MS SQL Server - IaaS vs PaaS Guidance

On-Premise SQL Server Deployment Options in Azure

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1 Executive Summary

1.1 Objective

As part of an overall data platform modernization effort, customers are evaluating options to migrate their Microsoft SQL Server Instances to Azure. However, often, its not an easy decision to select a target platform in the cloud. In majority of these cases, you will have an option to deploy your workload either on IaaS or PaaS.

This guidance document was created to review options you have to migrate your SQL server workload in Azure as each option is designed to support specific use cases. Azure services include both IaaS and PaaS offerings which means you can have your SQL Server workloads running in a hosted infrastructure (IaaS) or in a managed service (PaaS). However, within Azure PaaS, Azure has multiple deployment options and each deployment option has multiple service tiers. Purpose of this document is to help you narrow down the options and do further due diligence to finalize the target platform for your SQL workload.

IaaS with Azure SQL VM	**PaaS with Azure SQL DB and SQL MI**

1.2 Scope

- Microsoft SQL Server on Azure VM (IaaS) including HA options
- Microsoft SQL Server on Azure PaaS
- Microsoft SQL Server Reporting Services Options in Azure Cloud
- Microsoft SQL Server Integration Services Options in Azure Cloud

1.3 Disclaimer

The high-level Architecture, and guidelines in this document is developed in consultation and collaboration with Microsoft Corporation technical architects. This document represents current Microsoft high level architectural guidelines and practices. Because Microsoft must respond to changing market conditions, this document should not be interpreted as an invitation to contract or a commitment on the part of Microsoft.

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2   Microsoft SQL Server on Azure VM

SQL Server on Azure VM enables you to use full versions of SQL Server in the Cloud without having to manage any on-premises hardware. The virtual machine image gallery allows you to create a SQL Server VM with the right version, edition, and operating system (OS).

- Deploy Full SQL Server on Azure VM without having to manage any on-premises hardware.
- Deploy SQL Server 2017 on Windows or Linux OS
- Automated updates using SQL Server IaaS Agent Extension. - SQL Server Azure VMs can use Automated Patching to schedule a maintenance window for installing important windows and SQL Server updates automatically.
- Automated backups - SQL Server Azure VMs can take advantage of Automated Backup, which regularly creates backups of your database to blob storage.
- BYOL – Option to bring your own license(s).
- Automated storage configuration which is optimized for your performance requirements.

High Availability for SQL Server in Azure VMs - Most SQL Server HADR solutions are supported in Azure virtual machines, both as Azure-only and as hybrid solutions. In an Azure-only solution, the entire HADR system runs in Azure. In a hybrid configuration, part of the solution runs in Azure and the other part runs on-premises in your organization. SQL Server HADR technologies that are supported in Azure include:

- Always On Availability Groups
- Always On Failover Cluster Instances
- Log Shipping
- SQL Server Backup and Restore with Azure Blob Storage Service

Using these solutions, you can have a disaster recovery solution for their SQL Server databases in a hybrid-IT environment using availability groups, database mirroring, log shipping, or backup and restore with Azure blog storage. For example using SQL Server availability groups or database mirroring, primary database instance running in Azure VMs and other replicas running on-premises for cross-site disaster recovery. The production site can be either on-premises or in an Azure datacenter.

Availability Groups
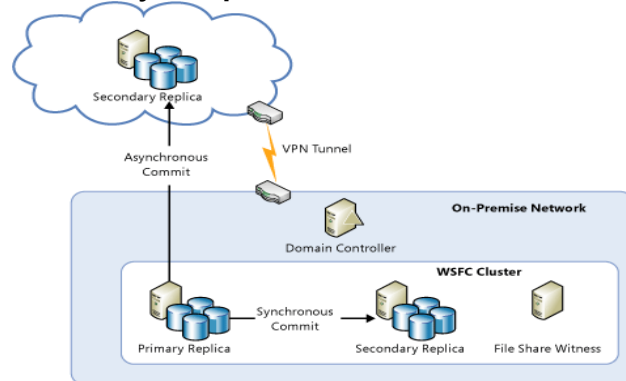
Database Mirroring
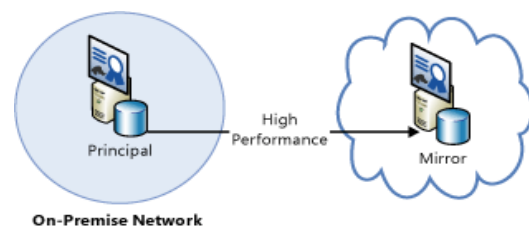
3   Microsoft SQL Server on Azure PaaS

