AZURE VIRTUAL DESKTOP FOR AZURE LOCAL TECHNICAL PERFORMANCE GUIDE

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CHAPTER 1 - INTRODUCTION TO AZURE VIRTUAL DESKTOP FOR AZURE LOCAL

Virtual Desktop Infrastructure (VDI) is a virtualization technology that enables organizations to deliver desktop environments to end users. A centralized enterprise system hosts these instances, which can be accessed from a wide range of thin devices, such as personal computers or tablets. This setup eliminates the need for 'heavy' physical machines allowing authorized users to securely access company servers, files, applications, and services using a desktop client or web browser on any approved device. This approach provides cost, manageability, and security advantages.

There are several types of virtual desktop infrastructure providers, each offering different solutions for creating and managing sessions, this guide specifically focuses on **Microsoft Azure Virtual Desktop (AVD)**. Microsoft's Azure Virtual Desktop service offers both on-premises (Azure Local) and cloud-based VDI solution. It is the former that we cover in this guide. The on-premises AVD solution can be achieved by **Azure Local** which is a cloud connected infrastructure primarily enabled by **Azure ARC**. With Azure Local, the hardware remains on-premises, but the infrastructure can be managed through the Azure portal. Azure Local uses Microsoft® Windows Server technology, particularly the Hyper-V Virtualization and software-defined networking/storage capabilities.

This tuning guide provides an overview of Azure Virtual Desktop (AVD) on Azure Local, steps to configure AVD and tuning parameters for optimizing server performance powered by AMD EPYC™ 9004 Series Processors, codenamed Genoa. The configuration and tuning recommendations are based on AMD's internal test results on AMD EPYC™ 9004 Series Processor. Additionally, it provides VDI sizing results to help estimate the amount of hardware needed.

CHAPTER 2 - AMD EPYC™ 9004 SERIES PROCESSORS

The AMD EPYC™ 9004 Series Processors represent the fourth generation of AMD EPYC ™ server-class processors. This generation features AMD's latest "Zen 4" based compute cores, next-generation Infinity Fabric, next-generation memory & I/O technology, and utilizes new SP5 socket/packaging.

Azure Local solutions are classified into three categories: Premier Solutions, Integrated Systems and Validated Nodes – each supporting AMD EPYC ™ Processors.

- **Validated nodes** provide the basic Azure Local enablement, with software tested by Microsoft®. However, customers must manage their own firmware, driver and OS updates.
- **Integrated systems** are a step further by offering validated updates across firmware, drivers and OS.
- **Premier solutions** are the turnkey offerings, providing maximum support from Microsoft® and its partners, enabling a deeply integrated system.

2.1 - General Specifications

AMD EPYC ™ 9004 Series Processors offer a variety of configurations with varying numbers of cores, Thermal Design Points (TDPs), frequencies, cache sizes, etc. that complement AMD's existing server portfolio with further improvements to performance, power efficiency, and value. Table 1-1 lists the features common to all AMD EPYC ™ 9004 Series Processors.

COMMON FEATURES OF ALL AMD EPYC ™ 9004 SERIES PROCESSORS	
Compute cores	Zen4-based
Core process technology	5nm
Maximum cores per Core Complex (CCX)	8
Max memory per socket	6 TB
Max # of memory channels	12 DDR5
Max memory speed	4800 MT/s DDR5
Max lanes Compute express Links	64 lanes CXL 1.1+
Max lanes Peripheral Component Interconnect	128 lanes PCIe® Gen 5

Table 1: Common features of all AMD EPYC™ 9004 Series Processors

The table below shows different features of Genoa, 4th Gen AMD EPYC™ processors

AMD EPYC™ 9004 SERIES PROCESSOR (FAMILY 19H) GENOA FEATURES	
Codename	"Genoa" *
Model #	91xx-96xx
Max number of Core Complex Dies (CCDs)	12
Number of Core Complexes (CCXs) per CCD	1
Max number of cores (threads)	96 (192)
Max L3 cache size (per CCX)	1,152 MB (96 MB)
Max Processor Frequency	4.4 GHz
Includes AMD 3D V-Cache (9xx4X) and high-frequency (9xx4F) models. *GD-122: The information contained herein is for informational purposes only and is subject to change without notice. Timelines, roadmaps, and/or product release dates shown herein and plans only and subject to change. "Genoa" is a codename for AMD architectures and is not a product name.	

Table 2: AMD EPYC ™ 9004 Series Processors Genoa Features

For more information related to Genoa processor specifications; layout can be found **here**.

CHAPTER 3 - BIOS SETTINGS BEST PRACTICES

BIOS settings that impact Azure Virtual Desktop on Azure Local server performance are discussed below. While default OEM hardware and BIOS configurations are generally optimized for most workloads and operating systems, certain specialized workloads like VDI may benefit from additional tuning adjustments. VDI is typically a high-consumption workload where optimal performance is expected immediately. Failing to ensure the system is properly optimized could result in slower logins and a laggy user experience. A detailed **BIOS & Workload Tuning Guide for AMD EPYC™ 9004 Series Processors** is also available for additional workloads.

If present, the following BIOS settings can impact both performance and other factors, such as power consumption.

