenario for SAP

* **Rearchitect (Rehost)**

Rehosting means when the current operating system (OS) and database management system (DBMS) that are being used on-premises can be migrated to Azure without the need to change either.

* + Assessment on Rehost scenario for SAP
    - Gather real resource utilization data from existing on-premises SAP servers
    - Identify the workload is virtualized or non-virtualized
    - Based on real resource utilization data choose VM Size in Azure from certified SKUs
  + Baseline Best Practice for rehost and rearchitect Scenario for SAP
    - **Choosing the Right Migration Strategy**
      * **Rehosting**: The rehosting strategy involves lifting and shifting and is ideal for organizations which want quick migration to the cloud.
      * **Re-architecting:** The re-architecting strategy is also one of the cloud migration best practices. Organizations can choose re-architecting for modifying entire applications for addressing business use-cases.
    - Identify and Review the Workloads
    - Document the Exiting Performance Baselines
    - Choosing the right cloud migration model
    - License management
    - Access management
    - Network management
    - Evaluate the chosen approach
* **Rebuild:** Use of ARM templates in Azure can be used to rebuild Entire SAP Environment. It Will include all azure resources

### OS/DB Migration

* **On-Prem OS to Cloud Migration**
* Assessment of the On-Prem Server and planning
* prepare a machine for the Azure Migrate replication appliance that's used to discover and migrate machines to Azure.
* Add the Azure Migrate Server Migration tool in the Azure Migrate hub.
* Set up the replication appliance and Install the Mobility service on machines you want to migrate.
* Enable replication and run a test migration to make sure everything's working as expected.
* Run a full migration to Azure.
* **Virtual VM to Cloud Migration**
* Prepare Azure to work with Azure Migrate.
* Create an Azure Migrate project
* Azure Migrate uses a lightweight Azure Migrate appliance to discover and assess Hyper-V VMs.
* Create Azure AD app and Set up an Azure network
* Prepare for assessment and Verify Hyper-V host requirements
* Allows you to create a local user account (not administrator) that the Azure Migrate
* Set up an Azure Migrate project and Set up, register an Azure Migrate appliance
* Start continuous discovery of on-premises VMs and Prepare to migrate Hyper-V VMs
* Start replicating VM an Run a test migration to make sure everything's working as expected.
* Run a full VM migration
* **On-Prem Database to Cloud Migration** **Database Migration Option (DMO)** with System Move option

SAP introduced the DMO to the Software Update Manager (SUM) originally to simplify the migration to the SAP HANA database. In this process below are three steps covered

* System upgrade
* Unicode conversion if required
* Database Migration + Cloud Migration
* DMO performs an in-place migration to SAP HANA, which means that no switch of application server is possible, and cross data center migration is not supported due to network latency and throughput SAP does allow you to use DMO for data center migration when it’s executed with the System Move option.
* The process of migrating the system using DMO starts on the source system, where the Software Update Manager (SUM) is started. During the first phase, SUM executes system checks and prepares the system for the update. When running the DMO as part of a cloud migration (with the System Move option), there are two ways to transfer the extracted data to the target environment:
  + **Sequential data transfer**

Sequential data transfer works in a similar way to classical migration. All data is exported to a filesystem on the on-premises system. When the export is over, the entire SUM directory has to be transferred and then the import continues.

* + **Parallel data transfer**

In the parallel data transfer mode, the SUM directory is manually transferred to the target environment before the source system is fully exported. A file replication mechanism using SAP-delivered scripts transfer the data to the cloud and the SUM imports the packages to the target environment in parallel to the source export process. When all data has been imported, the SUM continues with the Update downtime phase. The parallel data transfer mode significantly decreases the total system downtime and is an effective optimization technique where the target database is SAP HANA or SAP ASE.

### HANA Conversion

* + Check for [Configuration Guide](https://docs.microsoft.com/en-us/azure/virtual-machines/workloads/sap/hana-vm-operations)
* Correctly size your HANA landscape
* Choose the right platform, migration strategy and Cleanse your data
* Apply high implementation standards
* integrating sap HANA with your data center
* Transitioning custom code post HANA
* Do a proof of concept
* Prepare a Proper Test Plan

### Best Practice

* **Proximity Placement Group with AZ**

Limitation: Only Windows SOFS Clusters supported with ASR DR (as of Feb 2020), not Linux Cluster. For Linux workaround like RA-GRS Blob Storage custom job.

* Network Security ([Azure security capabilities](https://docs.microsoft.com/en-us/azure/security/fundamentals/overview))
* Workstation Security ([Point-to-Site VPN](https://docs.microsoft.com/en-us/azure/vpn-gateway/vpn-gateway-howto-point-to-site-rm-ps))
* **SAP Best Practices**
  + - SAP Architecture Components & HA requirements ([Readiness Checks](https://launchpad.support.sap.com/#/notes/2758146))
* SAP ASCS/SCS Clustering HA requirements & NW 7.4+ changes
  + - Hybrid Mode ([Non-Prod vs Production](https://launchpad.support.sap.com/#/notes/1619168))
* Windows: Using file share: Scale Out File Share (Windows 2016 SOFS + S2D)
* Windows: Using Azure Net App File (SMB) with WSFC
* Windows: Using clustered shared disks (WSFC + SIOS Data Keeper Shared Disk)
* Linux: Clustering by using the SLES cluster framework (With NFS Cluster OR ANF)
* Linux: Clustering by using RHEL GlusterFS framework (With GlusterFS OR ANF)
* New Option – Coming Soon: Azure Shared Disks with WSFS & Linux Cluster support for ASCS VMs
  + With SAP Software Provisioning Manager ([SWPM](https://wiki.scn.sap.com/wiki/display/SL/List+of+Important+SAP+Notes+and+KBAs))
  + With SAP Software Update Manager ([SUM](https://wiki.scn.sap.com/wiki/pages/viewpage.action?pageId=421366825))
* For MS SQL DB Migration SQL DB As Service Option Available

## Testing Environment after Azure Migration

Outline typical lift and shift of Dev Environment to Azure. Enables testing the water and aligns with standard business practices to meet the Application Testing Functionalities.