Azure SQL Database is a general-purpose relational database-as-a-service (DBaaS) based on the latest stable version of Microsoft SQL Server Database Engine. Azure SQL Database provides the following deployment options for an Azure SQL database:

- As a single database with its own set of resources managed via a SQL Database server. A single database is similar to a contained databases in SQL Server. With single databases, each database is isolated from each other, with its own guaranteed - compute, memory, and storage resources and the ability to dynamically scale up & down.
- An elastic pool, which is a collection of databases with a shared set of resources managed via a SQL Database server. Single databases can be moved into and out of an elastic pool.
- Managed instance, which is a collection of system and user databases with a shared set of resources. A managed instance is similar to an instance of the Microsoft SQL Server database engine.
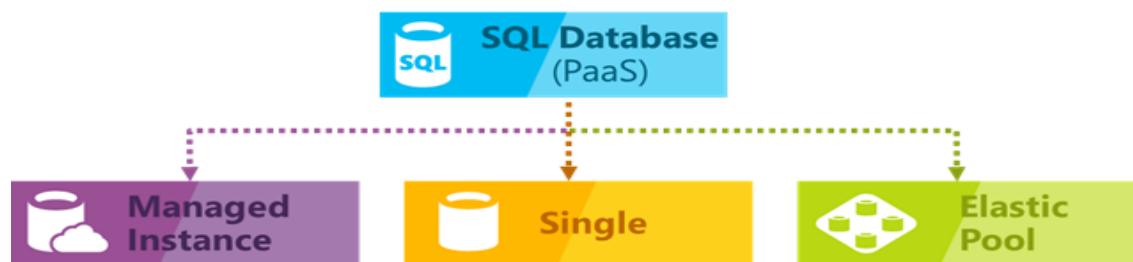
Size of the database is one of the criteria which will affect your target platform choice in Azure. Until recently, the max database size you can deploy in Azure is 8TB in Azure SQL DB (PaaS) and 64TB in SQL Server on Azure VM (IaaS). However, with the introduction of Hyperscale db, you can scale a SQL Server database up to 100 TB.

Hyperscale DB is in Public Preview in Azure SQL DB, tentative GA plan is Q4, FY2019, and Private Preview in Azure SQL MI, tentative GA plan is Q1, FY2020. See Azure SQL Database vCore-based and DTS-based purchasing model limits for a single database for additional information.

Azure SQL Managed instance is a deployment option of Azure SQL Database, providing near 100% compatibility with the latest SQL Server on-premises (Enterprise Edition) Database Engine, providing a native virtual network (VNet) implementation. The managed instance deployment model allows existing SQL Server customers to lift and shift their on-premises applications to the cloud with minimal application and database changes. Below table summarize the feature difference between Azure SQL DB and Azure SQL MI:

Azure SQL Managed instance	Azure SQL Single DB / Elastic Pool
- High compatibility with SQL Server on-premises. 99.99% availability guaranteed. - Built-in backups, patching, recovery. - Latest stable Database Engine version. - Easy migration from SQL Server.	- The most commonly used SQL Server features are available. 99.99% availability guaranteed. - Built-in backups, patching, recovery. - Latest stable Database Engine version.