3.1 - Symmetric Multi-threading

Symmetric Multi-threading (SMT) is a core configuration parameter that allows simultaneous processes to use a single processor core without interfering with each other. Disabling SMT means that only one virtual processor can be scheduled on a core at a given time. Enabling SMT means that two virtual processors can be scheduled to use the same core in different threads simultaneously, thereby doubling desktop density with little performance loss. Enabling SMT is therefore a recommended best practice for AVD.

3.2 - IOD Settings

C-States and P-states are controlled by "Operating Mode" or "BIOS Profile" set to "Max performance" in the BIOS Menu for certain OEMs.

- **SoC P-state:** Forcing the Data Fabric power state to highest performing state.
- **Data Fabric C-states:** Preventing the I/O Die from going into low power state.

Multiple tests were conducted with C-states Disable/Enabled and P-state set to Auto. The variance in performance is very minimal. Therefore, the recommendation is to set the Operating Mode to Maximum performance which indirectly controls the C and P-states.

3.3 - NUMA Settings

NUMA Nodes per Socket (NPS): This setting also relates to memory interleaving of the memory channels per socket. For example, NPS1 implies a single NUMA domain with all cores within the 9004 processor (socket) and all the corresponding memory in one NUMA domain. Memory is interleaved across the socket's twelve memory channels. All PCIe devices on the socket belong to this single NUMA domain. NPS2 i.e., 2 nodes per socket, interleaves memory across six channels. NPSx setting may be set independently of the LLC as NUMA Domain BIOS setting.

Extensive tests were conducted with NPS setting 1 and 4. The variance of performance in these tests is very minimal but NPS set to 1 shows slightly better performance. The best practice for AVD is to set NPS to 1.

Please see **NUMA Architecture*** for more information about NUMA in Windows.

3.4 - Memory Settings

High density desktops require populating the server with the maximum possible amount of memory. Further, the memory clock frequency provides marginally significant performance improvement in VDI environments, with memory operating at 4800 MHz providing the most optimal performance.

3.5 - Power Settings

Power Determinism: May increase power to die, to maximize core performance. This setting is controlled by the BIOS Profile – "Max Performance". In our testing it is set to "Maximum Performance".

NOTE: Secure Boot and Trusted platform Module (TPM) must be present and turned on in the BIOS Settings. These are the system requirements to deploy an Azure Local instance.

CHAPTER 4 - OPERATING SYSTEM SETTINGS

4.1 - Azure Local ISO Download

The Azure Local ISO can be downloaded from the Azure portal website. At the time of writing Azure Local 23H2 was the latest version available where the customer can deploy the instance through Azure portal. Azure Local, version 22H2 is also available in the portal to download but it will reach end of service by May 2025. If Azure Local solution hardware was obtained from the **Azure Local catalog** via a Microsoft® hardware partner, the Azure Local software should already be pre-installed. However, for validated Nodes the software must be downloaded from the Azure portal and installed.

4.2 - Deploying Azure Local Instance

To setup an instance there are some prerequisites to be followed before deploying such as preparing Active Directory, Storage VLANs, IP Network range for management network intents, Azure permissions etc. A detailed step by step procedure to deploy can be found **here**.

Starting with Azure Local 23H2, all deployments must be done through Azure portal only.

4.3 - Collaborative Processor Performance Control (CPPC)

Collaborative Processor Performance Control (CPPC) is defined in the Advanced Configuration and Power Interface (ACPI) specification and provides a mechanism for the OS to potentially request varying performance levels from processors. CPPC replaces traditional discrete frequency P-state requests.

Azure Stack HCI OS provides three power plans:

- Balanced (default).
- High Performance
- Power Saver

The default Azure Stack HCI OS power plan is Balanced. To obtain best performance, you can change the power plan to High Performance. Each of the three power plans has a separate GUID, for High Performance it is: 8c5e7fda-e8bf-4a96- 9a85-a6e23a8c635c.

For **High Performance** Mode with CPPC, use the Windows Powercfg,exe tool using a Window Command window running as Administrator:

- To show the current Power plan/scheme type: Powercfg /L
- To change to **High Performance**: Powercfg /s 8c5e7fda-e8bf-4a96-9a85-a6e23a8c635c
- To make the power scheme active: Powercfg /setactive scheme_current

Additionally, CPPC supports an autonomous mode, which AMD recommends, where AMD's System Management Unit (SMU) hardware promptly selects processor performance levels best suited to the current workload and power limits.

```
Powercfg /setacvalueindex scheme_current sub_processor PERFAUTONOMOUS 1
Powercfg /setacvalueindex scheme_current sub_processor PERFEPP 0
Powercfg /setacvalueindex scheme_current sub_processor PERFBOOSTMODE 4
Powercfg /setactive scheme_current
```

4.4 - BitLocker Encryption

Bit-Locker is a disk encryption feature included with Microsoft® Azure Stack HCI OS, designed to protect data by encrypting the drive and preventing unauthorized access. Trusted Platform Module (TPM), a pre-requisite for deploying an Azure local instance must be enabled in the BIOS Settings for Bit-locker encryption feature to function. It is crucial to download the keys, especially when using a single Azure Local instance. If the instance becomes unavailable and you do not have access to the keys, you might not be able to access the encrypted data or boot into the OS.