### OS/DB Testing

* Use SAP Standard Testing Methodologies
* Data Validations before and after Migration
* Server to server communication Network Layer Testing
* Integration Testing
* SAP Security and Authorizations Testing

### Application Testing

* Optimization of internal operations
* Server to server communication Testing
* Data Validations before and after Migration
* Automated and Manual Testing Methodologies
* SAP Interface Testing

### Functional Testing

* Conduct Base Line Testing Before Migration
* Functionalities Testing Before and After Migrations
* SAP Regression Testing
* Testing – Critical Process
* Scenario-based Testing
* SAP End-to-End Testing

### Performance Testing

* Network Testing
* Speed tests
* SAP Load Testing

# Governance

Governance specifies the accountability framework and provides oversight to ensure that risks are adequately mitigated, while management ensures that controls are implemented to mitigate risks.

## Govern – Cost Management

* M-series virtual machines (VMs)
* Consider Adoption of Cloud Services to reduce both Direct and Indirect costs
* Azure Large Instances for HANA
* NetWeaver-certified virtual machine updates
  + - Achieve a lower price to performance ratio with our new NetWeaver-certified virtual machines

## Azure Governance for SAP Workload

Azure Governance can be described simply as mechanisms and processes to maintain control over your applications and resources in Azure. Azure has many services and tools that work together to provide complete management. These services aren't only for resources in Azure, but also in other clouds and on-premises. Governance in Azure is one aspect of Azure Management.

* Need for Governance in Cloud
* Value of governance & Cloud native governance
* Overview of Azure Governance controls & services
* Generic Governance Controls
* Subscription Managements
* Naming Standards
* Resource Groups & RBAC
* Resource Organizing Controls
  + - Management Groups
    - Resource Tags
    - Resource Graph
* Resource Locks
* Azure Policies
* Overview of Azure Policy and its key Pillars
* Azure Policy helps to enforce organizational standards and to assess compliance at-scale. It evaluates resources in Azure by comparing the properties of those resources to business rules.
* Azure Policy in Development Process
* Azure Policy Demo & Example
* Allowed Storage Account SKUs (Deny): Determines if a storage account being deployed is within a set of SKU sizes. Its effect is to deny all storage accounts that don't adhere to the set of defined SKU sizes.
* Allowed Resource Type (Deny): Defines the resource types that you can deploy. Its effect is to deny all resources that aren't part of this defined list.
* Allowed Locations (Deny): Restricts the available locations for new resources. Its effect is used to enforce your geo-compliance requirements.
* Azure VM Guest Policy
* Azure Policy Best Practices
* Azure Blueprints
* Azure Blueprints enables cloud architects and central information technology groups to define a repeatable set of Azure resources that implements and adheres to an organization's standards, patterns, and requirements.

## Identity

Identity governance products differ from identity and access management systems by enabling organizations to define, enforce, review and audit IAM policy, but also map IAM functions to compliance requirements and in turn audit user access to support compliance reporting.

* Azure Active Directory
  + SAP Cloud for Customer SSO
* Single Sign on (SSO)
* SAP Native Identity

## Resource based access control & resource locking

* **RBAC:** Azure role-based access control (Azure RBAC) is a system that provides fine-grained access management of Azure resources. Using Azure RBAC, you can segregate duties within your team and grant only the amount of access to users that they need to perform their jobs.
  + [Allow](https://docs.microsoft.com/en-us/azure/role-based-access-control/overview) one user to manage virtual machines in a subscription and another user to manage virtual networks
  + Allow a DBA group to manage SQL databases in a subscription
  + Allow a user to manage all resources in a resource group, such as virtual machines, websites, and subnets
* **Resource Locking**

Lock Azure Resource. Resource Manager Locks provide a way for administrators to lock down Azure resources to prevent deletion or changing of a resource. These locks sit outside of the Role Based Access Controls (RBAC) hierarchy and, when applied, will place restrictions on the resource for all users.

* + [Accidental deletion](file:///C:\Users\ptghyd\Desktop\Microsoft\SAP\%09https:\docs.microsoft.com\en-us\azure\azure-resource-manager\resource-group-lock-resources) or modification of Azure resources
  + A read-only lock on a storage account prevents all users from listing the keys.
  + A read-only lock on an App Service resource prevents Visual Studio Server Explorer from displaying files
  + A read-only lock on a resource group that contains a virtual machine prevents all users from starting or restarting the virtual machine.
  + A cannot-delete lock on a resource group prevents Azure Resource Manager from automatically deleting deployments in the history.

## Security Authentication

Azure App Service provides built-in authentication and authorization support, so you can sign in users and access data by writing minimal or no code in your web app, RESTful API, and mobile back end, and also Azure Functions which are not required to use this feature for authentication and authorization

* **AzureAD SAML:** Azure Active Directory uses the SAML 2.0 (Security Assertion Markup Language) protocol to enable applications to provide a single sign-on experience to their users.
  + It supports On-Premises and Cloud scenario.
* **AD SSO Kerberos:** The Kerberos authentication protocol provides a mechanism for authentication - and mutual authentication - between a client and a server, or between one server and another server.
  + Deploy Active Directory Infrastructure in On-Premises to elevate Kerberos Authentication to Client, Servers, and Users with SSO capability.

## Data Integrity

Data integrity refers to the accuracy and consistency (validity) of data over its lifecycle. Data integrity can be compromised in several ways.

