interopLab

Bloombase StoreSafe and IBM Guardium Key Lifecycle Manager Integration Guide for Data-at-Rest Encryption

November 2025

BLOOMBASE®

Executive Summary

IBM Guardium Key Lifecycle Manager (GKLM) has been validated by Bloombase InteropLab to run with Bloombase StoreSafe Intelligent Storage Firewall. This document describes the steps carried out to integrate IBM GKLM with Bloombase StoreSafe software appliance on Broadcom VMware ESXi to deliver high bandwidth transparent storage encryption on Terabit Ethernet for mission critical software applications. Client host systems Microsoft Windows 11 and Ubuntu 22.04 LTS have been tested with IBM GKLM and Bloombase StoreSafe storage firewall solution to secure Microsoft Storage Server 2025 and Rocky Linux 9 storage backends via storage networking protocols including SMB, NFS, iSCSI and NVMe/TCP.

Document No.: BLBS-TN - Bloombase StoreSafe - IBM Guardium Key Lifecycle Manager (GKLM) Integration Guide - USLET-EN-R1.0.1

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Purpose and Scope

This document describes the steps necessary to integrate IBM GKLM with Bloombase StoreSafe to deliver agentless, transparent encryption security of traditional storage systems and next-generation storage services for mission-critical applications. Specifically, we cover the following areas:

- Install and configure Bloombase StoreSafe software appliance
- Integrate Bloombase StoreSafe with IBM GKLM
- Integrate Microsoft Windows 11 and Ubuntu 22.04 LTS client systems with Bloombase StoreSafe and IBM GKLM data-at-rest encryption security solution for Microsoft Windows Server 2025 and Rocky Linux 9 storage backends to demonstrate how high-bandwidth, agentless, application-transparent data encryption could be achieved for multiple network storage protocols namely SMB, NFS, iSCSI and NVMe/TCP.

Assumptions

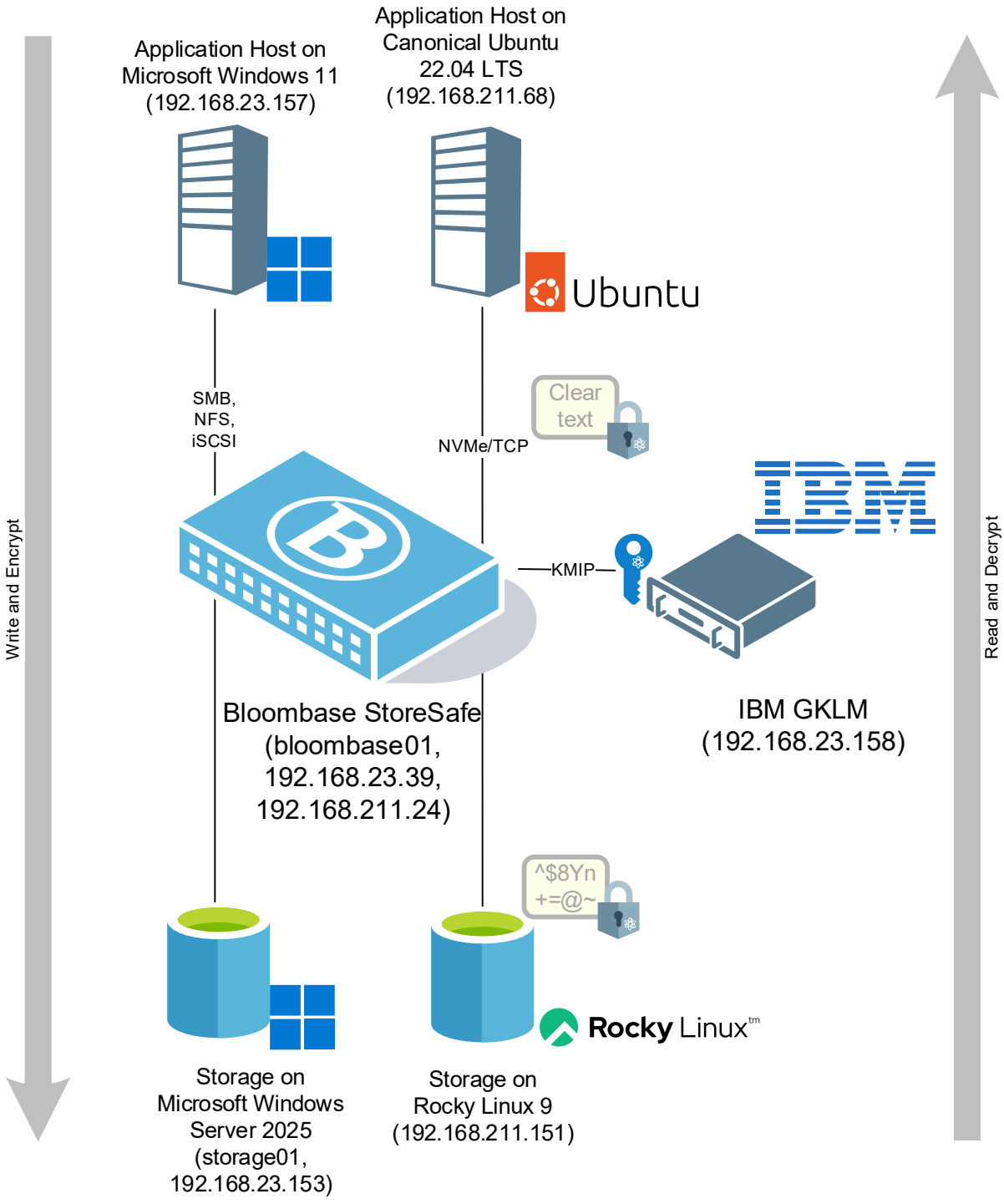
This document describes the integration of IBM GKLM with Bloombase StoreSafe. It is assumed that you are familiar with operation of IBM GKLM, storage systems, and major operating systems including Linux, Microsoft Windows, IBM AIX, HP-UX and Oracle Sun Solaris. It is also assumed that you possess basic UNIX administration skills. The examples provided may require modifications before they are run under your version of operating system.

As IBM GKLM is third party option to Bloombase StoreSafe data at-rest encryption security solution, you are recommended to refer to installation and configuration guides of specific model of IBM GKLM for your actual use cases. We assume you have basic knowledge of storage networking and information cryptography. For specific technical product information of Bloombase StoreSafe, please refer to our website at https://www.bloombase.com and Bloombase SupPortal https://supportal.bloombase.com.

Infrastructure

Setup

The integration discussed in this guide is based on the system block diagram below:



Storage Encryption

Storage Encryption	Bloombase StoreSafe Intelligent Storage Firewall Software Appliance v4.0
Server	Broadcom VMware ESXi 6.5 on Dell PowerEdge T440 server
Processor	4x Virtual CPU (vCPU)
Memory	8GB
Network Interface Card	NVIDIA ConnectX-6

Key Management System

Key Management System	IBM Guardium Key Lifecycle Manager (GKLM) 5.0

Storage Systems

Storage Systems	Microsoft Storage Server on Microsoft Windows Server 2025	NVMe over Fabrics (NVMe-oF) storage services on Rocky Linux 9

Storage Hosts

Client Hosts	Microsoft Windows 11	Ubuntu 22.04 LTS

Networking

Ethernet Switch	Celestica Seastone DX010 32-port 100GbE ONIE Switch
Network Interface Card	NVIDIA ConnectX-6
Network Cables	NVIDIA/Mellanox 100GbE QSFP28 DAC Cables

Configuration Overview

IBM Guardium Key Lifecycle Manager (GKLM)

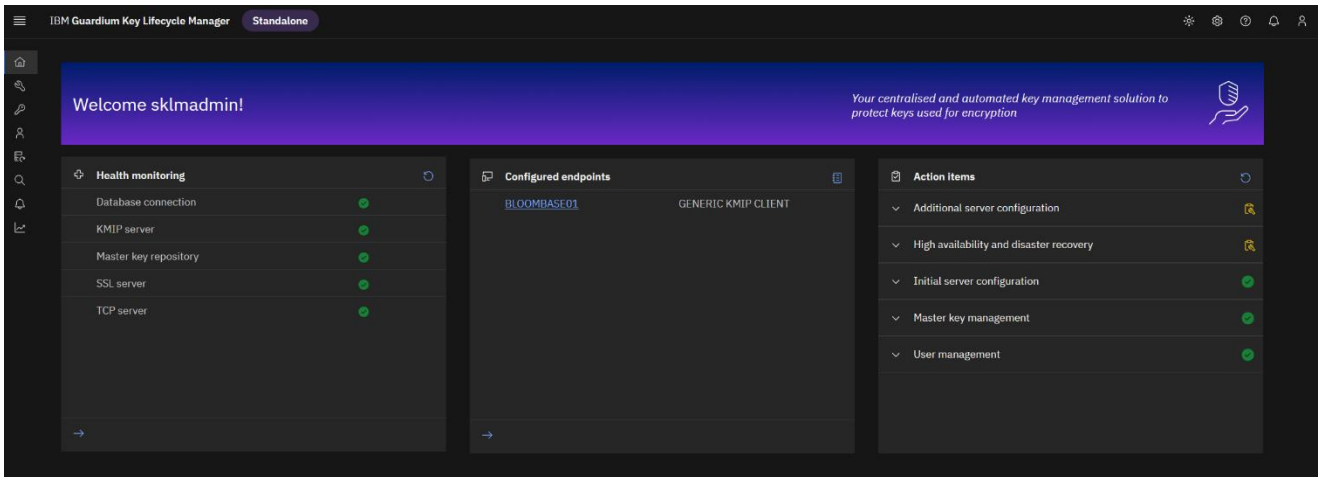
IBM Guardium Key Lifecycle Manager is an encryption key management tool that centralizes, simplifies and automates the key management process. It offers robust and security-rich key storage, key serving and key lifecycle management for encryption applications and solutions by using interoperability protocols, including KMIP.

The IBM GKLM can provide central management and secure storage of encryption keys used by Bloombase StoreSafe products. It provides intuitive web-based console, and APIs for managing of encryption keys.