The recovery key information can be retrieved using the Get-AsRecoveryKeyInfo command.

CHAPTER 5 - AZURE VIRTUAL DESKTOP

5.1 - Deploying Azure Virtual Desktop

To deploy an **Azure Virtual Desktop (AVD)** on Azure Local instance, you need to create a host pool, session hosts, workspace and application group. Once these components are created, a user group must be assigned to the application group to grant access to the AVD. The Azure portal provides a wizard to simplify the deployment process as shown below.

Begin by specifying the resource group where the host pool will be deployed, then select the host pool type. For testing a multi-session desktop, choose **Pooled**, which allows multiple users to share session hosts. Alternatively, select **Personal** if each session host is to be dedicated to a single user. In the next step, virtual machines can be added to the host pool. Subsequent steps in the wizard are straightforward and self-explanatory. Note that enabling diagnostic settings on the host pool is not recommended if you plan to enable Azure Monitor, as this may result in conflicting configurations.

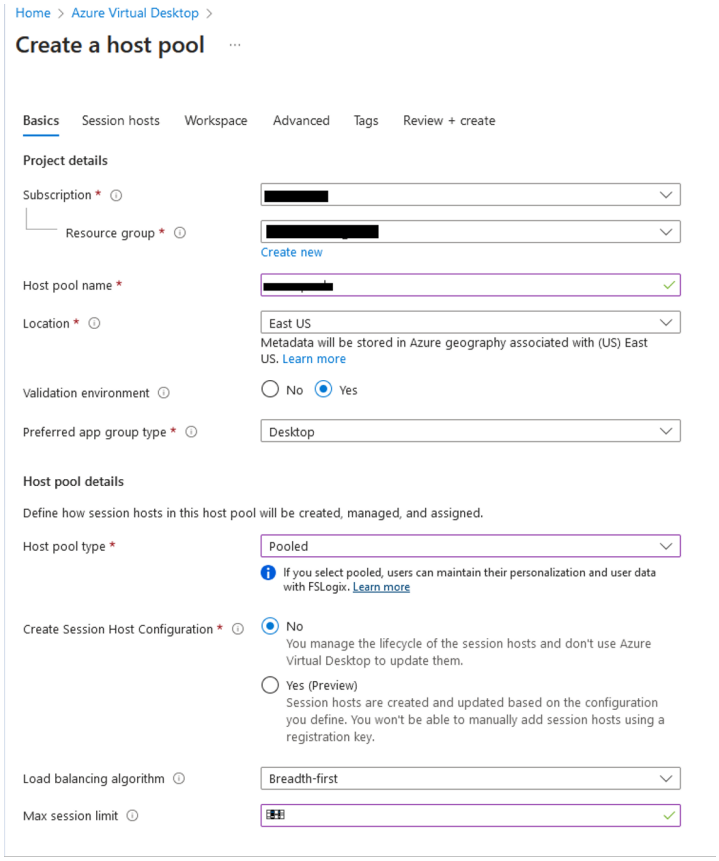

Figure 1: Azure virtual Desktop Host pool configuration

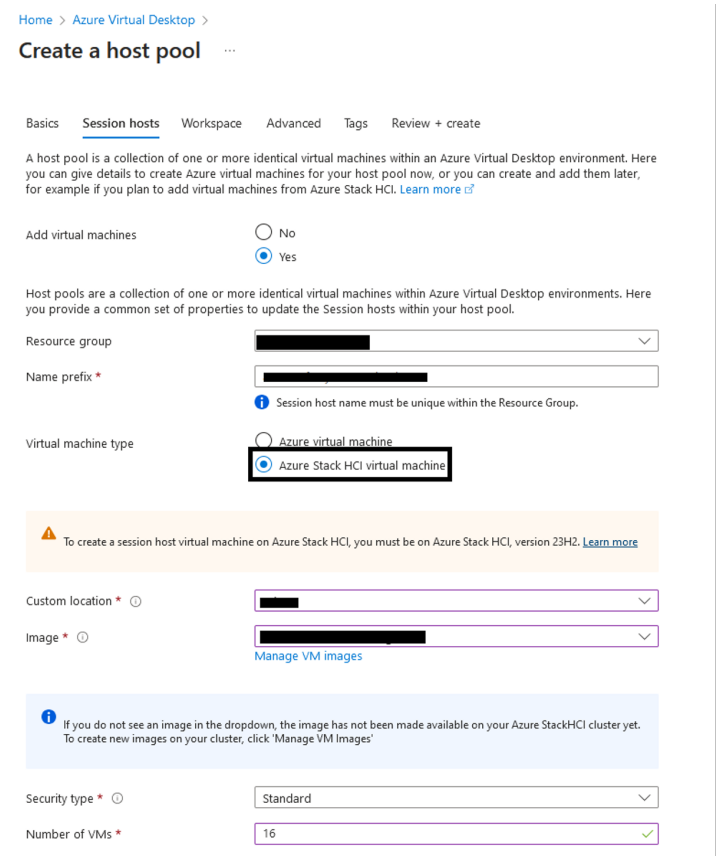

Figure 2: Azure virtual Desktop Host pool configuration

Several operating systems including those mentioned below are supported on the session hosts, and they can be downloaded from the Azure marketplace. There's also an option to download an update to the existing image for new session host deployments as well.