* [**Azure Storage Encryption**](https://docs.microsoft.com/en-us/azure/storage/common/storage-service-encryption)
  + **Application Server**
    - Recommended for Operating system and data disk
  + **Database Server**
    - Recommended for OS and any other disk other than DBMS
* **Hardening the Operating system**
  + [**Center of internet Security (CSI)**](https://docs.microsoft.com/en-us/azure/security/fundamentals/azure-disk-encryption-vms-vmss)
* [**Transport Data Encryption**](https://docs.microsoft.com/en-us/azure/azure-sql/database/transparent-data-encryption-tde-overview?tabs=azure-portal)
  + Leverage Options provided by DBMS Provider
  + Azure SQL Transparent Data Encryption with customer-managed key
* [**Backup Encryption**](https://docs.microsoft.com/en-us/azure/backup/backup-encryption)
  + Encryption of backup data using platform-managed keys/customer-managed keys
  + Backup of managed disk VMs encrypted using customer-managed keys
  + Infrastructure-level encryption for backup data
  + Backup of VMs encrypted using ADE

## Network Security

Network security could be defined as the process of protecting resources from unauthorized access or attack by applying controls to network traffic. Network connectivity is possible between resources located in Azure, between on-premises and Azure hosted resources, and to and from the internet and Azure.

* **Architecture level**
  + Hub and Spoke Design (Express Route)
  + Site-to-Site VPN
* **Network Security Groups (NSG)**
  + NSG (Network Security Group) is a software firewall to monitor and perform action on inbound and outbound traffic.
  + Configure NSG on Subnet Level for better control and management
* **Firewall port configuration**
  + Deploy Application Gateway with WAF Feature enabled
  + Application Gateway will work as gateway firewall and allow/deny the traffic on defined rules.
* **SAP Router configuration**
* **Operating system firewall configuration**
  + Enable Operating System firewall and Close all unnecessary ports
  + Enable required ports for specific IP/Subnet range

## Security Baseline

Security Baseline defines a set of basic security objectives which must be met by any given service or system. These details depend on the operational environment a service/system is deployed into, and might, thus, creatively use and apply any relevant security measure

### Azure Bastion

* Azure Bastion is a fully managed Azure PaaS service which provides secure and seamless RDP and SSH access to your virtual machines directly through the Azure Portal.
* Azure Bastion is provisioned directly in your Virtual Network (VNet) and supports all VMs in your Virtual Network (VNet) using SSL without any exposure through public IP addresses

### Security and Compliance

Design and implementation of the following services to SAP on Azure setup and configuration.

* Utilize [Azure Security Center](https://docs.microsoft.com/en-us/azure/security-center/security-center-intro) to strengthen the security and compliance posture of your infrastructure.
* Integrate [Security Center with Azure Sentinel](https://docs.microsoft.com/en-us/azure/sentinel/connect-azure-security-center) for proactive monitoring and threat mitigation.
* Implement Azure Firewall or a Network Appliance to restrict access only to SAP Resources
* Azure has the broadest [compliance coverage](https://aka.ms/AzureCompliance) in the industry, including key independent certifications and attestations such as ISO 27001, ISO 27017, ISO 27018, ISO 22301, ISO 9001, ISO 20000-1, SOC 1/2/3, PCI DSS Level 1, HITRUST, CSA STAR Certification, CSA STAR Attestation, US FedRAMP High, Australia IRAP, Germany C5, Japan CS Mark Gold, Singapore MTCS Level 3, Spain ENS High, UK G-Cloud and Cyber Essentials Plus, and many more.
* Microsoft Intelligent Security Graph:
* Azure Policy
* Microsoft Azure blueprint for Zero Trust

### Best Practice

* Design Monitoring & Governance Controls
* Define DevOps, Automation & Management Approach
* Detail Configuration Document for SSO for SAP
* Enable SSO for SAP

## Business Continuity and Disaster Recovery

* Customers can implement BCDR for their SAP hosts using ASR. This would protect the VMs and provide faster recovery from disasters.
* For BCDR solution use Azure Site Recovery Services from Azure which provide end-to-end Business continuity solution for Azure SAP Workloads
* Create Resource Group, Virtual Network/Subnets, Storage Account (General PurposeV2), VPN Gateway (On-Premises Site-to-Site) or Express Route in Secondary Region.
* Deploy Azure Site Recovery Services Vault in another (secondary region).
* Implement Traffic Manager to redirect the traffic to secondary/primary region after failover and failover.
* Document SAP Licenses

## Governance – Resource Consistency

**Asset classification**

Establish resource tagging standards and ensure IT staff apply them consistently to any deployed resources using Azure resource tags.

**Service discoverability and shadow IT**

Configure policy for resource tagging

**Service disturbance**

Microsoft Cloud services audit report and service alert configuration

[SAP on CAF Govern Security Policy Consolidated List](https://teams.microsoft.com/l/file/91123B0B-8F48-48BD-8AF5-6E9B9F67600F?tenantId=72f988bf-86f1-41af-91ab-2d7cd011db47&fileType=xlsx&objectUrl=https%3A%2F%2Fmicrosoft.sharepoint.com%2Fteams%2FCAFEnablementKitDevelopment%2FShared%20Documents%2FGeneral%2FCAF%20SAP%20-%20Partner%20Enablement%20Toolkit%2FCAF%20SAP%20-%20Technical%20Enablement%2FSAP%20on%20CAF%20Govern%20Security%20Policy%20Consolidated%20Ver1.0.xlsx&baseUrl=https%3A%2F%2Fmicrosoft.sharepoint.com%2Fteams%2FCAFEnablementKitDevelopment&serviceName=teams&threadId=19:ebd0bd36bcac46b08910c3636612eaa6@thread.tacv2&groupId=ad2e05a5-d50a-4987-9790-2f6bacb4c217)

# Manage

Management refers to the tasks and processes required to maintain your business applications and the resources that support them. Azure has many services and tools that work together to provide complete management.