• Private IP address within Azure VNet. • Built-in advanced intelligence and security. Online change of resources (CPU/storage).	• Ability to assign necessary resources (CPU/storage) to individual databases. • Private IP address cannot be assigned (you can limit the access using firewall rules). • Built-in advanced intelligence and security. • Online change of resources (CPU/storage).
• There is still some minimal number of SQL Server features that are not available. • Compatibility with the SQL Server version can be achieved only using database compatibility levels.	• Some SQL Server features are not available and migration from On-Premise SQL Server will require refactoring. • Compatibility with the SQL Server version can be achieved only using database compatibility levels.
• Max DB Size 8TB and 100TB with Hyperscale (Private Preview)	• Max DB Size 4TB and 100TB with hyperscale (Public Preview)

Because Azure SQL Database is a managed Platform as a Service, it provides built-in business continuity and global scalability including:
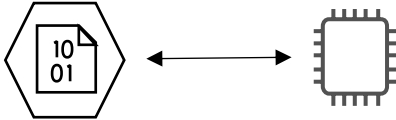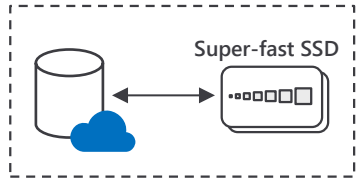
- **Automatic Backups** - SQL Database automatically performs weekly full, differential every 10-12 hrs, and transaction log backups every 5-10 minutes of Azure SQL databases to enable you to restore to any point in time.
- **Built-in Monitoring**
- **Point-in-time restores** – All SQL Database deployment options support recovery to any point in time within the automatic backup retention period for any Azure SQL database.
- **Active geo-replication**
- **Auto-failover groups**
- **Zone-redundant databases** - Provision premium or business critical databases or elastic pools across multiple availability zones.
- Built-in intelligence including automatic performance monitoring and tuning
- Advanced Security and Compliance
- Advanced Threat Protection
- Data Encryption

Below table includes list of key features supported in Azure SQL DB vs Azure SQL MI. For further information please refer https://docs.microsoft.com/en-us/azure/sql-database/sql-database-features.

SQL Feature	Azure SQL Managed Instance	Azure SQL Single Databases/Elastic Pools
Active geo-replication	No, see Auto-failover groups	Yes - General Purpose and Business Critical service tiers only. Configure up to four readable secondary databases in either the same or globally distributed Azure data centers.
Auto-failover groups	Yes, in public preview	Yes - General Purpose and Business Critical service tiers only
High Availability	High availability is included with every database. Disaster recovery is discussed in Overview of business continuity with Azure SQL Database	
Backup	System-initiated automated backups and user initiated COPY-ONLY backups - see Backup differences	Only system-initiated automatic backups - see Automated backups
Change Data Capture	Yes	No
Collation - server/instance	Yes, in public preview	No
CLR	Yes - see CLR differences	No
Cross-database queries	Yes, plus Elastic queries	No - see Elastic queries
Cross-database transactions	Yes - see Linked server differences	No
Database Mail	Yes	No
Distributed partition views	Yes	No
Linked Servers	Only to SQL Server and SQL Database	No - see Elastic query
Service Broker	Yes - see Service Broker differences	No
SQL Server Agent	Yes - see SQL Server Agent differences	No - see Elastic jobs

Azure SQL Managed Instance is available in two service tiers, guarantee 99.99% availability and enable you to independently select storage size and compute capacity.

- **General purpose**: Designed for applications with typical performance and IO latency requirements.
- **Business critical**: Designed for applications with low IO latency requirements and minimal impact of underlying maintenance operations on the workload.

Feature	General Purpose	Business Critical
Architecture		
H/W	**Gen4** Based on Intel E5-2673 v3 (Haswell) 2.4-GHz processors, attached SSD, physical cores, 7GB RAM per core. **Gen5** Based on Intel E5-2673 v4 (Broadwell) 2.3-GHz processors, fast NVMe SSD, hyper-threaded logical core. 5.1GB RAM per core	
Number of vCores*	Gen4: 8, 16, 24 Gen5: 8, 16, 24, 32, 40, 64, 80	Gen4: 8, 16, 24, 32 Gen5: 8, 16, 24, 32, 40, 64, 80
Memory	Gen4: 56 GB - 168 GB Gen5: 40.8 GB - 408 GB *Proportional to the number of vCores	Gen4: 56 GB - 168 GB Gen5: 40.8 GB - 408 GB *Proportional to the number of vCores