- Windows 11 Enterprise multi-session with Microsoft® 365 apps
- Windows 11 Enterprise multi-session
- Windows 11 Enterprise
- Windows 10 Enterprise multi-session
- Windows 10 Enterprise multi-session with Microsoft® 365 apps
- Windows 10 Enterprise
- Windows Server 2019
- Windows Server 2022
- Windows Server 2025

The recommendations provided in this guide are based on Windows 10 Build 19045.5073. This version also addresses the appx service faulting issue. More information can be found **here**.

5.2 - User Profile Management

In virtual desktop computing, FSLogix helps maintain consistent user profiles by redirecting them to a storage provider and mounting them as a VHD/VHDX file. By default, the session host comes with a 128GB disk size, but for efficient user profile management, it is recommended to use **roaming profile** or **FSLogix**.

In our study, an SMB Share was configured on a separate Windows server to manage user profiles using FSLogix. FSLogix is installed by default on the Azure Local instances and session hosts. A Group Policy Object (GPO) must be created and linked to the OU group on the domain controller which is the same OU used while deploying the instance. This article provides step by step instructions to enable FSLogix through group policy management editor.

The image below shows the settings used to enable FSLogix using the gpmc.msc tool.

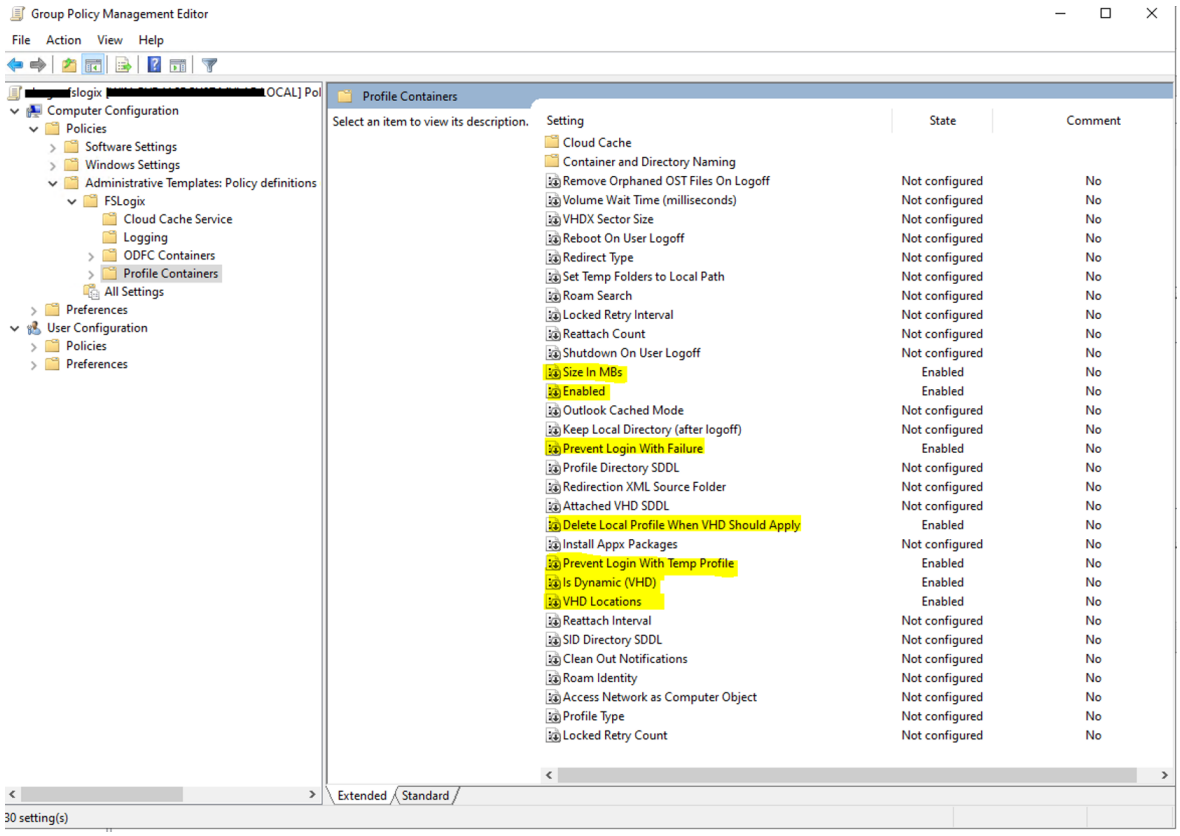

Figure 3: Group policy management editor

5.3 - Microsoft Entra ID and Single sign-on

Microsoft Entra ID formerly known as Azure Active Directory, is Microsoft's identity and access management solution. It supports user and group management on-premises and Cloud. The on-prem users, groups and devices can synchronize a local Active Directory with Azure through cloud sync. **Microsoft Entra Connect cloud sync** is designed to achieve hybrid identity goals for synchronizing users, groups and contacts to Microsoft® Entra ID. This enables a unified user identity for authentication and authorization to all resources regardless of their location. This type of user and device join is known as Microsoft® Entra Hybrid join.