* Manage: Establish governance Team & governance benchmark

Cloud governances is an iterative process. When migration performed completely from On-premise to Azure Cloud, governance will be stage to ensure all the migrated assets meets the organization compliance policy. To ensure this Cloud Adoption Framework recommends establishing an initial cloud governance foundation.

There are two approaches to establish an initial governance foundation

* [Standard Governance Guide](https://docs.microsoft.com/en-us/azure/cloud-adoption-framework/govern/guides/standard/)

A standard governance guide, for most organizations is based on the recommended initial two-subscription model, designed for deployments in multiple regions but not spanning public and sovereign /government clouds.

* [Governance guide for complex enterprises.](https://docs.microsoft.com/en-us/azure/cloud-adoption-framework/govern/guides/complex/)

This guide is for enterprises which are managed by multiple independent IT business units or span public and sovereign /government clouds

**Governance benchmark tool**

Cloud adoption framework provides a governance benchmark tool which can be used to identify gaps in organization across six key domains as defined in the framework. Please refer to [Governance Benchmark tool](https://cafbaseline.com/) for more details.

* **Architecture Review & Optimization with best practices** 
  + Cost Optimization is one of the key components in Optimization section which can be done by reviewing the architecture. To achieve this, use Cost Management tool.
  + Azure Cost Management

Azure Cost management provides the tools to plan, analyze and reduce the spending to maximize cloud investments. Please refer for Best practices of [Azure Cost management](https://docs.microsoft.com/en-us/azure/cost-management-billing/costs/cost-mgt-best-practices)

* **Establish Operational SLA & Management Baseline.** 
  + This section will elaborate through various transitions into operational SLA and management baseline in the cloud. As per the cloud adoption framework, there are two best practices which references to guide operations management maturity in the cloud.
    - * [Azure Server Management](https://docs.microsoft.com/en-us/azure/cloud-adoption-framework/manage/azure-server-management/)

Azure Server Management means, an onboarding guide to incorporating the cloud-native tools and services needed to manage operations.

* [Hybrid Monitoring](https://docs.microsoft.com/en-us/azure/cloud-adoption-framework/manage/monitor/)

Hybrid Monitoring help to compare the cloud-native reporting tools with Operation Manager tooling (SCOM).

For more information, please refer to [Establish Operational SLA & Management Baseline](https://docs.microsoft.com/en-us/azure/cloud-adoption-framework/manage/best-practices)

* **Documentation and Training**
  + Establish centralized documentation repository
    - Create a central repository in SharePoint or Azure Files to store all the documents related to migration activity.
  + Handover
  + Managed Support Services
* **Hyper Care Planning**
* **Support Planning (**[**SLA**](https://azure.microsoft.com/en-us/support/legal/sla/)**)**
  + Definitions of Support at Azure: ([**Key Services**](https://help.sap.com/viewer/d0224eca81e249cb821f2cdf45a82ace/2005/en-US/8c02926e86691014b692e1804de14a0b.html?q=Infrastructure%20as%20a%20Service))
  + IaaS: Infrastructure as a Service
  + PaaS: Platform as a Service
  + SaaS: Software as a Service
* **Monitoring IaaS & Challenges**

Azure Monitor for SAP Solutions is an Azure-native monitoring product for customers, running their SAP landscapes on Azure. With Azure Monitor for SAP Solutions, customers can collect telemetry data from Azure infrastructure and databases in one central location and visually correlate telemetry data for faster troubleshooting.

* + **How the applications consume the following resources:**
* CPU
* Memory
* Network bandwidth
* Disk space
  + **CPU resource consumption:** CPU resources available to work through the data that is stored in memory. Nevertheless, there might be cases where HANA consumes many CPUs executing queries due to missing indexes or similar issues.
  + **Memory consumption:** Monitor how the data is consuming HANA allocated memory in order to stay within the required sizing guidelines of SAP.
  + **Network bandwidth:** Monitor the data received by all the Azure VMs within a VNet to figure out how close you are to the limits of the Azure gateway SKU you selected.
  + **Disk space:** Disk space consumption usually increases over time. Most common causes are: data volume increases, execution of transaction log backups, storing trace files, and performing storage snapshots.

Companies may not initially realize many cloud computing benefits when they migrate their SAP systems to the cloud. Multiple unexpected and expensive challenges can arise throughout the migration process. Here are the three major challenges to watch for.

* + **Inconsistent Standards:** One hurdle SAP customers need to jump when migrating SAP systems to (and operating them in) the cloud is inconsistent standards. Usually, SAP migrations to the cloud, at least in their initial stages, are hybrid. These hybrid migrations combine the legacy on-premise systems with those migrated to the cloud. This can potentially result in gross inefficiencies, or even worse, failures.
  + **Lack of Visibility:** Regardless of whether a business is running its SAP systems completely in the cloud or using a hybrid solution, a crippling lack of landscape visibility and insights around SAP system performance can happen for IT operators and MSPs when they rely on the cloud provider's default monitoring tools. With no cross-environment visibility, it becomes practically impossible to do accurate planning and budgeting for cloud and infrastructure resources.
  + **Higher Expenses Than Expected Due to** Inefficient **Scaling:** Properly and automatically scaling SAP systems in the cloud is paramount to minimize operating costs and ensure user satisfaction, due to optimal system functionality. Inefficiently scaling SAP systems hosted on pay-as-you-use cloud environments can skyrocket operation costs, as you’ll be running the system consistently in maximum capacity.
* Azure Monitor Architecture
  + Azure Monitor Components
    - Azure monitors provide comprehensive solution for collection, analyzing and acting on telemetry from cloud and on-premises environments.
    - Azure monitor provides the ability to understand how applications are performing and identifies the issues proactively which are affecting then and their dependencies.
    - Azure monitor includes
    - Detect and diagnose issues across applications and dependencies with Application Insights.
    - Correlate infrastructure issues with Azure Monitor for VMs and Azure Monitor for Containers.
    - Drill into your monitoring data with Log Analytics for troubleshooting and deep diagnostics.
    - Support operations at scale with smart alerts and automated actions.
  + Data Store Types & Source Collection
    - In Azure Monitor data get stored in two streams.
      * Metrics, is a numerical time series data.
      * Logs is events that occurs within a system.
        + Activity Log can be collected through subscription level events.
        + Diagnostics logs can be collected through resource level events.