Max storage size	8 TB	Gen4: 1 TB
		Gen5: - 1 TB for 8, 16 vCores
		     - 2 TB for 24 vCores
		     - 4 TB for 32, 40, 64, 80 vCores

Max storage per database	Determined by the max storage size per instance	
Max number of databases per instance	100	100
Max database files per instance	Up to 280	32,767 files per database
Data/Log IOPS (approximate)	500 - 7,500 per file *Depends on the file size	11 K - 110 K (1,375 per vCore)
Log throughput	22 MB/s per instance	3 MB/s per vCore Max 48 MB/s per instance

Data throughput (approximate)	100 - 250 MB/s per file *Depends on the file size	24 - 48 MB/s per vCore
IO latency (approximate)	5-10 ms	1-2 ms
Max tempDB size	192 - 1,920 GB (24 GB per vCore)	No constraints - limited by the max instance storage size
Read Replica	None	1
High Availability	Built-in high-availability based on reliable Azure Blob storage and Azure Service Fabric	Built-in high availability based on Always On Availability Groups and Azure Service Fabric.

The **Hyperscale** service tier in Azure SQL Database is the newest service tier which decouples compute, log and storage. Compared to current Azure SQL Database service tiers, Hyperscale provides the following additional capabilities:

- Supports up to 100TB database size
- Nearly instantaneous database backups (based on file snapshots stored in Azure Blob storage) regardless of size with no IO impact on Compute
- Fast database restores (based on file snapshots) in minutes rather than hours or days (not a size of data operation)
- Rapid scale up/down and point-in-time restore, regardless of the database size
- Higher log throughput than current service tiers
- Scale out read-only workload with read-scale replicas without data copy

Azure SQL DB Hyperscale DB in Public Preview, tentative GA plan is Q4, FY2019, and Azure SQL MI Hyperscale is in Private Preview, tentative GA plan is Q1, FY2020.
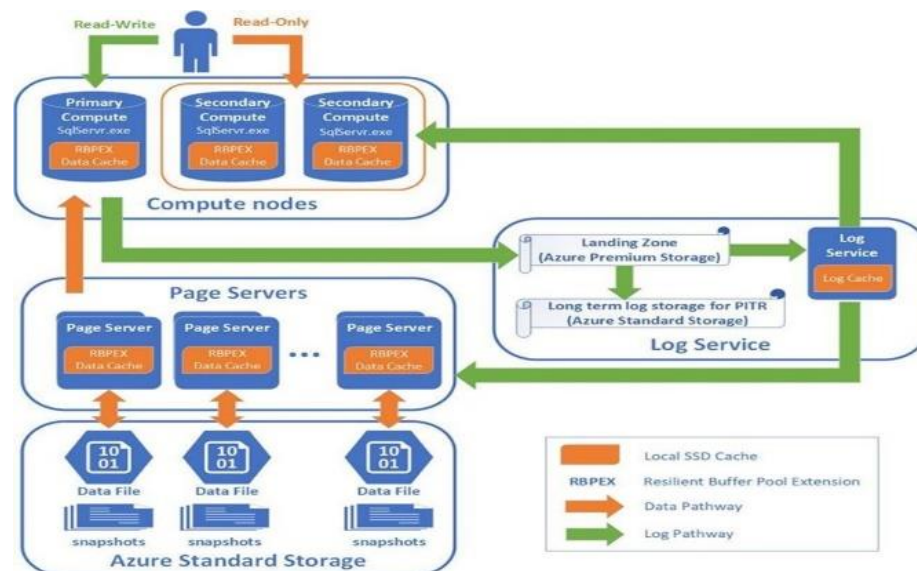
4 SQL Server on Azure VM vs Azure SQL MI

SQL Server on Azure virtual machines is a good option for migrating on-premises SQL Server databases without any database change. All recent versions and editions of SQL Server are available for installation in an Azure IaaS VM. However, because it's an IaaS offering, you will be responsible to manage everything above the OS layer including OS and SQL Server. On the other hand, an Azure SQL Managed Instance is like an instance of the Microsoft SQL Server database engine offering shared resources for databases and additional instance-scoped features. Managed instance supports database migration from on-premises with minimal to no database change. This option provides all of the PaaS benefits of Azure SQL Database but adds capabilities that were previously only available in SQL VMs.