Best practice is to have a virtual machine dedicated to this synchronization service. Once this software is downloaded and configured as mentioned **here**, the synchronization happens almost immediately.

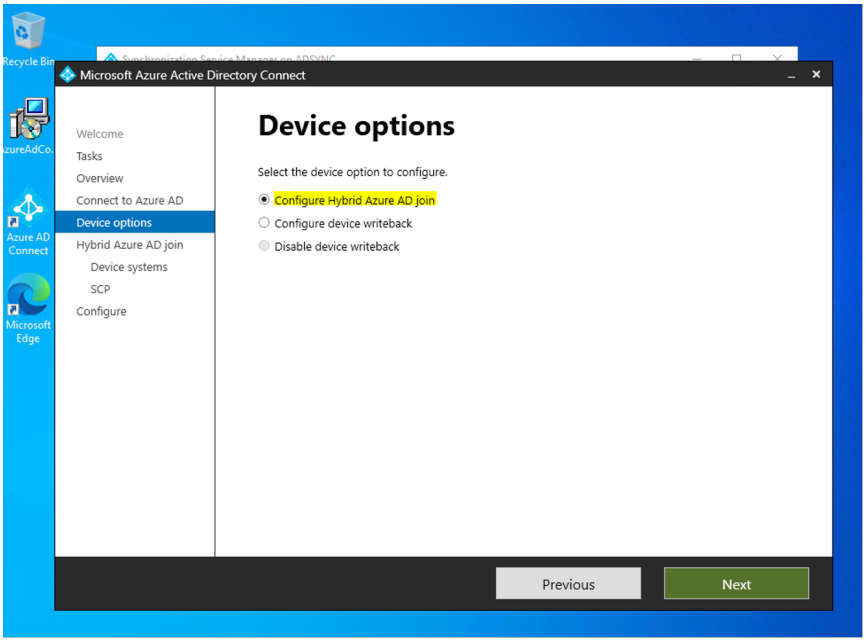

Figure 4: Microsoft Entra Connect configuration

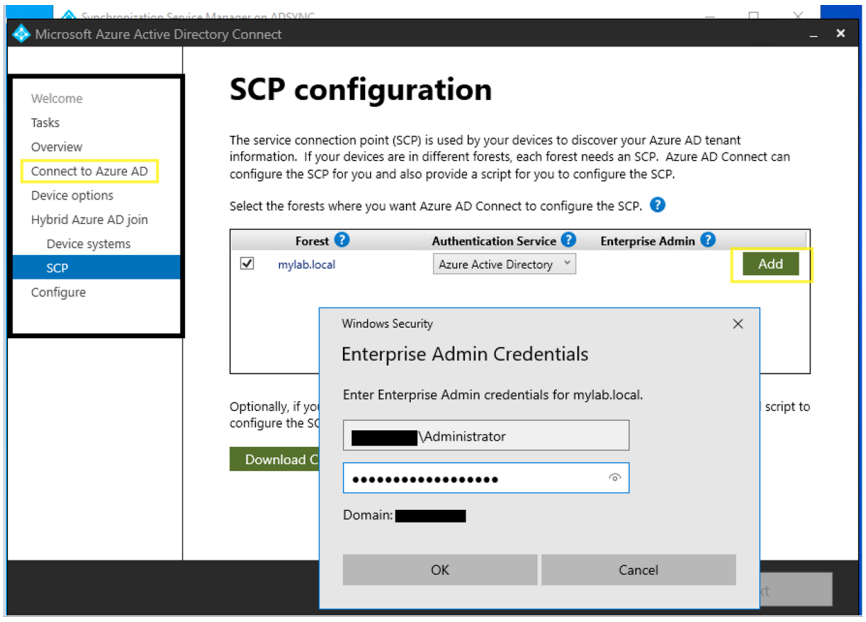

Figure 5: Microsoft Entra Connect configuration

Additionally, the synchronization options can also be configured for the domain controller using the above-mentioned tool. Below are the helpful commands used to check if a device is domain joined or to trigger a manual join.

```
dsregcmd /join /debug
dsregcmd /status
```

Tip: If a device in Azure Virtual Desktop fails to auto-join and manually triggering the join results in error code 0x801c03f3 or HTTP Status 400, verify whether the domain controller has recently synced with the Azure portal. If not, initiate a manual sync to ensure the devices are properly synchronized with Microsoft® Entra

5.4 - Configure Host Pool to Enable Single sign-on

To enable single sign-on to your hostpool, you must configure the RDP property, which can be done using Azure Portal or PowerShell. Detailed documentation to configure single sign on for the host pool is available **here**.