Below is the source of Logs.

* + Application monitoring data:

Data about the performance and functionality of the code you have written, regardless of its platform

* + Guest OS monitoring data:

Data about the operating system on which your application is running. This could be running in Azure, another cloud, or on-premises.

* + Azure resource monitoring data:

Data about the operation of an Azure resource.

* + Azure subscription monitoring data:

Data about the operation and management of an Azure subscription, as well as data about the health and operation of Azure itself.

* + Azure tenant monitoring data:

Data about the operation of tenant-level Azure services, such as Azure Active Directory.

* Monitoring VM & Storage with Azure Monitor
  + Azure Monitor for VMs
    - Resource Utilization: Top N Chart
    - Performance monitoring
    - RCA & Troubleshooting:
      * Maps
      * Log Analytics
  + Alerts
    - Alerts proactively notify when important conditions are found in monitoring data. Alerts allow you to identify and address issues before the users of your system notice them.
  + In-Built Monitoring Policies
  + 3rd Party Integration & Partner Ecosystem
* Monitoring Network with Azure Monitor
  + Overview of Azure Network Monitoring Services /Tools
    - Network Performance Monitor is a cloud-based hybrid network monitoring solution which helps to monitor network performance between various points in network infrastructure monitor the performance of Azure ExpressRoute.
    - Network Performance Monitor detects network issues like traffic blackholing, routing errors, and issues that conventional network monitoring methods aren't able to detect. It also generates alerts and notifies the action group when a threshold is breached.
  + Azure Network Watcher
    - Azure Network Watcher provides tools to monitor, diagnose, view metrics, and enable or disable logs for resources in an Azure virtual network.
    - Network Watcher is structured to monitor and repair the network health of IaaS (Infrastructure-as-a-Service) products which includes Virtual Machines, Virtual Networks, Application Gateways, Load balancers.
* Monitoring SAP Application in Azure
  + Azure Enhanced Monitoring Extension for SAP
    - Azure Monitor for SAP solutions is an Azure-Native Monitoring product. This works on both SAP on Azure VMS and SAP on Azure Large Instances.
    - From Azure Monitor for SAP we can collect telemetry data from Azure Infrastructure and database in centralized location and can be used to troubleshooting.
    - Azure Monitor for SAP Solutions is offered through Azure Marketplace. We can monitor different components of an SAP landscape such as Azure VMs, High Availability Cluster, SAP HANA Database etc.
    - Supported Infrastructure
    - Azure Virtual Machine
    - Azure Large Instance
    - Supported Databases
    - SAP HANA Database
    - Microsoft SQL Server
    - Azure Monitor for SAP Solutions uses existing azure Monitor capabilities such as Log Analytics and Workbooks to provide additional monitoring capabilities.
    - Data Collected by Azure Monitor for SAP Solutions.
    - High-Availability Pacemaker Cluster Telemetry
    - Quorum votes and ring status
    - SAP HANA telemetry
    - CPU, Memory, disk and network utilization
    - HANA System Replication (HSR)
    - HANA backup
    - HANA host status
    - Index server and name server roles
    - Microsoft SQL Server telemetry
    - CPU, Memory, disk utilization
    - Hostname, SQL Instance name, SAP System ID
    - Batch Requests, Compilations, and page Life Expectancy over time
    - Problems recorded in the SQL Server Error logs
    - Blocking processes and SQL Wait Statistics over time
* Azure Monitor for SAP Solutions

Data collection in [Azure Monitor for SAP Solutions](https://docs.microsoft.com/en-us/azure/virtual-machines/workloads/sap/azure-monitor-overview) depends on the providers that are configured by customers. During Public Preview, the following data is being collected.

* + High-availability Pacemaker cluster telemetry:
* Node, resource, and SBD device status
* Pacemaker location constraints
* Quorum votes and ring status
  + SAP HANA telemetry:
* CPU, memory, disk, and network utilization
* HANA System Replication (HSR)
* HANA backup
* HANA host status
* Index server and Name server roles
  + Microsoft SQL server telemetry:
* CPU, memory, disk utilization
* Hostname, SQL Instance name, SAP System ID
* Batch Requests, Compilations, and page Life Expectancy over time
* Top 10 most expensive SQL statements over time
* Top 12 largest table in the SAP system
* Problems recorded in the SQL Server Error logs
* Blocking processes and SQL Wait Statistics over time
* Other Monitoring Considerations
  + Azure Service Health
    - Azure Service Health provides the ability to track the health of azure services in the regions. Also, we can track active events like ongoing service issues, upcoming planned maintenance or relevant health advisories.
    - Azure Service Health can be used to create and manage service health alerts which proactively notify us when service issues are affecting.
  + Service Health tracks four types of health events that may impact your resources:
    - Service issues
    - Problems in the Azure services that affect you right now.
    - Planned maintenance
    - Upcoming maintenance that can affect the availability of your services in the future. Health advisories
    - Changes in Azure services that require your attention. Examples include deprecation of Azure features or upgrade requirements (e.g. upgrade to a supported PHP framework).
    - Security advisories
    - Security related notifications or violations that may affect the availability of your Azure services.
  + Azure Advisor

Azure Advisor is a personalized cloud consultant that helps us follow best practices to optimize your Azure deployments. It analyzes your resource configuration and usage telemetry and then recommends solutions that can help you improve the cost effectiveness, performance, Reliability, and security of your Azure resources.