Category	SQL Server on Azure VM	Azure SQL Managed Instance
H/W Options	• Azure provides different VM shapes to deploy SQL server on Azure VMs including General Purpose, Compute Optimized, Memory Optimized, High Performance Compute, etc.	• **Gen4** Based on Intel E5-2673 v3 (Haswell) 2.4-GHz processors, attached SSD, physical cores, 7GB RAM per core, and compute sizes between 8 and 24 vCores. • **Gen5** Based on Intel E5-2673 v4 (Broadwell) 2.3-GHz processors, fast NVMe SSD, hyper-threaded logical core, and compute sizes between 8 and 80 cores.
SLA and Misc Features	• Full control over the SQL Server engine. • Up to 99.95% availability. • Full parity with the matching version of on-premises SQL Server. • Fixed, well-known database engine version. • Easy migration from SQL Server on-premises. • Private IP address within Azure VNet. • Ability to deploy application or other services (SSRS, SSIS, etc) on the host where SQL Server is placed.	• 99.99% availability guaranteed. • Built-in backups, patching, recovery. • Latest stable Database Engine version. • Easy migration from SQL Server. • Private IP address within Azure VNet. • Built-in advanced intelligence and security. • Online change of resources (CPU/storage).
Management	• You need to manage your backups and patches. Automated Backup on Azure Blob storage and Automated Patching to schedule a maintenance window for installing important windows and SQL Server updates automatically. • There is a downtime while changing the resources(CPU/storage)	• There is some minimal number of SQL Server features that are not available. • Compatibility with the SQL Server version can be achieved only using database compatibility levels.
Supported DB Size	• SQL Server instances with up to 64 TB of storage. The instance can support as many databases as needed.	• Up to 8TB for SQL MI GP. Max 100 DBs • Up to 4TB for SQL MI BC. Max 100 DBs
Monitoring	• Built-in monitoring for the Azure VM and you need to setup SQL server monitoring.	• Built-In comprehensive monitoring capabilities including Single Pane of Glass for your entire Azure SQL DB fleet cross-subscriptions using Azure SQL Analytics (Preview)
High Availability	• You need to setup HA either using SQL Server Always ON or Availability Group. Will require multiple VMs.	• Built-In High Availability including an option to setup Azure SQL MI Fail-over group across the Azure regions.

Security	• Azure AD integration	• Comprehensive set of advanced security features such as Managed instance auditing, Threat Detection, Data encryption in motion, TDE, RLS, etc. which can be used to protect your data. • Option to centrally manage identities of database user and other Microsoft services with Azure Active Directory integration.

4.1   Key Differences Between SQL Server On-Premise and Azure SQL MI

The managed instance deployment option benefits from being always-up-to-date in the cloud, which means that some features in on-premises SQL Server may be either obsolete, retired, or have alternatives. There are specific cases when a particular feature works in a slightly different way or that service is not running in an environment you do not fully control:

- High-availability in Azure SQL MI is built in and pre-configured using technology similar to Always On Availability Groups.
- Automated backups and point in time restore. Customer can initiate `copy-only` backups that do not interfere with automatic backup chain.
- Managed instance does not allow specifying full physical paths so all corresponding scenarios have to be supported differently: RESTORE DB does not support WITH MOVE, CREATE DB doesn't allow physical paths, BULK INSERT works with Azure Blobs only, etc.
- Managed instance supports Azure AD authentication as cloud alternative to Windows authentication.
- Managed instance automatically manages XTP filegroup and files for databases containing In-Memory OLTP objects
- Managed instance supports SQL Server Integration Services (SSIS) and can host SSIS catalog (SSISDB) that stores SSIS packages, but they are executed on a managed Azure-SSIS Integration Runtime (IR) in Azure Data Factory (ADF), see Create Azure-SSIS IR in ADF.