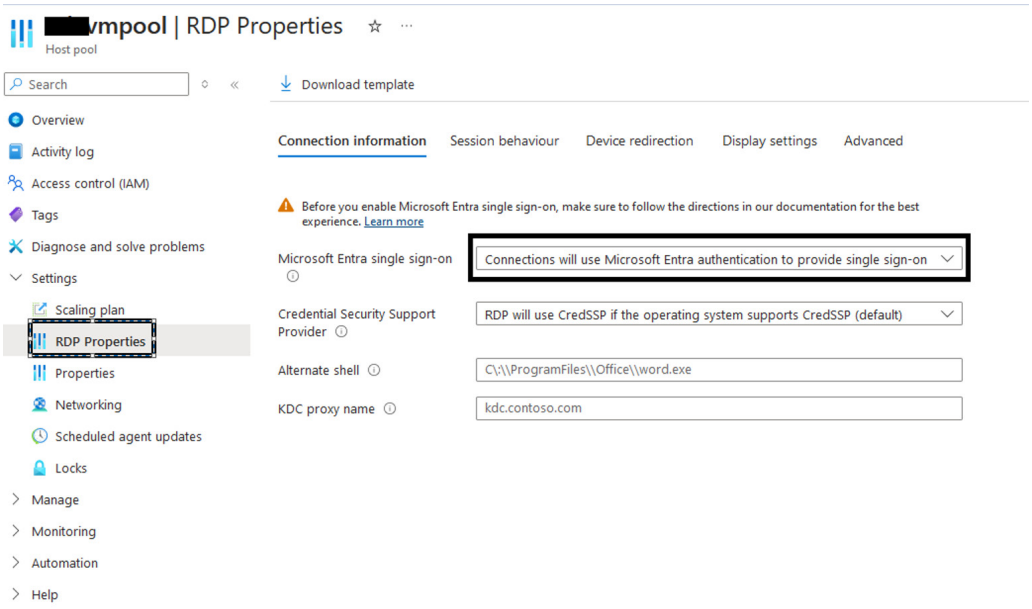

Figure 6: Host pool property configuration

CHAPTER 6 - AZURE VIRTUAL DESKTOP PERFORMANCE ANALYSIS

6.1 - Measuring AVD Performance

The tuning recommendations in this tuning guide are based on tests conducted using the industry-standard Login Enterprise software.

6.1.1 - About the Benchmark

Login Enterprise, by **Login VSI**, is the industry-standard software used to simulate a human-centric workload used for the purpose of benchmarking the capacity and performance of a VDI solutions. The virtual user technology of Login Enterprise simulates real-world users performing real-world tasks while measuring the time required for each interaction. Login Enterprise assesses desktop performance, application performance, and user experience to determine the overall responsiveness of the VDI solution. Using Login Enterprise for VDI capacity planning helps to determine the optimal hardware configuration to support the desired number of users and applications.

6.1.2 - Understanding EUX Score

The Login Enterprise End-User Experience (EUX) Score is a unique measurement that provides an accurate and realistic evaluation of user experience in virtualized or physical desktop environments. The score is based on metrics that represent system resource utilization and application responsiveness. The results are then combined to produce an overall score between 1 and 10 that closely correlates with the real user experience. See the table below for general performance guidelines with respect to the **EUX Score**.

SCORE	ASSESSMENT
Greater than 8.5	Excellent
7.5 – 8.5	Very Good
6.5 – 7.5	Good
5.5 – 6.5	Fair
Less than 5.5	Poor

Table 3: Login enterprise EUX Score

The Baseline and Steady state EUX Scores provide additional dimensions to the experience your Virtual Users are having. The standard EUX Score provides a single score for the duration of the entire test, including the login period and the application interaction period during the test run. As more users are steadily added to the system being tested, naturally the system will work harder and start to impact the user experience. The Steady State and Baseline EUX Scores show us what the user experience is like during specific periods of the test run.

Baseline EUX Score

The Baseline EUX Score represents the best possible performance of the system and is the average EUX score of the best 5 minutes of the test. This score indicates how the system performs when it is not under stress. Typically, the Baseline Score is captured at the beginning of the test before the system is fully loaded.

Steady State EUX Score

The Steady State period represents the time after all users have logged in (login storm) and the system starts to normalize. The Steady State EUX Score is the average of the EUX Scores captured 5 minutes after all sessions are logged in, until the end of the test.

6.1.3 - VSImax

The Login Enterprise VSImax is a performance metric used to measure the maximum user capacity or scalability of a virtualized desktop infrastructure (VDI) environment. The EUX Score is used to determine the VSImax and it represents the maximum number of virtual users that can be supported by the infrastructure while still maintaining acceptable performance levels.

6.1.4 - Login Enterprise Workloads

Login Enterprise Workloads are human-centric workloads designed to simulate a user interacting with predetermined applications in a human-paced way. The industry-standard workloads that come with Login Enterprise are **Knowledge Worker** and Task Worker. These workloads are based on the Microsoft® Office suite and popular browsers used in the enterprise. Other workloads are available from Login VSI.

The workload used in this testing is the Login Enterprise Knowledge Worker which is a medium to heavy duty productivity user that regularly uses a web browser, an email client, and specializes in a wide range of software to create spreadsheets, documents and presentations. It is common for Knowledge Workers to have multiple applications and browsers open at once, regularly switching between these applications. The Knowledge Worker expects a responsive user experience and has little tolerance for variation in performance. This Knowledge Worker mostly aligns to the heavy user profile noted by Microsoft® in the following **article**.