* + - Azure Advisor capabilities
    - Get proactive, actionable, and personalized best practices recommendations.
    - Improve the performance, security, and reliability of your resources, as you identify opportunities to reduce your overall Azure spend.
    - Get recommendations with proposed actions inline.
  + Azure Cost Management & Monitoring
    - Azure Billing features are used to review your invoiced costs and manage access to billing information.
    - Azure Cost Management + Billing helps organizations plan with cost in mind. It also helps to analyze costs effectively and act to optimize cloud spending.
    - Cost Management shows organizational cost and usage patterns with advanced analytics. Reports in Cost Management show the usage-based costs consumed by Azure services and third-party Marketplace offerings.
    - The reports help you understand the spending and resource use which can help to find spending anomalies. Predictive analytics are also available in Cost Management.

## SAP Management and Monitoring

* SAP Solution Manager Considerations (Getting Started)
* Understand Azure Support Prerequisites (SAP on Microsoft Azure)
* Understand SAP Supported VM’s ([Platform Support](https://launchpad.support.sap.com/#/notes/1928533))
* Requirement other than lift and shift scenario (Getting Started)
* Making Strategy for Technical Monitoring (Tech Mon)
* Making Strategy in the Business Monitoring Area (BPM)
* Event Management
  + For Event Management in Azure we can leverage Event Grid service from Azure Cloud Server Family which is a fully managed service.
  + Event Grid also manages the event routing from any source to any destination. It is High Availability, consistent performance and dynamic scale.
* Access Management
  + Azure Resource Graph is a service in Azure that is designed to provide efficient and performant resource exploration with the ability to query at scale across a given set of subscriptions so that you can effectively govern your environment
* Service Request Management,
* Incident Management,
* Problem Management

## Backup Management

Azure backup provides simple, secure, and cost-effective solutions to back up your data and recover it from the Microsoft

### Backup and Restore Strategy

* RPO and RTO Requirements

The recovery point objective and recovery time objective enable an organization to know how much data it can lose and how long it can be down. These are the key elements of a [backup and Disaster Recovery plan](https://docs.microsoft.com/en-us/azure/architecture/framework/resiliency/backup-and-recovery).

* RPO (Recovery Point Objective)

RPO means the data which can be explicitly recovered from a crash incident. This also differs the time-frame between a schedule backup.

* RTO (Recovery Time Objective)

RTO measure the amount of time from the occurrence of a crash incident to when the affected resources must be fully operational and ready to support the organization's objectives.

### SAP NetWeaver Components

* Azure Site Recovery (ASR)
  + Replicate to another Azure Region Provides DR capability
  + Azure Site Recovery is Business Continuity and Disaster Recovery solution which helps to keep business apps and workloads running during outages.
  + Site Recovery replicates workloads running on physical and virtual machines (VMs) from a primary site to a secondary location. When an outage occurs at your primary site, organization can fail over the workload to secondary location, and access apps from there. After the primary location is running again, you can fail back to it.
* Azure Backup
  + Backup VMs
  + Azure Backup Service can be used to backup SAP NetWeaver virtual machines in Azure. It allows to backup entire virtual machine and provide capability to restore the virtual machine back-in-place in case of crash incident.

### Backup SAP SQL Server

* Manual Backups
  + SQL Backup to direct attached disks
    - Simple, but data still needs to be replicated off system
  + Backup direct to [Azure Storage URL](file:///C:\Users\ptghyd\Desktop\Microsoft\SAP\%09https:\docs.microsoft.com\en-us\sql\relational-databases\backup-restore\sql-server-backup-to-url%3fview=sql-server-2017)
    - SQL 2012 CU4 or later
    - Many restrictions
* Automated Backup for SQL
  + Service is provided by the SQL Server IaaS Agent Extension
  + Supports up to 12TB backups
* Azure [Backup for SQL VMs](file:///C:\Users\ptghyd\Desktop\Microsoft\SAP\o%09https:\docs.microsoft.com\en-us\azure\backup\backup-azure-sql-database)
  + Currently Public Preview
  + SQL Server VSS/VDI interface to stream backups to an Azure Recovery Service vault
  + Many advantages from centralization
* Third party Backup Solutions
  + Bring-Your-Own backups
  + Extending existing backup solutions into Azure usually worked well with most of the main vendors in this space

### Hana Backup on VMs

There are two types of backup in Azure which can be used to Backup SAP HANA Database Servers.

* Backint
  + Azure Backup integrates and is certified as backup solution for SAP HANA using the proprietary SAP HANA interface called backint.
* Application Consistent Backup
  + Azure Backup service is to create an application consistent backup using disk snapshots of Azure Premium Storage. Other HANA certified Azure storages, like Azure Ultra disk and Azure NetApp Files are not supporting this kind of snapshot through Azure Backup service.
* HANA backup through Azure Backup Services
  + HANA Large Instances Not supported
  + Azure Linux VMs only
  + Up to 2 TB of full backup size per SAP HANA instance
  + SAP HANA Backup [Supported Scenarios](https://docs.microsoft.com/en-us/azure/backup/sap-hana-backup-support-matrix#scenario-support)
  + Backup guide for [SAP HANA on Azure Virtual Machines](https://docs.microsoft.com/en-us/azure/virtual-machines/workloads/sap/sap-hana-backup-guide)
* HANA backup to the file system in an Azure Linux Virtual Machine
  + See SAP HANA Azure Backup on file level
  + The standard method to backup/restore SAP HANA Database at the file level is with a file-based backup via SAP HANA Studio or via SAP HANA SQL statements SAP HANA SQL and System Views Reference.
  + Blobxfer was used for copying SAP HANA backup files. It is open source, used by many customers in production environments, and available on GitHub. This tool allows one to copy data directly to either Azure blob storage or Azure file share.
* HANA backup based on storage snapshots using the Azure storage blob snapshot
  + Manually or Azure Backup service
  + Limitation
    - On Azure, know the Azure blob snapshot feature does not provide file system consistency across multiple disks