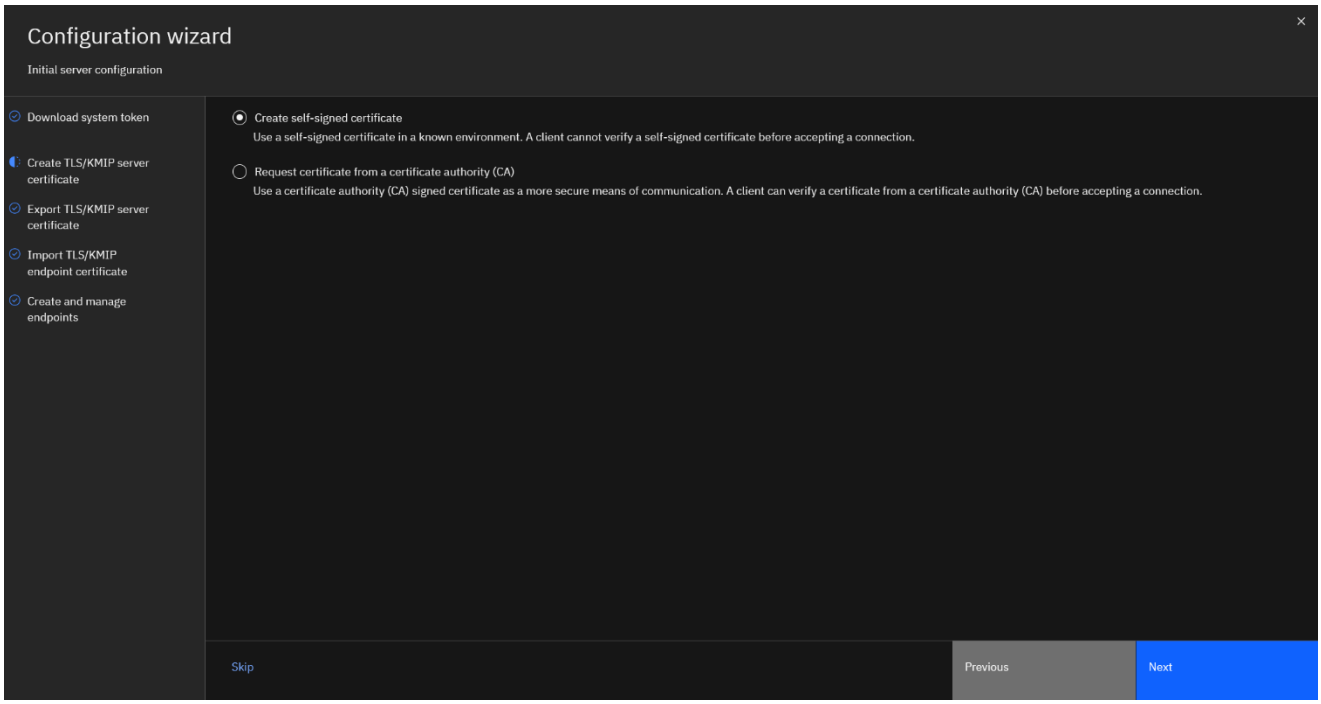
The KMIP services provided by IBM GKLM are used by Bloombase StoreSafe for encryption protection of data-at-rest use cases.

IBM GKLM Configurations

In this demo, an IBM Guardium Key Lifecycle Manager (GKLM) is installed and configured as a single node network attached virtual appliance with IP address `192.168.23.158` assigned.



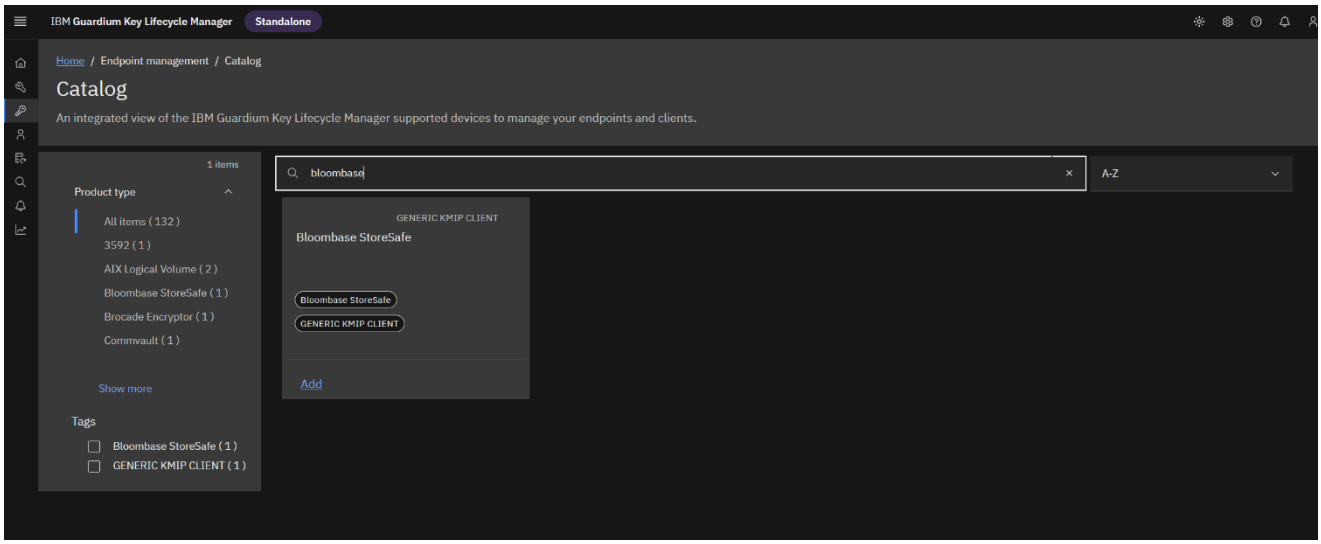
IBM GKLM can be managed remotely via web-based management console at port `9443`. During initial server configuration, a KMIP certificate needs to be chosen. This certificate needs to be downloaded for use with the Bloombase StoreSafe client.



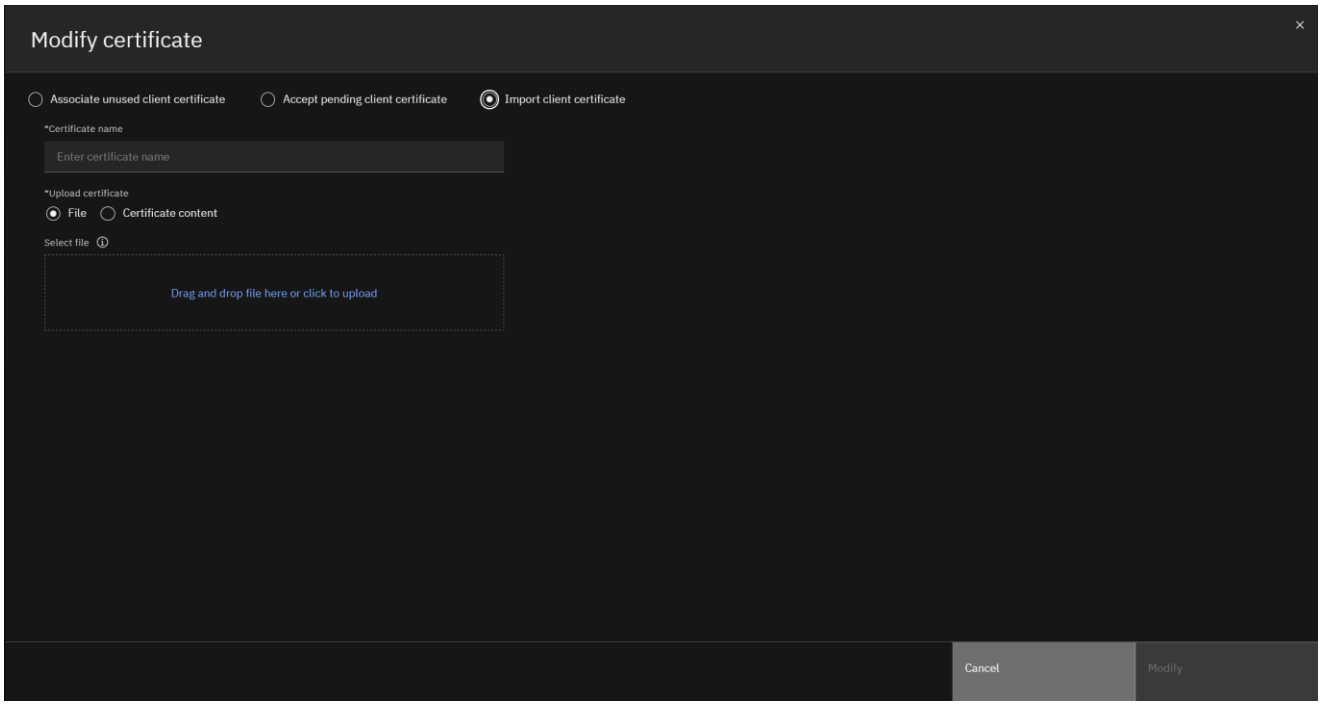
KMIP Client

For the purpose of this interoperability testing, KMIP client “bloombase01” is provisioned and assigned for the Bloombase StoreSafe software appliance instance.

A Bloombase StoreSafe profile can be found in the GKLM catalog.



The client certificate can either be uploaded manually or accepted after a connection attempt.



The KMIP client and GKLM certificate are later added to the Bloombase StoreSafe web management console.

Network Configuration

Ethernet Switch Configuration

Celestica Seastone DX010 32-port 100GbE ONIE switch has been used in this integration testing.

Ports 24 and 28 of the 100Gb Ethernet switch are connected to the NVIDIA ConnectX-6 NICs via DAC cables as shown in the SONiC console below.

```
Linux sonic 5.10.0-8-2-amd64 #1 SMP Debian 5.10.46-4 (2021-08-03) x86_64
You are on
  ____   ___   _   _  ___
 / ___| / _ \| \ | |/ ___|
 \___ \| | | |  \| | |
  ___) | |_| | |\  | |___
 |____/ \___/|_| \_|\____|

-- Software for Open Networking in the Cloud --

Unauthorized access and/or use are prohibited.
All access and/or use are subject to monitoring.
```

```
admin@sonic:~$ sudo config vlan add 210
admin@sonic:~$ sudo config vlan member add -u 210 Ethernet24
admin@sonic:~$ sudo config vlan member add -u 210 Ethernet28
```

```
admin@sonic:~$ show vlan brief
+-----------+--------------+------------+----------------+-------------+-----------------------+
|   VLAN ID | IP Address   | Ports      | Port Tagging   | Proxy ARP   | DHCP Helper Address   |
+===========+==============+============+================+=============+=======================+
|       210 |              | Ethernet24 | untagged       | disabled    |                       |
|           |              | Ethernet28 | untagged       |             |                       |
+-----------+--------------+------------+----------------+-------------+-----------------------+
```

```
admin@sonic:~$ show interfaces status
  Interface            Lanes    Speed    MTU    FEC    Alias    Vlan    Oper    Admin             Type    Asym PFC
-----------  ---------------  -------  -----  -----  -------  ------  ------  -------  ---------------  ----------
  Ethernet0      65,66,67,68     100G   9100     rs     Eth1   trunk    down       up              N/A         N/A
  Ethernet4      69,70,71,72     100G   9100     rs     Eth2   trunk      up       up  QSFP28 or later         N/A
  Ethernet8      73,74,75,76     100G   9100    N/A     Eth3   trunk    down       up              N/A         N/A
 Ethernet12      77,78,79,80     100G   9100     rs     Eth4   trunk      up       up  QSFP28 or later         N/A
 Ethernet16      33,34,35,36     100G   9100     rs     Eth5   trunk    down       up  QSFP28 or later         N/A
 Ethernet20      37,38,39,40     100G   9100    N/A     Eth6   trunk    down       up              N/A         N/A
 Ethernet24      41,42,43,44     100G   9100    N/A     Eth7   trunk      up       up  QSFP28 or later         N/A
 Ethernet28      45,46,47,48     100G   9100    N/A     Eth8   trunk      up       up  QSFP28 or later         N/A
```

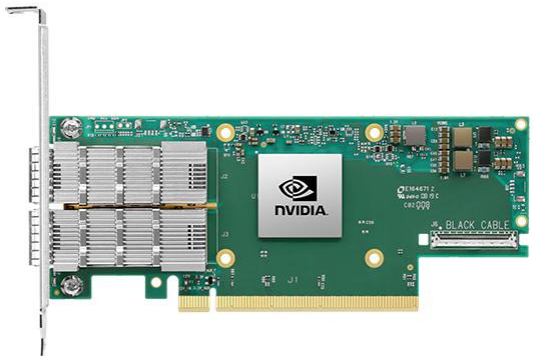
```
Ethernet24: SFP EEPROM detected
        Application Advertisement: N/A
        Connector: No separable connector
        Encoding: Unspecified
        Extended Identifier: Power Class 1(1.5W max)
        Extended RateSelect Compliance: QSFP+ Rate Select Version 1
        Identifier: QSFP28 or later
        Length Cable Assembly(m): 2
        Nominal Bit Rate(100Mbs): 255
        Specification compliance:
                Extended Specification compliance: 100GBASE-CR4, 25GBASE-CR CA-25G-L or 50GBASE-CR2
with RS
        Vendor Date Code(YYYY-MM-DD Lot): 2021-12-06
        Vendor Name: FS
        Vendor OUI: 00-02-c9
        Vendor PN: Q28-PC02
        Vendor Rev: A2
        Vendor SN: G2140009608-2
```

Direct Attach Copper (DAC) Cable

NVIDIA/Mellanox 100GbE QSFP28 DAC cables have been used in this interoperability testing.