6.2 - Azure Virtual Desktop Sizing for AMD EPYC ™ 9004 Series Processors

The table below outlines the VDI sizing recommendations for AMD EPYC™ 9004 Series processors with a Knowledge Worker workload. Testing was conducted on a single node, with session hosts running Windows 10 Enterprise Multi-session Build 10.0.19045.5073 and Microsoft® Office 365 applications. The session host configuration used for these tests included 16 vCPUs and 64 GB of memory.

AMD EPYC ™ PROCESSOR (9XX4)	VDI SIZING BASED ON VSIMAX	EUX SCORE
Two socket 9554 (64 Core)	~ 588	7.5
Two Socket 9654 (96 Core)	~ 727	7.7

The VDI sizing recommendations are based on achieving a VSImax while maintaining an **EUX Score** of at least 7.0. A comparative study using different VM sizes—8 vCPUs with 32 GB memory and 16 vCPUs with 64 GB memory—revealed minimal variation in the number of total sessions per node. To ensure effective maintenance, monitoring and troubleshooting of the VDI environment, it is recommended to choose a manageable number of VMs.

Benchmark Analysis

Tests conducted with the Login Enterprise benchmark, and a Knowledge Worker workload revealed that each AMD EPYC™ 9004 Series CPU core can support 3-4 virtual users. The graph below showcases the performance results of a two-processor server equipped with the AMD EPYC™ 9554 64-Core Processor.

Test Summary:

- **Login Phase:** Over the first 75 minutes, 600 users logged in, averaging 8 virtual users entering the session host pool per minute.
- **Workload Execution:** Once all users were logged in, a Knowledge Worker workload was executed for approximately 30 minutes.
- **Performance Metrics:**
  - **EUX Baseline Score:** 8.6 (calculated from the best-performing 5 minutes when the system was lightly utilized).
  - **Steady-State Score:** 7.4 (average score recorded after all sessions were active).

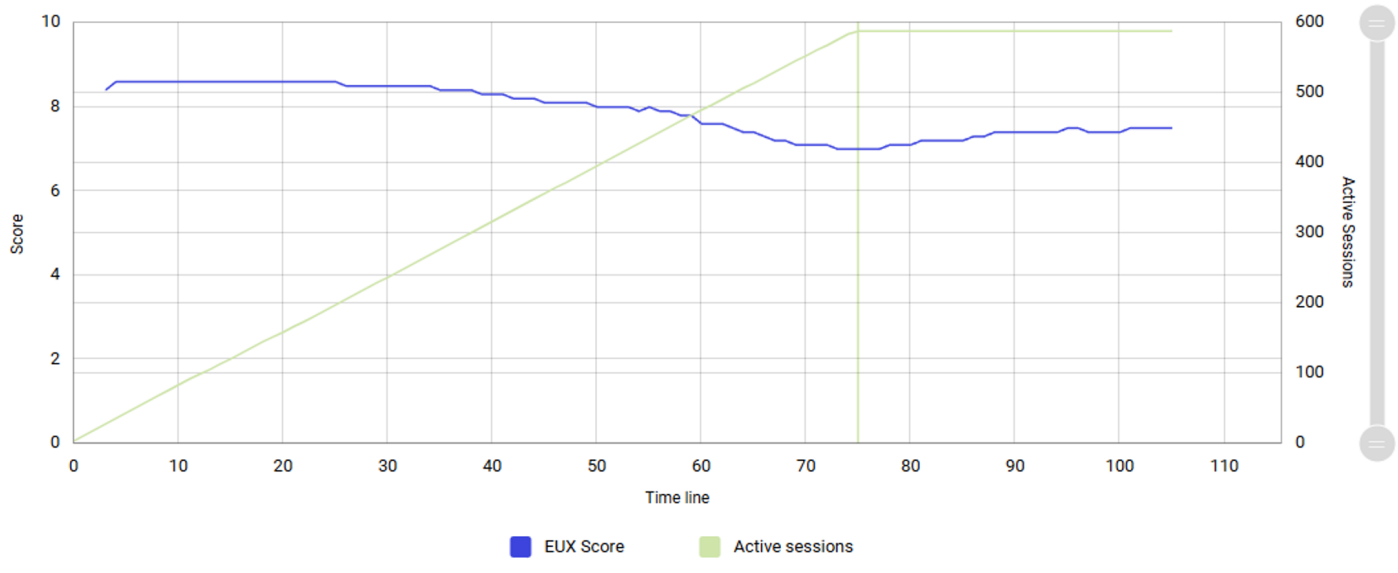

Figure 7: Login Enterprise Knowledge Worker workload results

CPU and Memory Utilization

The CPU and memory utilization of the session hosts during the test run are depicted in the following two graphs. To assess the system's maximum capacity, the CPU was nearly fully saturated, reaching up to 95% utilization during the virtual user login phase. After the login phase was complete and the workload tests began, a slight drop of 3-4% in CPU utilization was observed, which is consistent with expectations. The active sessions, represented by the green line in the graph, remained stable with no session drops, demonstrating the system's ability to manage such a heavy workload effectively.