### HANA Backup on HLI

* DIY Backup
  + Backup to Filesystem or NFS share then backup content from there
  + 3rd party tools can be used after content reaches Azure Storage account
* Infrastructure backup and restore functionality
  + Native backup and restore functionality provided by Azure
    - Storage Snapshots
      * Consumes fixed volume space
      * 250 Snapshots or less recommended (255 max)
      * Allows Point in time recovery

### Monitor, Retention and Restore

* Retention
  + Retention Policy
    - The Retention policy means how long the backup copies must be stored in storage. Retention Policy is basically used to optimize the storage and ensure the compliance by storing the required backup copies.
  + Retention Duration
    - Retention Duration is defined based on the organization compliance policy. It allows to store the backup files for the define retention duration in Retention Policy.
* Monitor
  + Monitoring the number and size of backup
* Restore
  + Restore Procedures
  + Periodic Restore tests

### Leveraging Third Party Tools

* Commvault
  + Data Protection and Snapshot Management with [Commvault](https://azure.microsoft.com/en-us/resources/protecting-sap-hana-in-azure/)

## Disaster Recovery

### DR Failover Procedures

DR Failover in Azure from primary to secondary region using Azure Site recovery is a simple activity compare to on-premise failover to azure. Failover can be performed as a planned activity (Drills) or unplanned activity (outage occurs). For more details please refer the link [Azure VM Failover Process.](https://docs.microsoft.com/en-us/azure/site-recovery/azure-to-azure-tutorial-failover-failback)

### Failover and Failback

Failover and Failover are process in Disaster Recovery which are integrated in Azure Site Recovery services. Failover can be performed on planned activity as test drills to validate the latest recovery point is up-to-date and running.

Failback is a process when we reverse the migrated workload to primary region from secondary region after being fully operational.

* + [Microsoft snapshot tools for SAP HANA on Azure](https://github.com/Azure/hana-large-instances-self-service-scripts/blob/master/snapshot_tools_v4.3/Microsoft%20Snapshot%20Tools%20for%20SAP%20HANA%20on%20Azure%20v4.3.pdf)

## Monitoring

### Application Monitoring

* Enable Application Insights

There are two ways to enable application monitoring for Azure App Services hosted applications:

* Agent-based application monitoring (Application Insights Agent)

This method is the easiest to enable, and no advanced configuration is required. It is often referred to as "runtime" monitoring. For Azure App Services we recommend at a minimum enabling this level of monitoring, and then based on your specific scenario you can evaluate whether more advanced monitoring through manual instrumentation is needed.

* Manually instrumenting the application through code by installing the Application Insights SDK.

This approach is much more customizable, but it requires adding a [dependency on the Application Insights SDK NuGet packages](https://docs.microsoft.com/en-us/azure/azure-monitor/app/asp-net). This method also means you have to manage the updates to the latest version of the packages yourself. If you need to make custom API calls to track events/dependencies not captured by default with agent-based monitoring, you will need to use this method. Check out the [API for custom events](https://docs.microsoft.com/en-us/azure/azure-monitor/app/api-custom-events-metrics) and metrics article to learn more. This is also currently the only supported option for Linux based workloads. Provided link [here](https://docs.microsoft.com/en-us/azure/azure-monitor/app/azure-web-apps?tabs=net).

* Enable agent-based monitoring
* Select Application Insights in the Azure control panel for your app service. Choose to create a new resource unless you already set up an Application Insights resource for this application.
* After specifying which resource to use, you can choose how you want application insights to collect data per platform for your application. ASP.NET app monitoring is on-by-default with two different levels of collection

### Operating System Monitoring

By using Azure Monitor, we can collect the metrics from guest operating system as a part of Operating System Monitoring. This will enable the visibility to identity the performance and other issues.

### Virtual Machine Monitoring

* [Azure Monitor for VMs](https://docs.microsoft.com/en-us/azure/azure-monitor/insights/vminsights-overview) is an [insight](https://docs.microsoft.com/en-us/azure/azure-monitor/insights/insights-overview) in Azure Monitor that is the primary tool for monitoring virtual machines in Azure Monitor. It provides the following additional value over standard Azure Monitor features.
* Simplified onboarding of Log Analytics agent and Dependency agent to enable monitoring of a virtual machine guest operating system and workloads.
* Pre-defined trending performance charts and workbooks that allow you to analyze core performance metrics from the virtual machine's guest operating system.

[Enable Azure Monitor for VMs](https://docs.microsoft.com/en-us/azure/azure-monitor/insights/vminsights-enable-overview) from the Insights option in the virtual machine menu of the Azure portal.

* Monitoring in the Azure portal:

Once you configure collection of monitoring data for a virtual machine, you have multiple options for accessing it in the Azure portal

* Use the Azure Monitor menu to access data from all monitored resources.
* Use Azure Monitor for VMs for monitoring sets of virtual machines at scale.
* Analyze data for a single virtual machine from its menu in the Azure portal. The table below lists different options for monitoring the virtual machines menu.
* Alerts:

[Alerts](https://docs.microsoft.com/en-us/azure/azure-monitor/platform/alerts-overview) in Azure Monitor proactively notify you when important conditions are found in your monitoring data and potentially launch an action such as starting a Logic App or calling a webhook. Alert rules define the logic used to determine when an alert should be created. Azure Monitor collects the data used by alert rules, but you need to create rules to define alerting conditions in your Azure subscription.

* Activity log alert rules:

[Activity log alert rules](https://docs.microsoft.com/en-us/azure/azure-monitor/platform/alerts-activity-log) fire when an entry matching criterion is created in the activity log. They have no cost so they should be your first choice if the logic you require is in the activity log.

* Metric alert rules:

[Metric alert rules](https://docs.microsoft.com/en-us/azure/azure-monitor/platform/alerts-metric) fire when a metric value exceeds a threshold. You can define a specific threshold value or allow Azure Monitor to dynamically determine a threshold based on historical data. Use metric alerts whenever possible with metric data since they cost less and are more responsive than log alert rules.