4.2   Storage Performance – Azure SQL VM vs Azure SQL MI GP

Azure SQL MI GP (General Purpose) uses Azure Premium Storage to store database files for all databases, except for the *tempdb* database. From the perspective of the database engine, this storage type is remote which means there is no disk or a network share that hosts database files; instead, file path is an HTTPS URL, and each database file is a page blob in Azure Blob Storage.

The current implementation of MI GP does not use blobs smaller than 128 GB (P10). The system will use 128 GB (P10) blobs even for very small database files, to avoid negative performance impact that would be likely with smaller blob sizes (P4 and P6). Additionally, when allocating blobs in Premium Storage, MI always uses the maximum blob size within a storage performance tier. If database file size is 900 GB, MI GP will use a 1 TB (P30) blob for that file. The disk/blob size shown in the limits table is the maximum size for which the corresponding limit applies. For example, a blob that is > 64 GB and <= 128 GB (equivalent to a P10 disk) can achieve up to 500 IOPS and up to 100 MB/second throughput.

Premium SSD Sizes	P4	P6	P10	P15	P20	P30	P40	P50	P60
Disk size in GiB	32	64	128	256	512	1,024	2,048	4,095	8,192
IOPS per disk	Up to 120	Up to 240	Up to 500	Up to 1,100	Up to 2,300	Up to 5,000	Up to 7,500	Up to 7,500	Up to 12,500
Throughput per disk	Up to 25 MiB/sec	Up to 50 MiB/sec	Up to 100 MiB/sec	Up to 125 MiB/sec	Up to 150 MiB/sec	Up to 200 MiB/sec	Up to 250 MiB/sec	Up to 250 MiB/sec	Up to 480 MiB/sec

When you deploy SQL Server on Azure VM, the performance of your database depends on many factors such as the size of a virtual machine, and the configuration of the data disks. Different VM sizes have different limits on the number of IOPS and bandwidth supported, see the tables on IOPS per VM size. For more throughput, you can add additional data disks and use Disk Striping. However, for SQL VMs, available IOPS/throughput are shared among all database files using a disk (or a storage pool) and cannot exceed supported IOPS/throughput for that VM. The important difference between MI GP and SQL VM is that the per-VM IOPS/throughput limits, documented for each VM type as *Max uncached disk throughput: IOPS / MBps* , do not apply to MI.

4.3 Azure Database Migration Service (DMS)

Once the target platform has been picked, next question is how to migrate from On-Premises to Azure. The Azure Database Migration Service is a fully managed service designed to enable seamless migrations from multiple database sources to Azure data platforms with minimal downtime (online migrations). The service uses the Data Migration Assistant to generate assessment reports that provide recommendations to guide you through the changes required prior to performing a migration.

5 SQL Server Integration Services (SSIS) in Azure

With Azure Data Factory (v2), you can now move your SQL Server Integration Services (SSIS) projects, packages, and workloads to the Azure cloud. Deploy, run, and manage SSIS projects and packages in the SSIS Catalog (SSISDB) on Azure SQL Database or SQL Database Managed Instance with familiar tools such as SQL Server Management Studio (SSMS).

The most significant difference is the separation of storage from runtime. Azure Data Factory hosts the runtime engine for SSIS packages on Azure. The runtime engine is called the Azure-SSIS Integration Runtime (Azure-SSIS IR). For more info, see Azure-SSIS Integration Runtime.

Location	Storage	Runtime	Scalability
On premises	SQL Server	SSIS runtime hosted by SQL Server	SSIS Scale Out (in SQL Server 2017 and later)

On Azure	Azure SQL Database or Managed Instance	Azure-SSIS Integration Runtime, a component of Azure Data Factory	Scaling options for the Azure-SSIS Integration Runtime