Network Interface Card (NIC)

NVIDIA ConnectX-6 NIC has been used in this integration testing.



Install and configure NVIDIA ConnectX-6 NIC using the install image or the driver available from your distribution's repo.

```
[root@rocky24 ~]# lspci |grep ConnectX
01:00.0 Ethernet controller: Mellanox Technologies MT42822 BlueField-2 integrated ConnectX-6 Dx network controller (rev 01)
01:00.1 Ethernet controller: Mellanox Technologies MT42822 BlueField-2 integrated ConnectX-6 Dx network controller (rev 01)
```

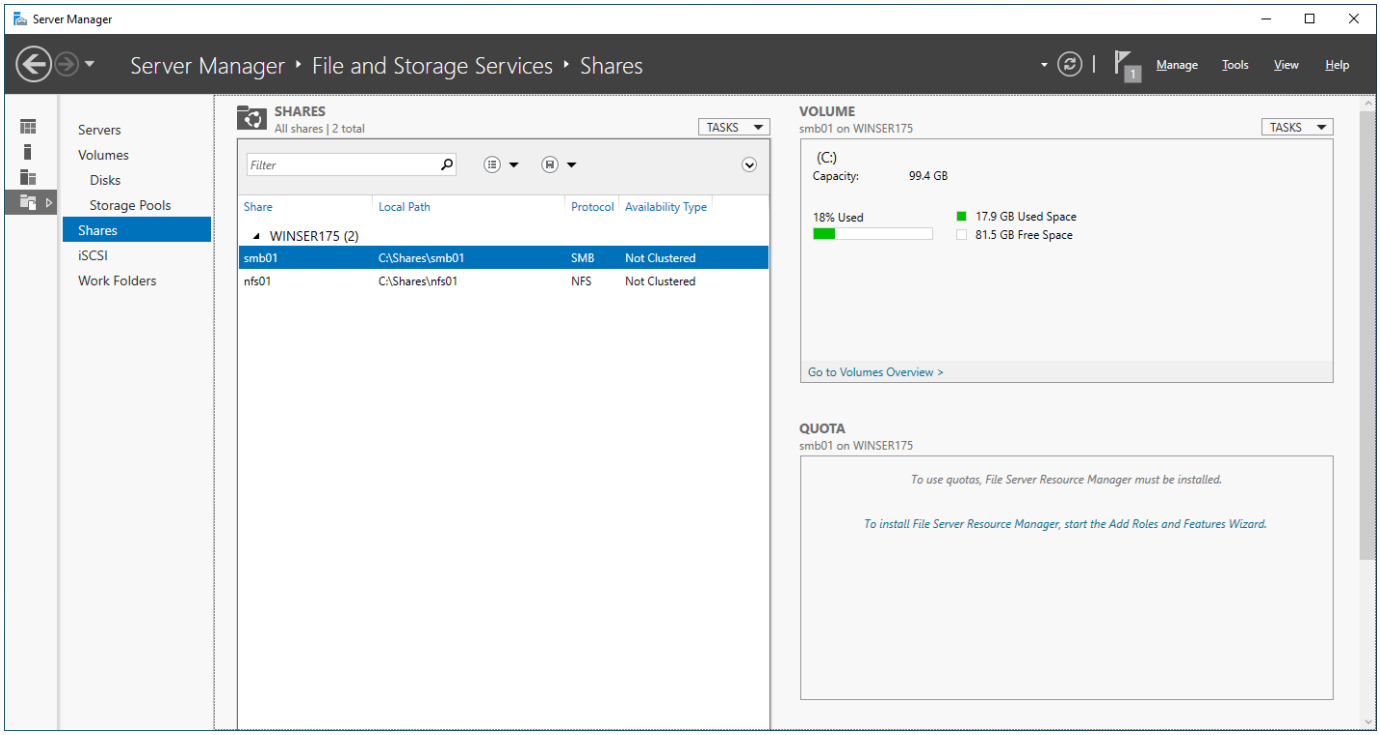
```
[root@rocky24 ~]# ibstat
CA 'mlx5_0'
        CA type: MT41686
        Number of ports: 1
        Firmware version: 24.39.2048
        Hardware version: 1
        Node GUID: 0xb8cef60300d214b2
        System image GUID: 0xb8cef60300d214b2
        Port 1:
                State: Active
                Physical state: LinkUp
                Rate: 40
                Base lid: 0
                LMC: 0
                SM lid: 0
                Capability mask: 0x00010000
                Port GUID: 0xbacef6fffed214b2
                Link layer: Ethernet
CA 'mlx5_1'
        CA type: MT41686
        Number of ports: 1
        Firmware version: 24.39.2048
        Hardware version: 1
        Node GUID: 0xb8cef60300d214b3
        System image GUID: 0xb8cef60300d214b2
        Port 1:
                State: Active
                Physical state: LinkUp
                Rate: 40
                Base lid: 0
                LMC: 0
                SM lid: 0
                Capability mask: 0x00010000
                Port GUID: 0xbacef6fffed214b3
                Link layer: Ethernet
```

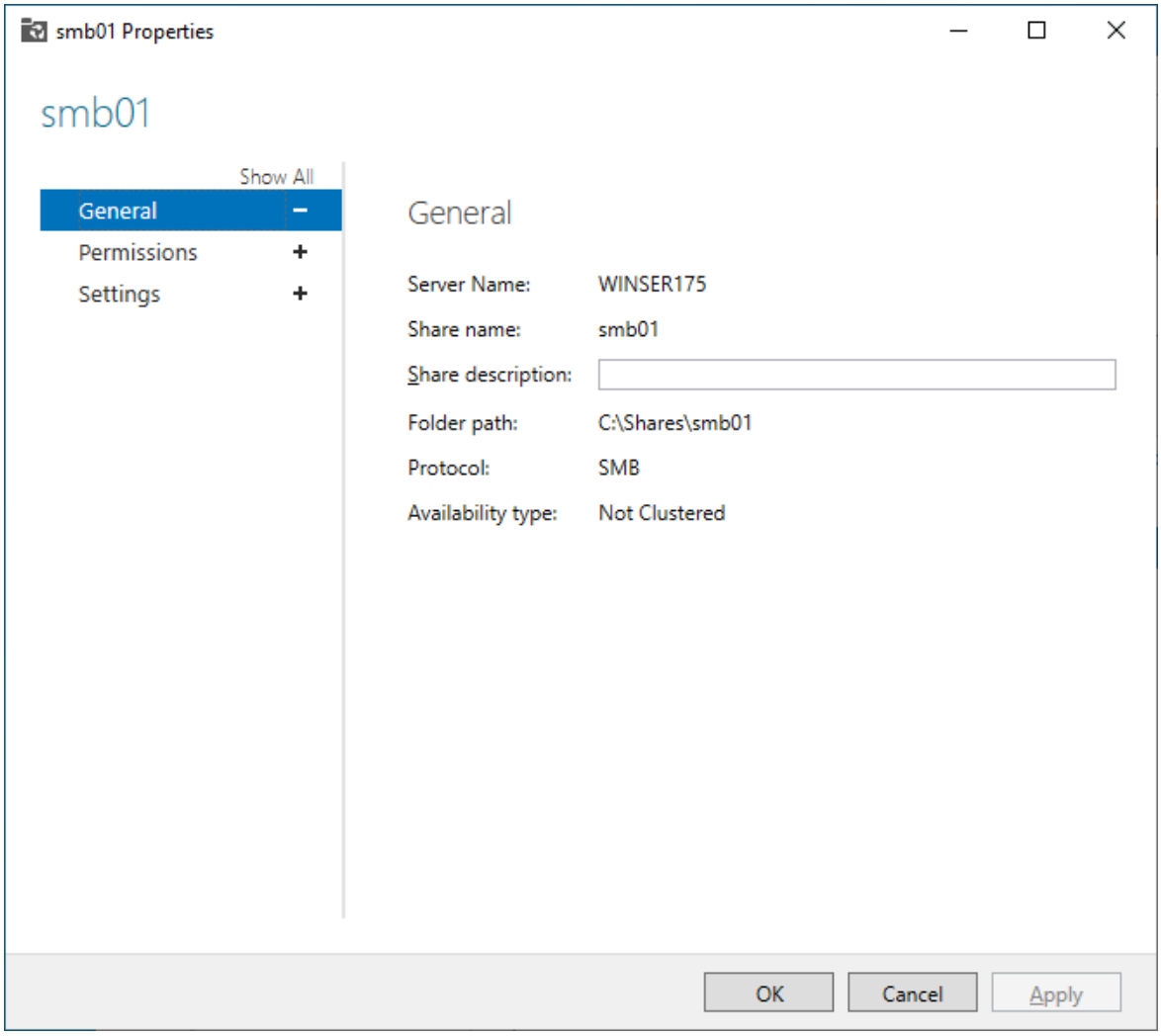
Microsoft Storage Server on Microsoft Windows Server 2025 Storage Backends

Microsoft Storage Server on Microsoft Windows Server 2025 running on Broadcom VMware ESXi is used in this interoperability test which is able to provide storage services over network storage protocols including iSCSI, NFS, SMB, CIFS, REST, etc.

Microsoft Windows Server 2025 is deployed as a virtual appliance (VA) on Broadcom VMware ESXi.