* Log alerts:

[Log alert rules](https://docs.microsoft.com/en-us/azure/azure-monitor/platform/alerts-log) fire when the results of a scheduled log query match certain criteria. Log query alerts are the most expensive and least responsive of the alert rules, but they have access to the most diverse data and can perform complex logic that can't be performed by the other alert rules.

### Monitoring and troubleshooting from HANA

* [SAP Note #2222200 – FAQ: SAP HANA Network](https://launchpad.support.sap.com/#/notes/2222200)
* [SAP Note #2100040 – FAQ: SAP HANA CPU](https://launchpad.support.sap.com/#/notes/0002100040)
* [SAP Note #199997 – FAQ: SAP HANA Memory](https://launchpad.support.sap.com/#/notes/2177064)
* [SAP Note #200000 – FAQ: SAP HANA Performance Optimization](https://launchpad.support.sap.com/#/notes/2000000)
* [SAP Note #199930 – FAQ: SAP HANA I/O Analysis](https://launchpad.support.sap.com/#/notes/1999930)
* [SAP Note #2177064 – FAQ: SAP HANA Service Restart and Crashes](https://launchpad.support.sap.com/#/notes/2177064)
* Refer to [this](https://docs.microsoft.com/en-us/azure/virtual-machines/workloads/sap/hana-monitor-troubleshoot) guide for Additional details

## Patch Management

Patch Management is process to update the patches to fix the vulnerabilities, bugs, features. This patch is release by OEM vendor of application or hardware.

### SAP Notes

SAP Notes provide the update information in SAP which is frequently released by SAP.

In SAP Notes below information is published.

* Product errors
* Product modifications
* Product upgrades
* FAQs
* Consulting Notes
* Customizing notes

### SAP Security Notes

SAP Security Notes are Patch Day Security Notes and Support Package Security Notes which is focused on important fixes on patch days and the rest to be implemented automatically during SP upgrades

### SAP Kernel Patching

The SAP kernel is the core component of any SAP system. It consists of the executable files that run on the server to handle connections to the system and execute the SAP program. To ensure the system runs smoothly we need to patch the SAP kernel as well based on SAP best practices and released Kernel Patches

### SAP GUI and NWBC Patching

SAP NetWeaver Business Client (NWBC) is a user interface to access all the applications from a single platform.

In SAP system, a patch is used to fix bug. Below are the four different types of patches which are also called as support packs. This patch should be applied in the following sequence.

* BASIS (SAPKB620XXXX)
* ABAP (SAPKA620XXXX)
* HR (SAPKE470XXXX)
* APPLICATIONS (SAPKH470XXXX)

Structure followed by a Patch = SAPKA <Rel><No>

### OS Kernel Patching

Azure Update Management can be used to manage operating system updates for Windows and Linux machines in Azure, On-prem or in multi-cloud. It will quickly assess the status of available updates on all agent machines and manage the process of installing required updates for servers. For more details please refer to [Azure Update Management](https://docs.microsoft.com/en-us/azure/automation/automation-update-management)

### DB Patching

Database Patching process can be done manually which is totally depends on which database is used in SAP environment. If the database if different than SQL i.e. HANA, Oracle, DB2 then we must manually download the latest patches and update on the database server.

### DB Upgrade

Database Upgrade process is completely different than patching the database. Database upgrade means changing the version of existing database i.e. from old to latest version. In this process we must download the latest upgrade path from database OEM vendor support site and execute the activity. For Upgrade please refer [SAP Maintenance Planner tool.](https://support.sap.com/en/alm/solution-manager/processes-72/maintenance-planner.html)

### SAP Support Pack & Stack Upgrade

The Support package stack is a list of ABAP and Java support packages which is compatible for all software components. This also included in SAP NetWeaver. This is used to bring each software component of SAP NetWeaver on a defined Support Pack Level For more information please refer [SAP Support Stack Strategy](https://support.sap.com/en/my-support/software-downloads/support-package-stacks/support-package-stack-strategy.html)

Support Package Stack Upgrade can be performed manually, or we can use [Software Update Manager (SUM)](https://support.sap.com/en/tools/software-logistics-tools/software-update-manager.html) tool can be used to perform support package stacks updates.

### SAP Version Upgrade

SAP Version upgrade refers to the upgrade of SAP release. Support Pack Stack Version have a release number, and a Stack number. In SAP environment each software component has a separate sequence of Support Packages. Below is the list which contains the technical names of several components and the notation for their Support Packages:

* COP (Component Package):
* SAP\_APPL (SAP APPL Support Package): SAPKH<rel><no>
* SAP\_BASIS (Basis Support Package): SAPKB<rel><no>
* SAP\_ABA (Application Basis SP): SAPKA<rel><no>
* SAP\_HR (SAP HR Support Package): SAPKE<rel><no>
* SAP\_SCM (SCM Support Package): SAPKY<rel><no>
* SAP\_BW (BW Support Package): SAPKW<rel><no>
* SAP\_CRM (CRM Support Package): SAPKU<rel><no>

To Upgrade the version , we can use [Software Update Manager (SUM) tool](https://support.sap.com/en/tools/software-logistics-tools/software-update-manager.html). As SUM tool is multi-purpose tool which can perform release upgrades, installation of SAP enhancement packages, support package stacks etc.

### Recommended Patch Cycle

Recommended patch cycle for operating system and SAP software application component is to schedule the patch on monthly basis. This will keep the infrastructure and application in a compliance. Patch tracker management is recommended to track the patches and release upgrades data, which can be used further as a reference for rollbacks, analysis the performance etc.

Reduce manual intervention using Update Management Feature: <https://docs.microsoft.com/en-us/azure/automation/automation-tutorial-update-management>