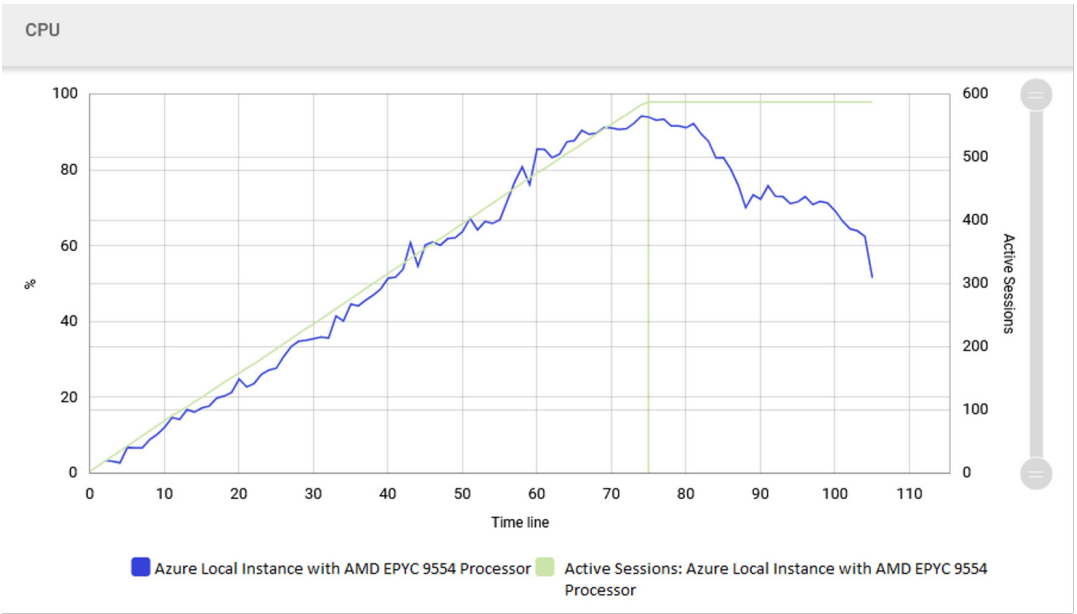

Figure 8: CPU Utilization

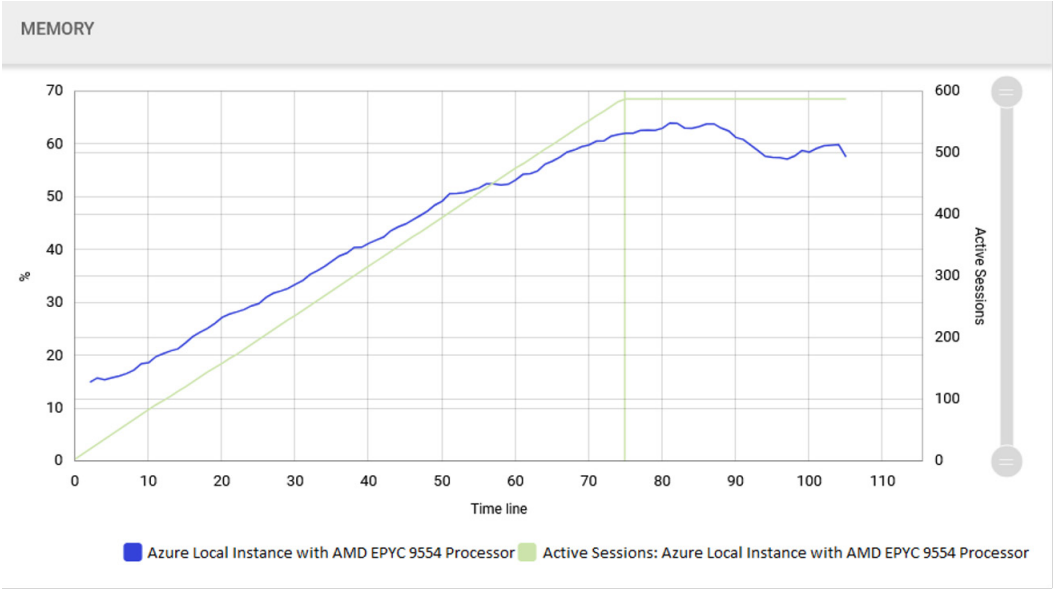

Figure 9: Memory Utilization

- Exceeding the system's capacity to support virtual users can result in session disconnections or slower performance, leading to poor EUX Scores.
- These tests were conducted without any security software installed besides Windows Defender, and actual performance may vary based on specific configurations and test conditions. It is recommended to test and optimize AVD on Azure Local solutions after the system has been configured with production desktop images that include information security software and line of business applications.

CHAPTER 7 - SUMMARY

Tuning your server for maximum capacity and performance of the AVD on Azure Local solution using AMD EPYC ™ 9004 Series processors can increase user productivity and reduce cost. The guide provides insights into configuring BIOS tuning parameters, Hyper-V tuning parameters and best practices for achieving the best performance from the system. A two-socket platform with AMD EPYC™ 9554 processors can accommodate approximately 588 virtual users, while the AMD EPYC™ 9654 platform supports around 727 users, averaging three to four virtual users per physical core maintaining a very strong EUX Score.