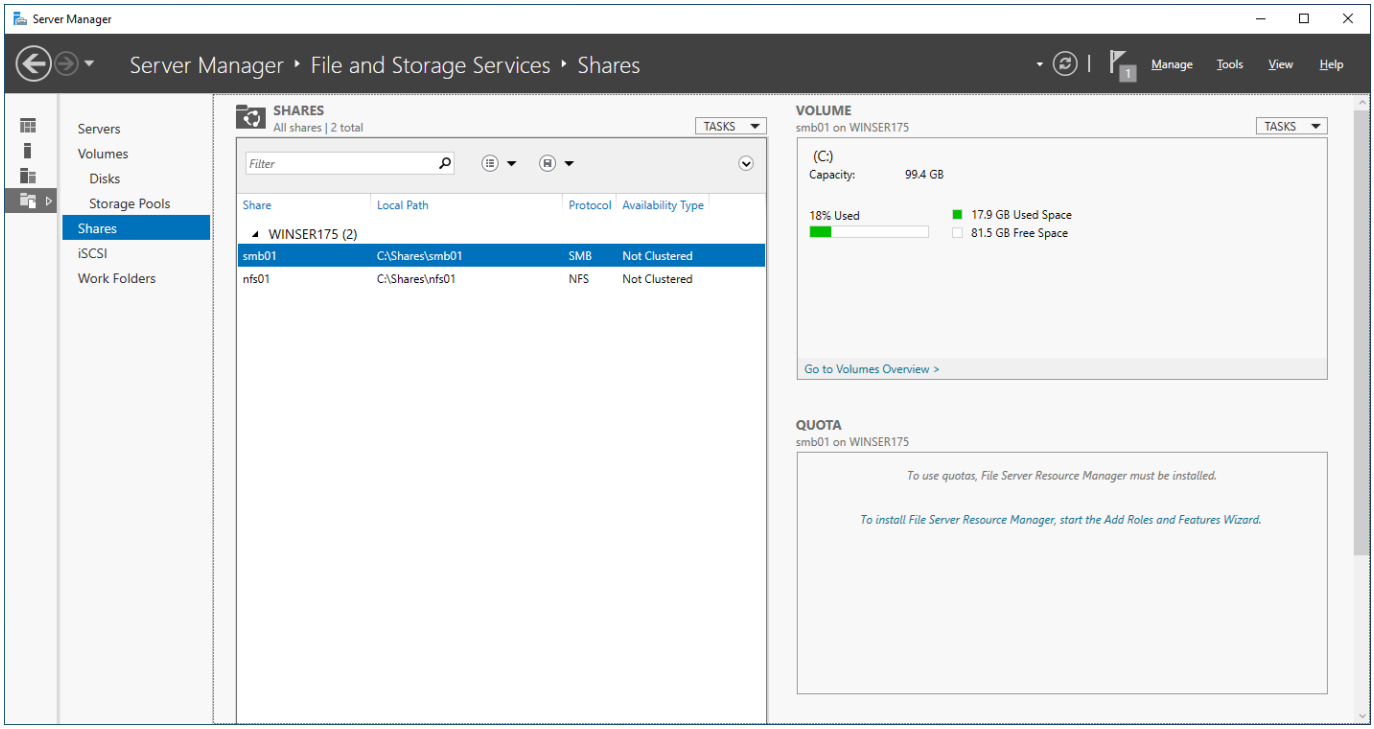
SMB Services Configuration

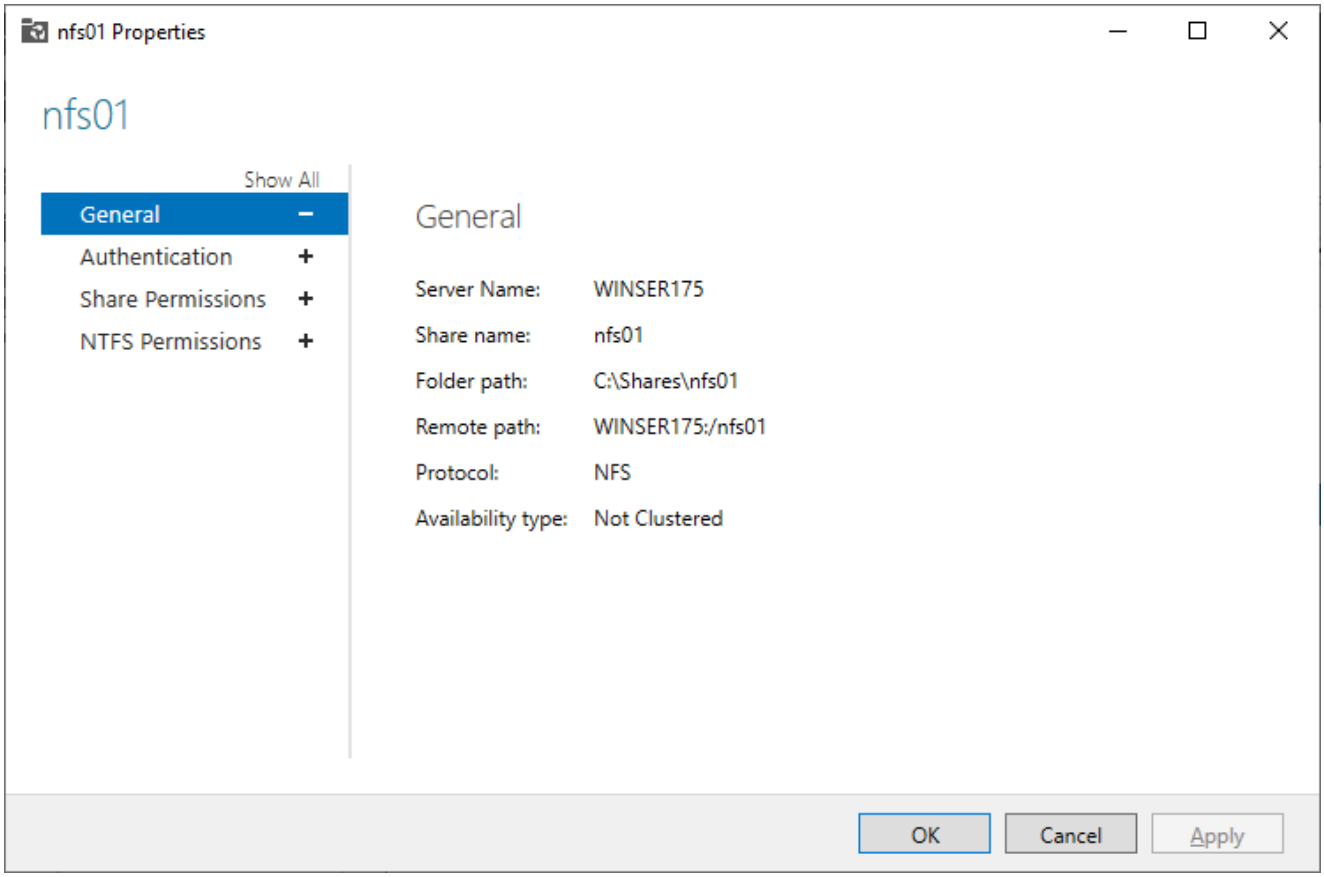




Microsoft Windows Server 2025 File Management is configured to provide the SMB share backend storage to client system users.

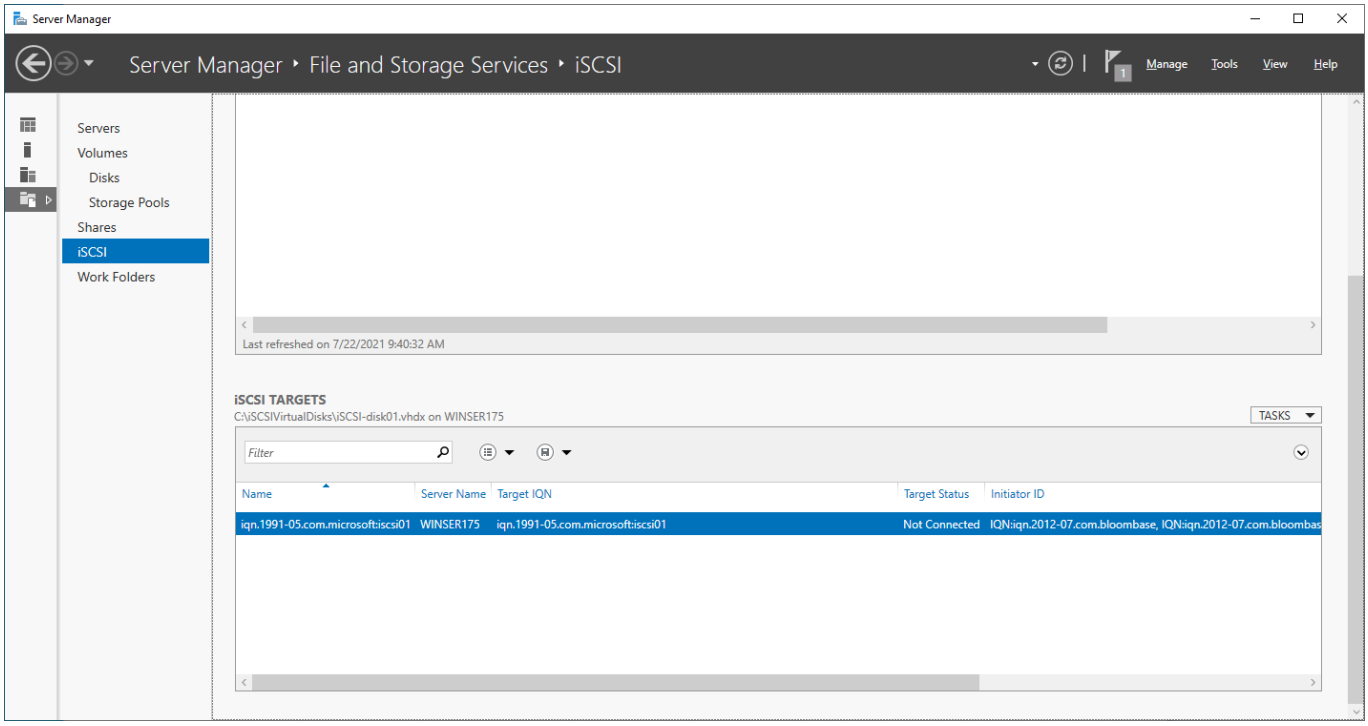
NFS Services Configuration





NFS storage service is provisioned on Microsoft Windows Server 2025 to be used in this integration testing.

iSCSI Services Configuration



iSCSI storage service is also provisioned on Microsoft Windows Server 2025 to be used in this integration testing.