6   SQL Server Reporting Services (SSRS) in Azure

As discussed in the "SQL Server on Azure VM" (Section 2) of this document, **SQL Server on Azure VM** enables you to use full versions of SQL Server in the Cloud without having to manage any on-premises hardware. Similarly, you can install SQL Server Reporting Services (SSRS) on Azure VM. The SQL Server editions supported in the Azure Marketplace gallery images are the same installation files you can install to on-premises computers and Azure virtual machines. The following table summarizes the Business Intelligence features installed on the common Microsoft Azure Virtual Machine gallery images for SQL Server:

- SQL Server 2016 SP1 Enterprise
- SQL Server 2016 SP1 Standard
- SQL Server 2014 SP2 Enterprise
- SQL Server 2014 SP2 Standard
- SQL Server 2012 SP3 Enterprise
- SQL Server 2012 SP3 Standard

There are two options available to publish existing reports from an on-premises computer to the report server hosted on the Microsoft Azure Virtual Machine:

Report Builder: The virtual machine includes the click-once version of Microsoft SQL Server Report Builder for SQL 2014 and 2012. To start Report builder the first time on the virtual machine with SQL 2016:

1. Start your browser with administrative privileges.
2. Browse to the web portal, on the virtual machine, and select the **Download** icon in the upper right.
3. Select **Report Builder**.

SQL Server Data Tools is installed on the Azure virtual machine and can be used to create **Report Server Projects** and reports on the virtual machine. SQL Server Data Tools can publish the reports to the report server on the virtual machine.

Power BI is another option is to publish Paginated SSRS reports (*.RDL format), which are based on the RDL report technology, to a Power BI Premium workspace, and view reports within the Power BI web app. No SSRS server is required. Report Builder is the standalone tool for authoring paginated reports. You can preview your report in Report Builder, then publish it to the Power BI service, http://app.powerbi.com.

7   References

- **Automate management tasks on Azure Virtual Machines with the SQL Server Agent Extension (Resource Manager)** - https://docs.microsoft.com/en-us/azure/virtual-machines/windows/sql/virtual-machines-windows-sql-server-agent-extension
- **Automated Patching for SQL Server in Azure Virtual Machines (Resource Manager)** - https://docs.microsoft.com/en-us/azure/virtual-machines/windows/sql/virtual-machines-windows-sql-automated-patching
- **Automated Backup v2 for Azure Virtual Machines (Resource Manager)** - https://docs.microsoft.com/en-us/azure/virtual-machines/windows/sql/virtual-machines-windows-sql-automated-backup-v2
- **Sizes for Windows virtual machines in Azure** - https://docs.microsoft.com/en-us/azure/virtual-machines/windows/sizes?toc=%2fazure%2fvirtual-machines%2fwindows%2ftoc.json
- **Always On availability groups: a high-availability and disaster-recovery solution** - https://docs.microsoft.com/en-us/sql/database-engine/availability-groups/windows/always-on-availability-groups-sql-server?view=sql-server-2017
- **High availability and disaster recovery for SQL Server in Azure Virtual Machines** - https://docs.microsoft.com/en-us/azure/virtual-machines/windows/sql/virtual-machines-windows-sql-high-availability-dr
- **Azure SQL Database** - https://docs.microsoft.com/en-us/azure/sql-database/
- **Azure SQL Managed Instance** - https://docs.microsoft.com/en-us/azure/sql-database/sql-database-managed-instance
- **Hyperscale service tier (preview) for up to 100 TB** - https://docs.microsoft.com/en-us/azure/sql-database/sql-database-service-tier-hyperscale
- **Azure SQL Database metrics and diagnostics logging** - https://docs.microsoft.com/en-us/azure/sql-database/sql-database-metrics-diag-logging
- **Monitor Azure SQL Database using Azure SQL Analytics (Preview)** - https://docs.microsoft.com/en-us/azure/azure-monitor/insights/azure-sql
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- **SQL Server Reporting Services (SSRS) reports for Power BI Premium (Public Preview)** - https://docs.microsoft.com/en-us/business-applications-release-notes/april18/power-bi/service/sql-server-reporting-services-ssrs-reports-power-bi-premium
- **What are paginated reports in Power BI Premium? (Preview)** - https://docs.microsoft.com/en-us/power-bi/paginated-reports-report-builder-power-bi

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