NVMe over Fabrics (NVMe-oF) Storage Target on Rocky Linux 9 Storage Target

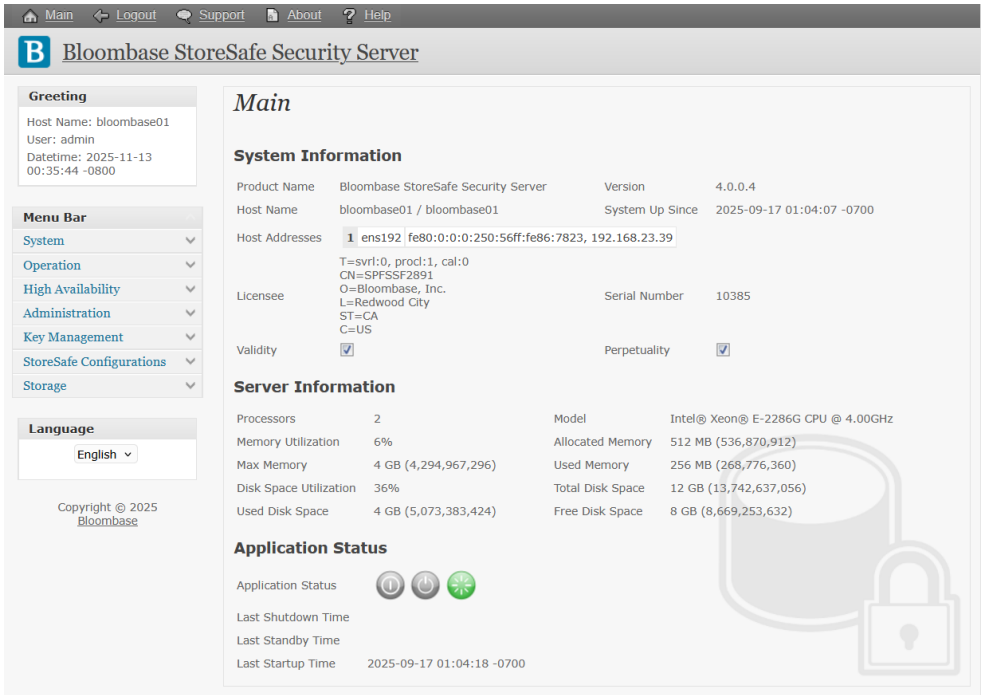
Linux NVMe-oF target software is used to be the storage backend secured by Bloombase StoreSafe Intelligent Storage Firewall.

```
[root@carocky151 ~]# nvmetcli
/> ls
o- / ..... [...]
  o- hosts ..... [...]
  | o- nqn.2014-08.org.nvmexpress:uuid:4af97520-1bfe-4c8d-9069-5fb9ab632709 ..... [...]
  o- ports ..... [...]
  | o- 1 ..... [trtype=tcp, traddr=192.168.211.151, trsvcid=4420, inline_data_size=16384]
  | | o- ana_groups ..... [...]
  | | | o- 1 ..... [state=optimized]
  | | o- referrals ..... [...]
  | | o- subsystems ..... [...]
  | |   o- nqn.2014-08.org.nvmexpress:NVMf:uuid:7079993e-7413-4338-9b9b-a3af82259b18 ..... [...]
  | o- 2 ..... [trtype=rdma, traddr=192.168.211.151, trsvcid=4420, inline_data_size=4096]
  |   o- ana_groups ..... [...]
  |   | o- 1 ..... [state=optimized]
  |   o- referrals ..... [...]
  |   o- subsystems ..... [...]
  |     o- nqn.2014-08.org.nvmexpress:NVMf:uuid:7079993e-7413-4338-9b9b-a3af82259b18 ..... [...]
  o- subsystems ..... [...]
    o- nqn.2014-08.org.nvmexpress:NVMf:uuid:7079993e-7413-4338-9b9b-a3af82259b18 [version=1.3, allow_any=0, serial=cdbdf55fefeea52243d3]
      o- allowed_hosts ..... [...]
      o- namespaces ..... [...]
        o- 1 ..... [path=/dev/nullb0, uuid=e581a156-7460-45e2-b6ae-0457e0762342, grpid=1, disabled]
```

Bloombase StoreSafe Intelligent Storage Firewall

Bloombase StoreSafe delivers unified data at-rest encryption security of files, block devices, objects, sequential storages, etc. In this interoperability test, both file-based and block-based encryption security services are validated against Bloombase StoreSafe with keys managed at IBM GKLM.

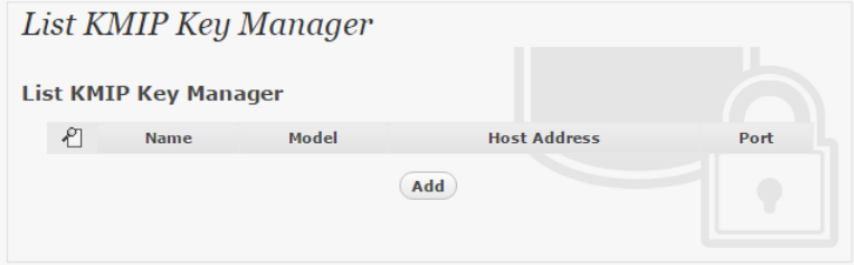
Bloombase StoreSafe Intelligent Storage Firewall software appliance is deployed as a virtual appliance (VA). Bloombase StoreSafe Web Administration Console in this example can be accessed using web browser at IP `192.168.23.39` and port `8443`



IBM Guardium Key Lifecycle Manager (GKLM) and Bloombase StoreSafe Integration

Bloombase supports IBM GKLM out of the box due to both products' support of OASIS Key Management Interoperability Protocol (KMIP).

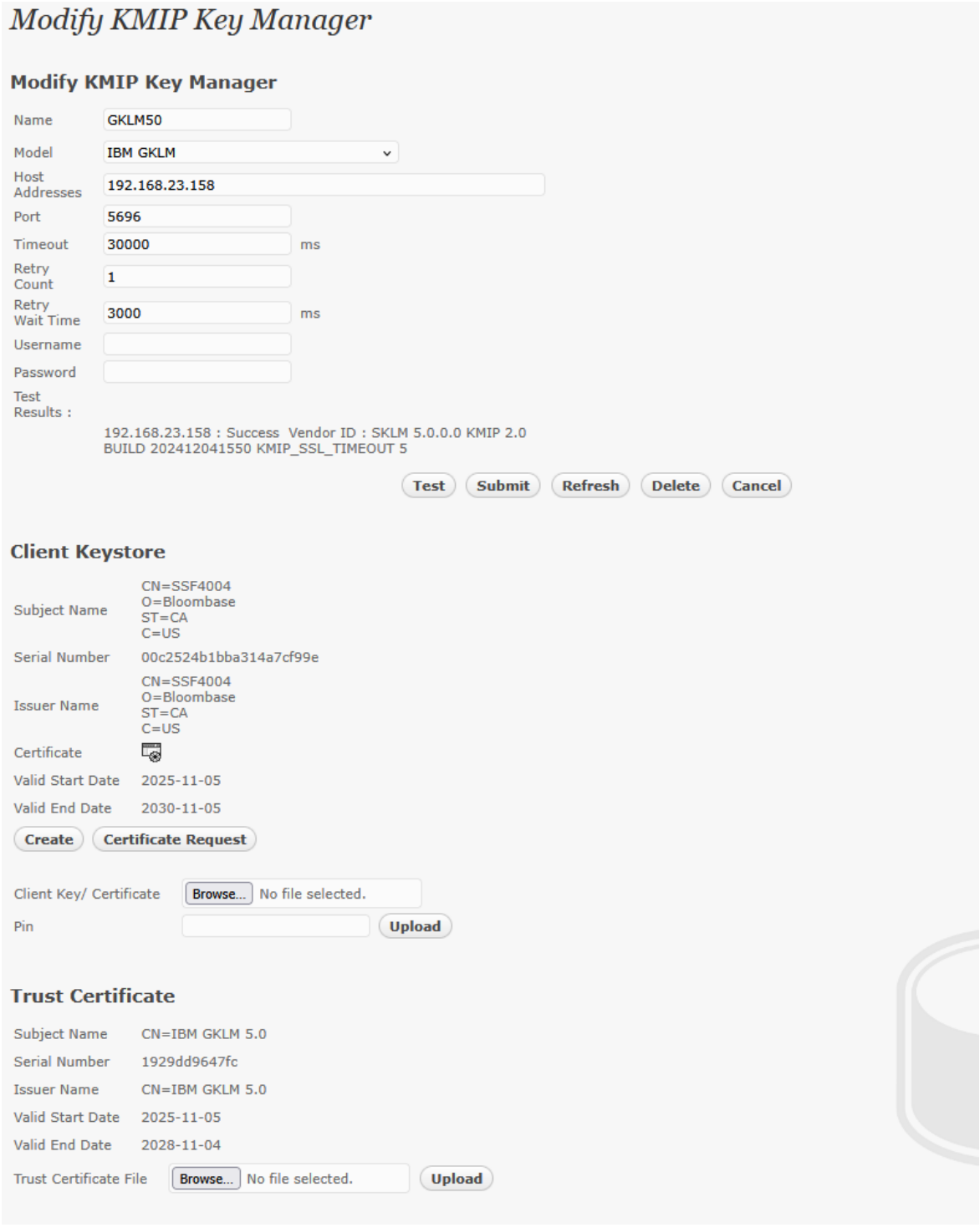
To enable the built-in Bloombase KeyCastle to utilize keys managed in the network attached IBM GKLM, the KMIP service configuration at Bloombase web management console must be set up. This is done by navigating to Menu Bar -> Key Management -> OASIS KMIP Key Manager.



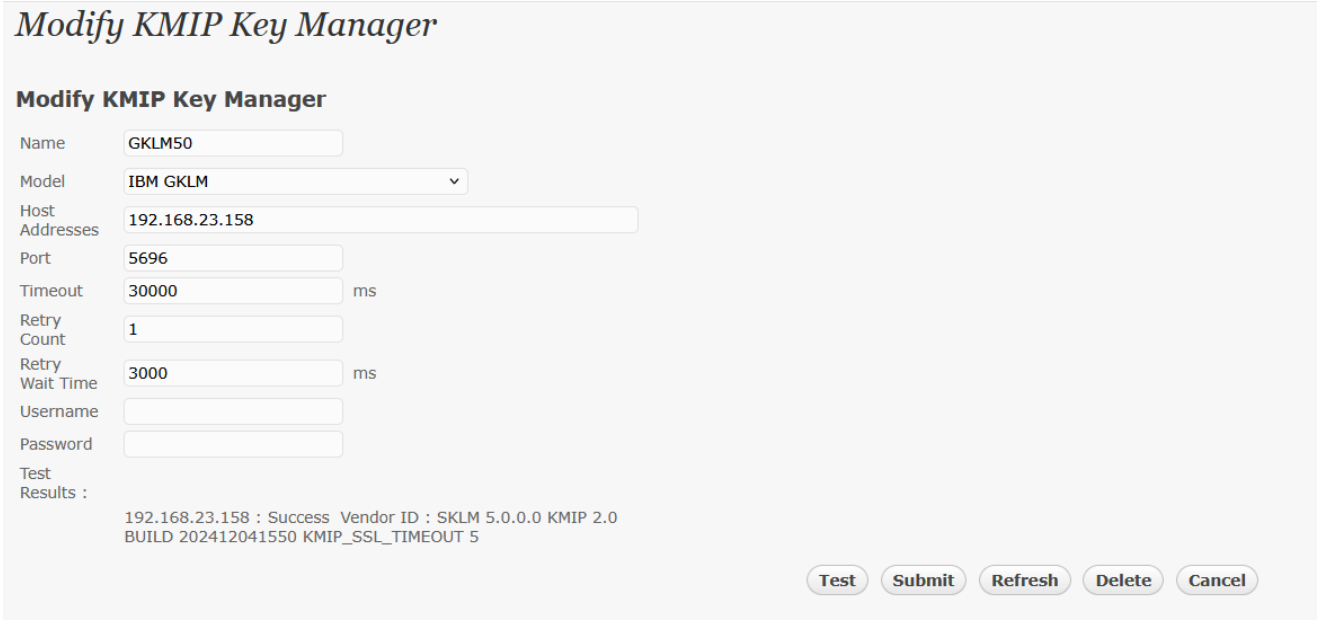
Input a name for the configuration, and select Model as

```
IBM GKLM
```

Input the host address and port to access the IBM GKLM, import or create the "Client Keystore", and upload the server certificate on IBM GKLM as "Trust Certificate". Multiple comma-separated IP host addresses may be included if using a cluster.



The client certificate CN=SSF4004 is generated and approved as the client authentication key pair for Bloombase StoreSafe on the GKLM interface.



Click ‘Submit’ to commit the configuration. If the certificates are setup properly, “test results” of the KMIP Key Manager would return “Success”.

Encryption Key Provisioning

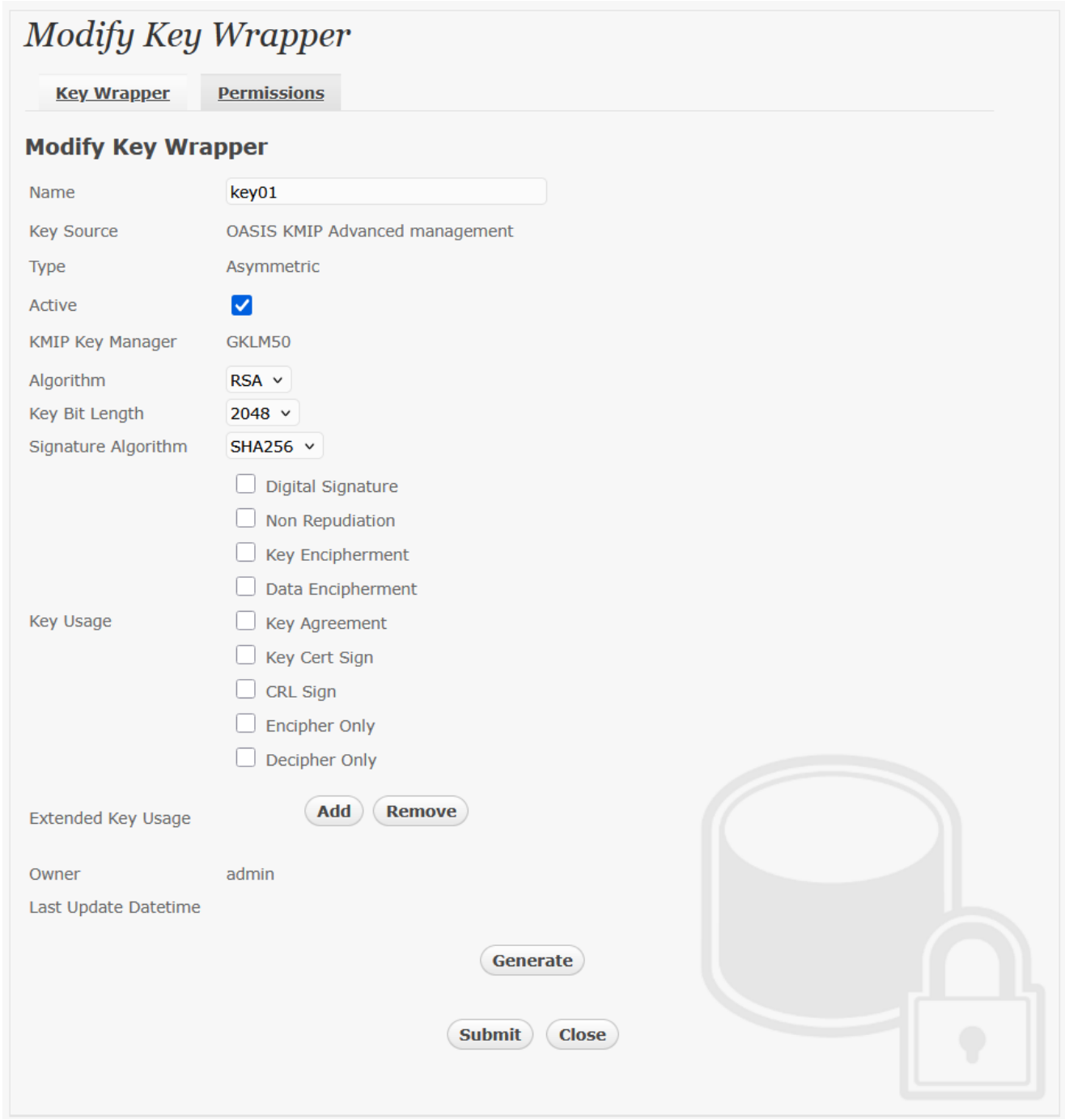
To generate key in attached IBM GKLM, select Key Source Type as

```
OASIS KMIP Key Manager
```

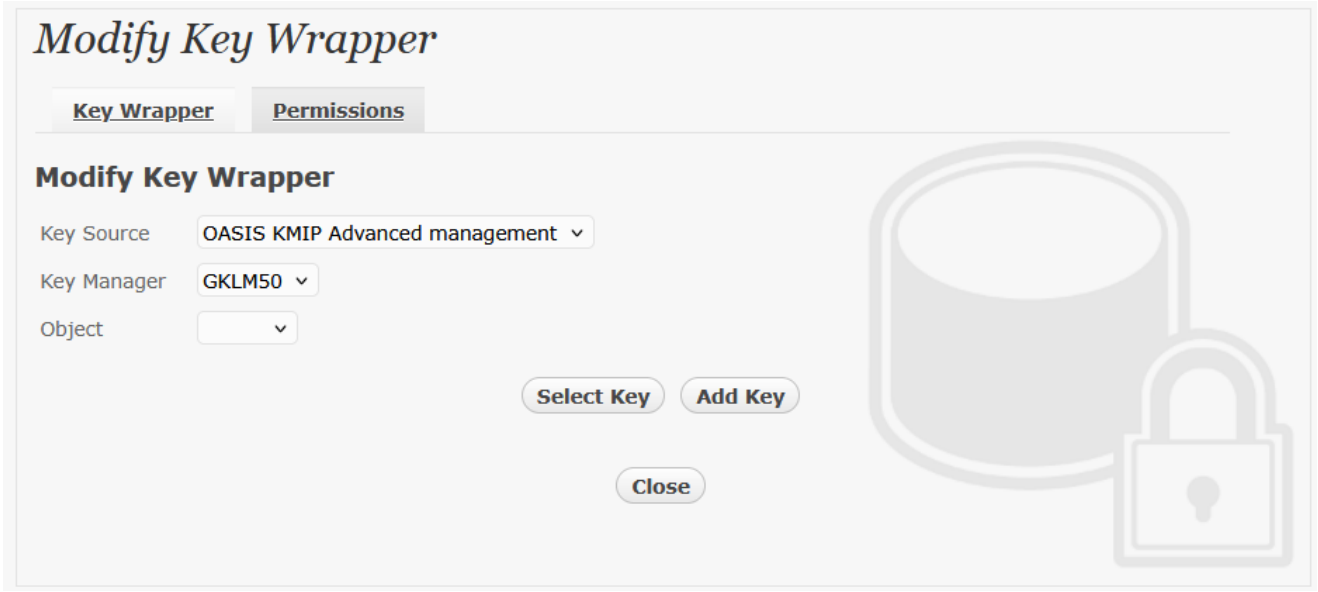
and the assigned Key Manager label, in this case

```
GKLM50
```

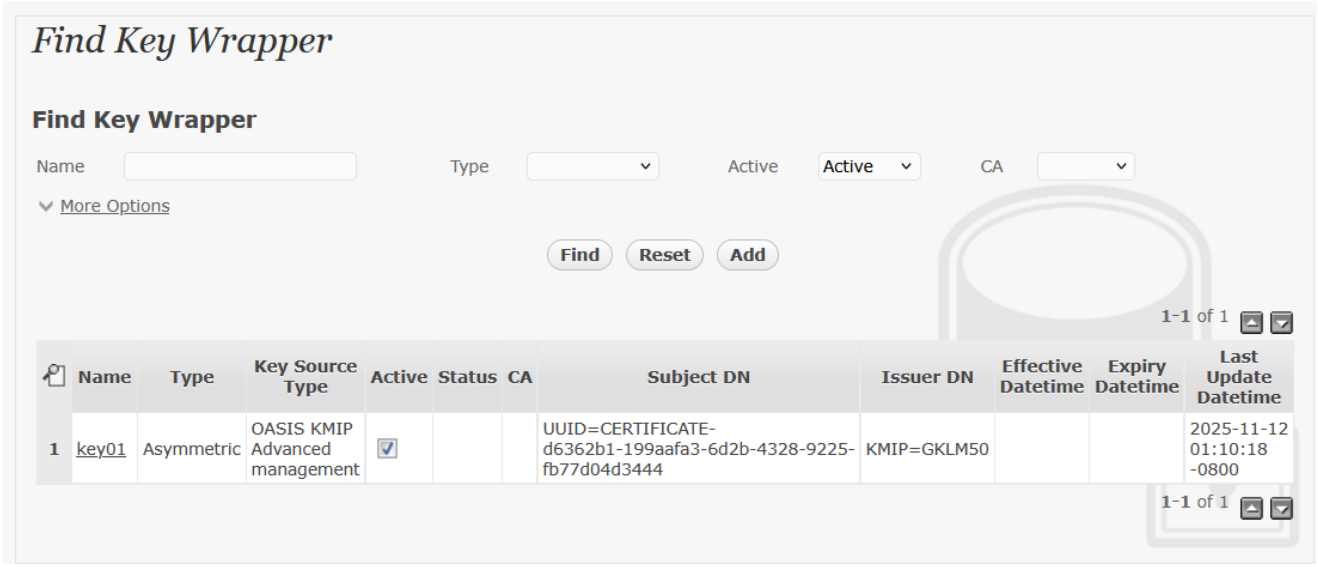
Select “Add Key” and “generate” to create a new key on the key manager.



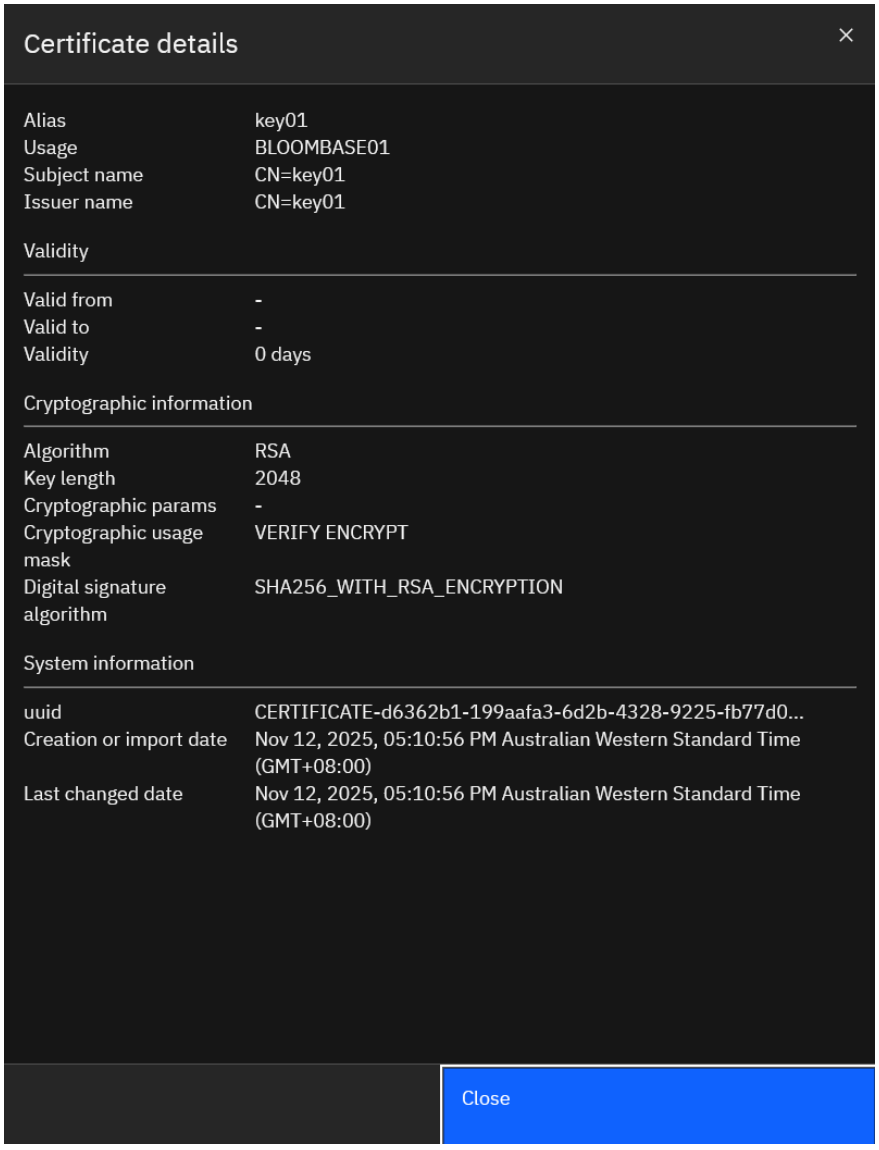
Or if key already exists, simply choose from the dropdown box.



Ensure you import a key from the key manager before you submit the key wrapper.



The new key with matching UUID can be found on the IBM GKLM management console.

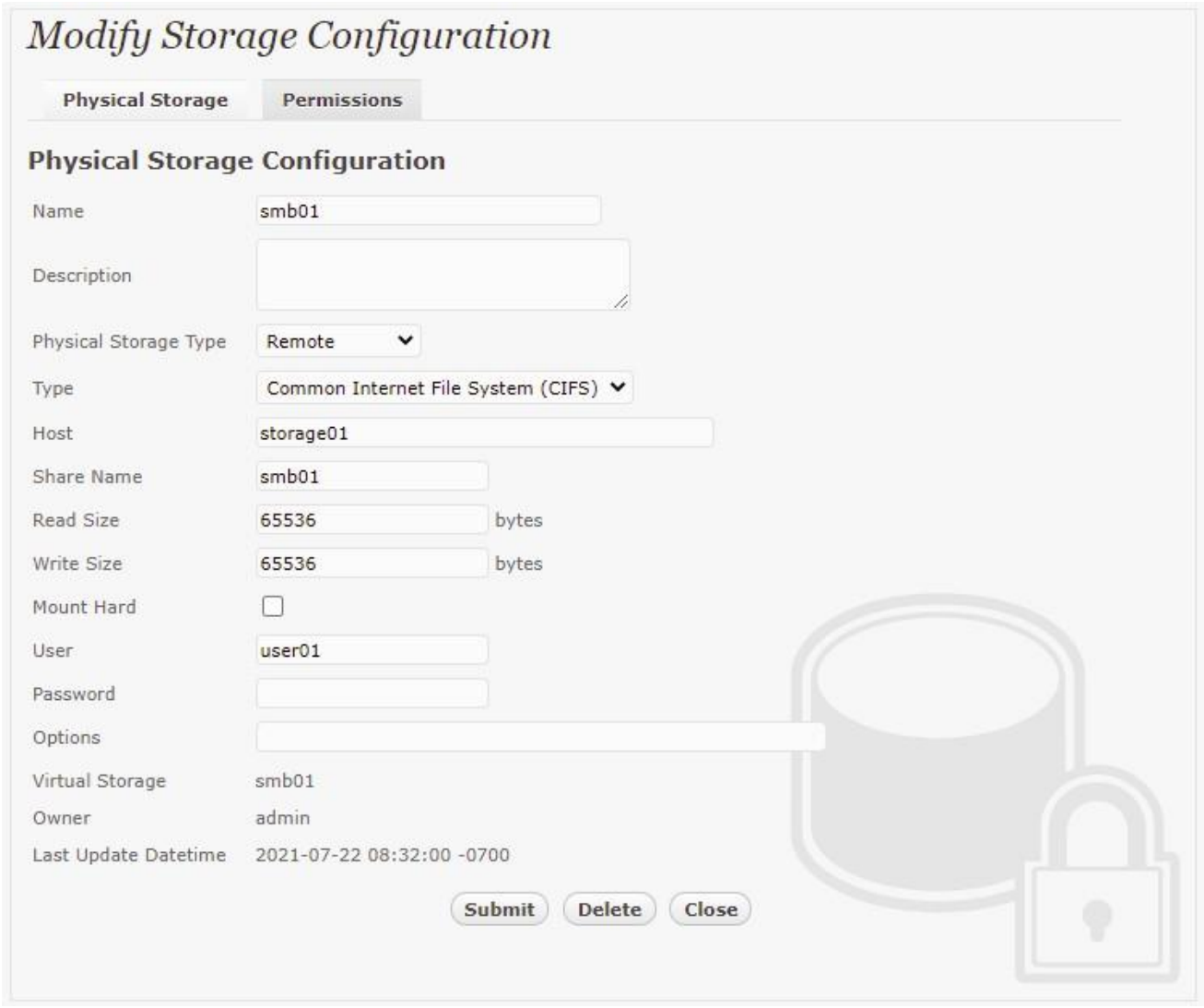


Bloombase StoreSafe Data-at-Rest Encryption for SMB Configuration

Physical storage namely

```
smb01
```

is configured to be secured by Bloombase StoreSafe using encryption.



Virtual storage namely

```
smb01
```

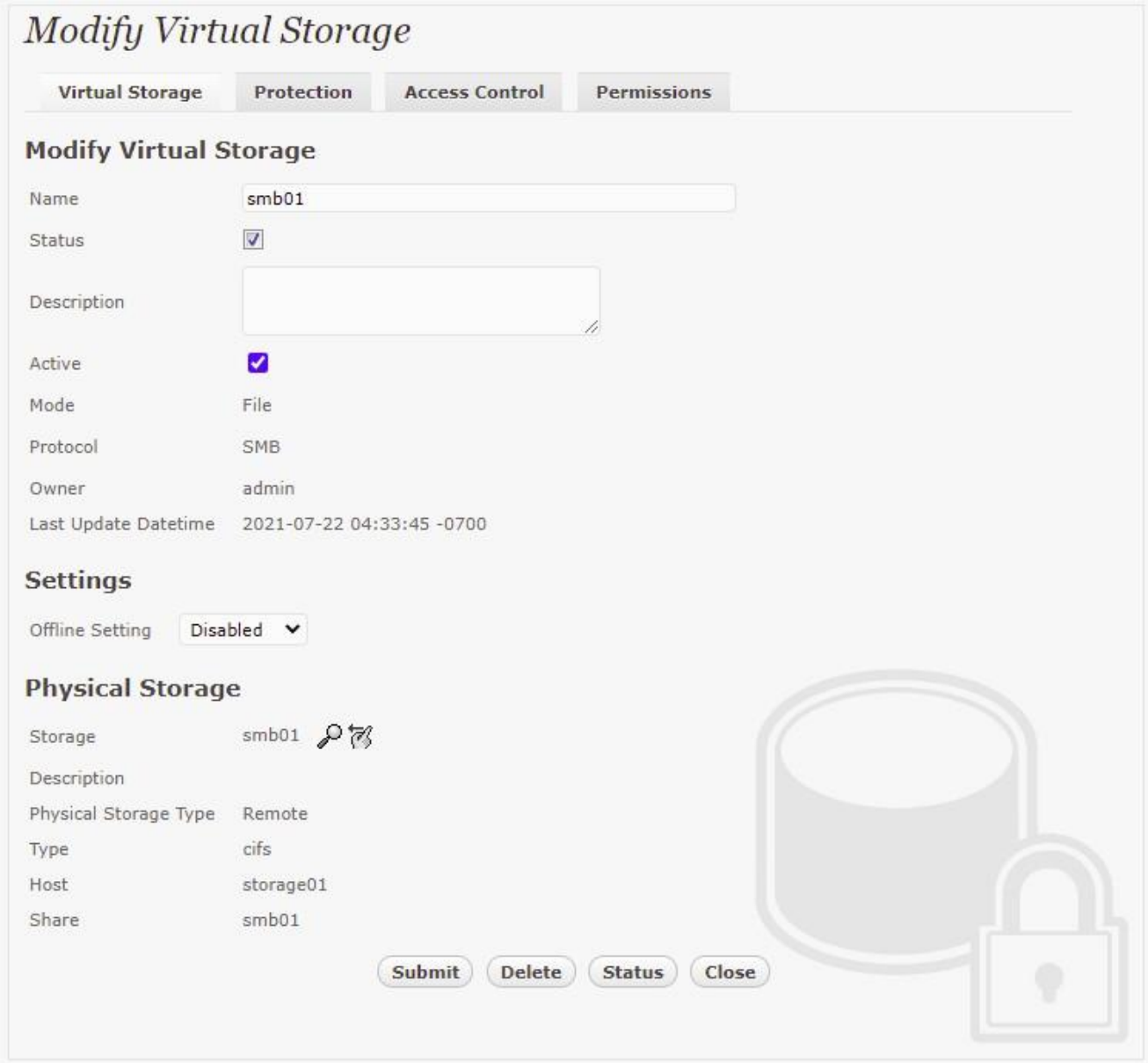
of type

```
File
```

is created to virtualize physical storage

```
smb01
```

for application transparent encryption protection over network file protocols including SMB.



Protection type is specified as

```
Privacy
```

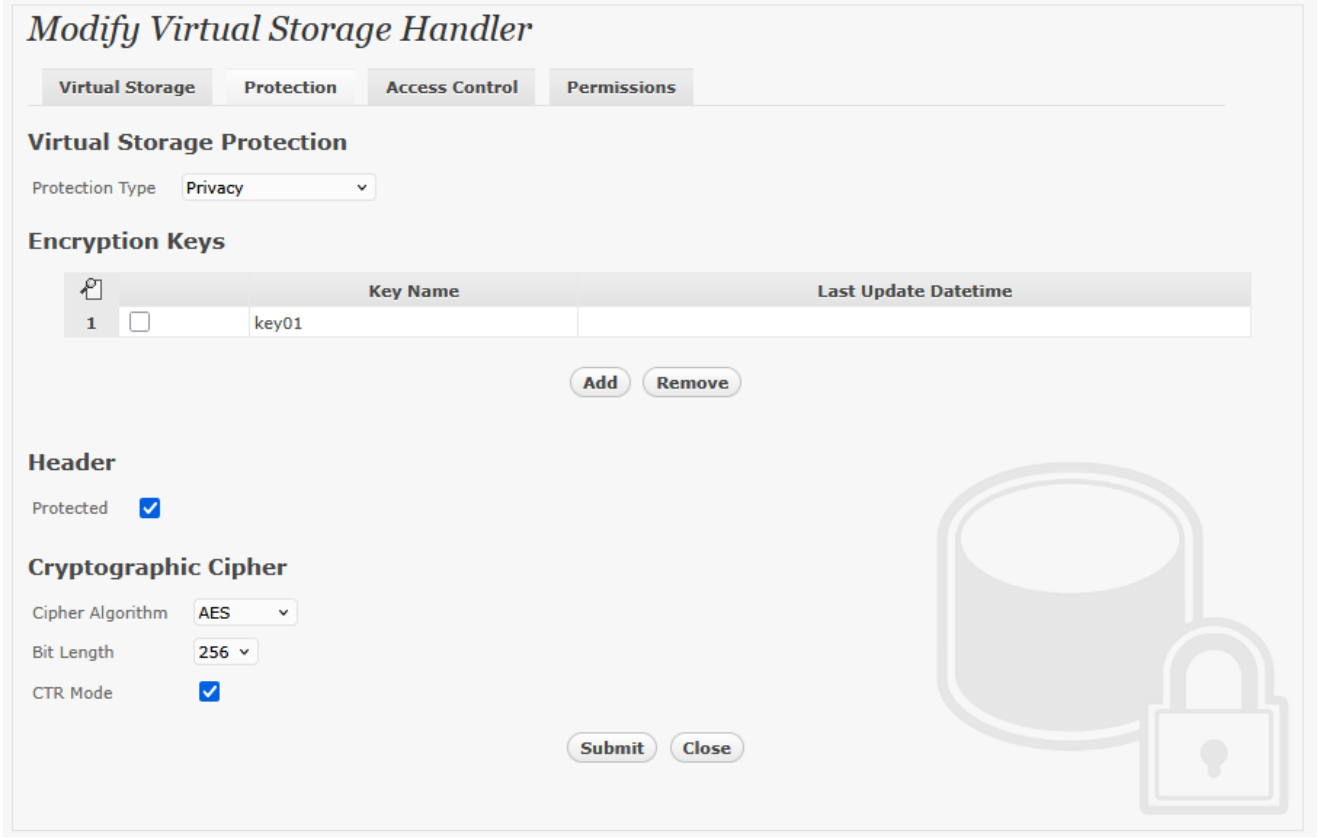
and secure the Microsoft Storage Server storage backend using

```
AES 256-bit
```

encryption and encryption key

```
key01
```


managed at IBM GKLM.



SMB/CIFS storage protocol relies mainly on user-password authentication for access control. In this test, the Bloombase StoreSafe secure storage resource

```
smb01
```

is provisioned for user

```
user01
```

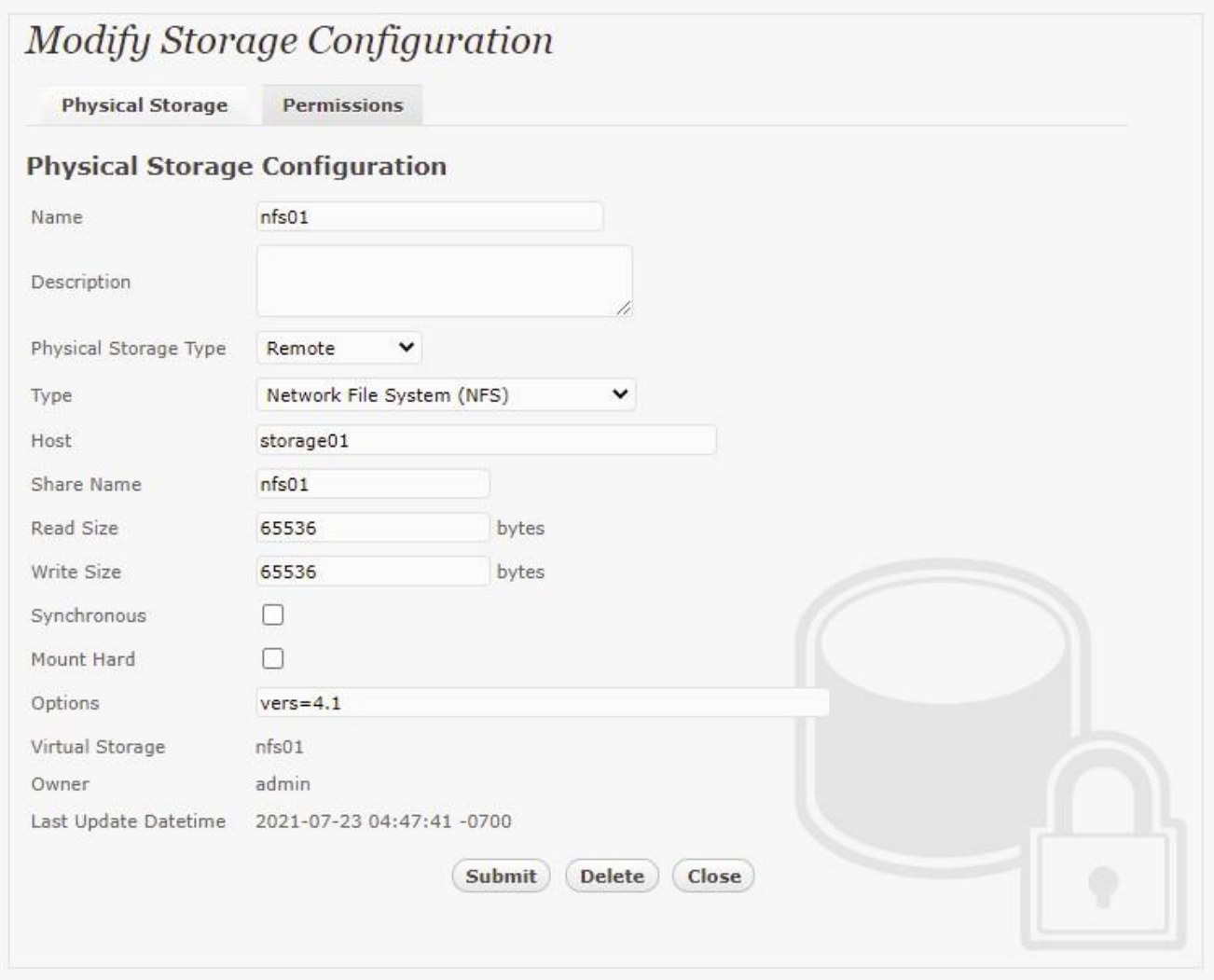
with Microsoft Active Directory (MSAD) integration for user-password authentication and single sign-on.

Bloombase StoreSafe Data-at-Rest Encryption for NFS Configuration

Physical storage namely

```
nfs01
```

is configured to be secured by Bloombase StoreSafe using encryption.



Virtual storage namely

```
nfs01
```

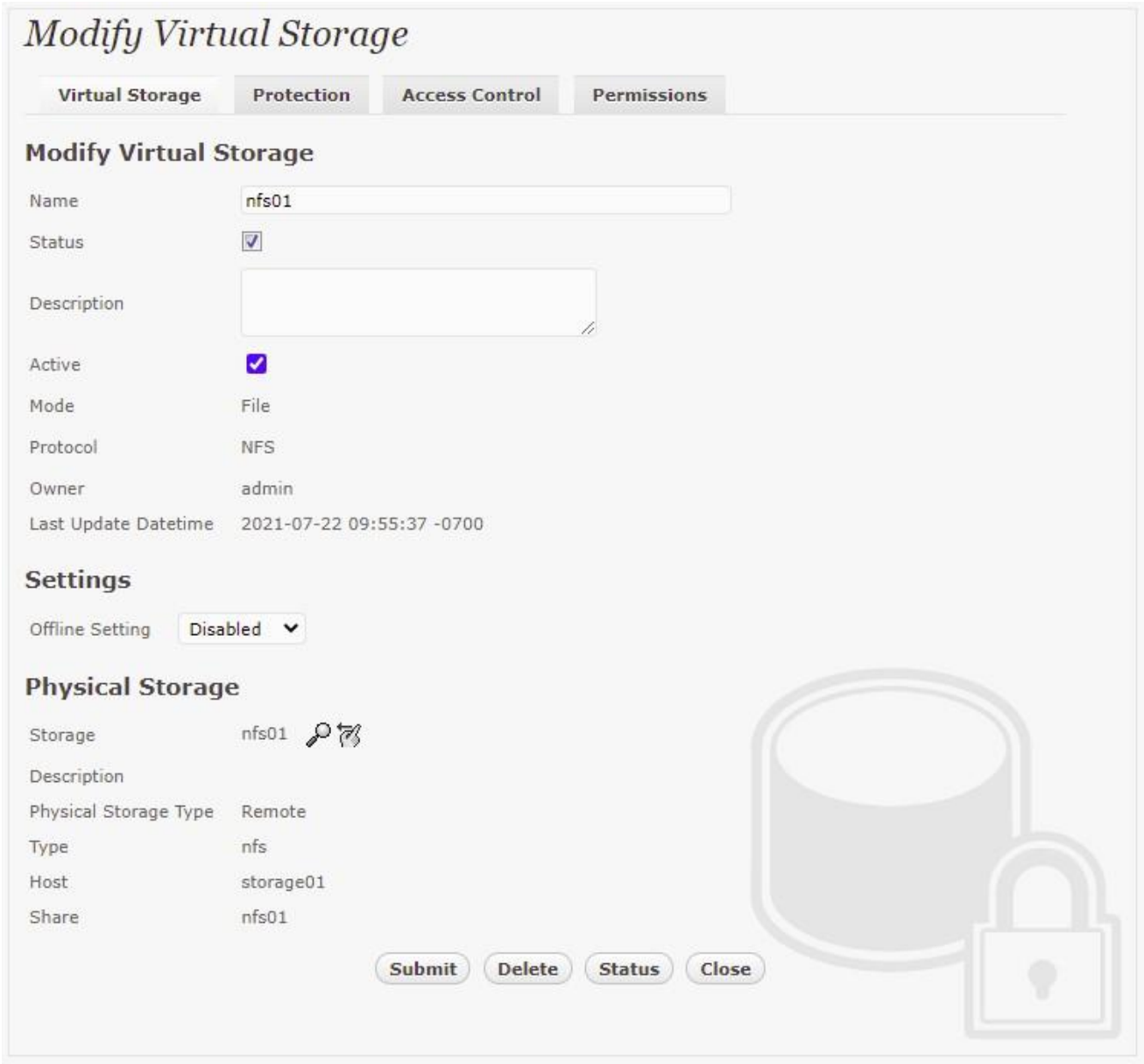
of type

```
File
```

is created to virtualize physical storage

```
nfs01
```

for application transparent encryption protection over network file protocols including NFS.



Protection type is specified as

```
Privacy
```

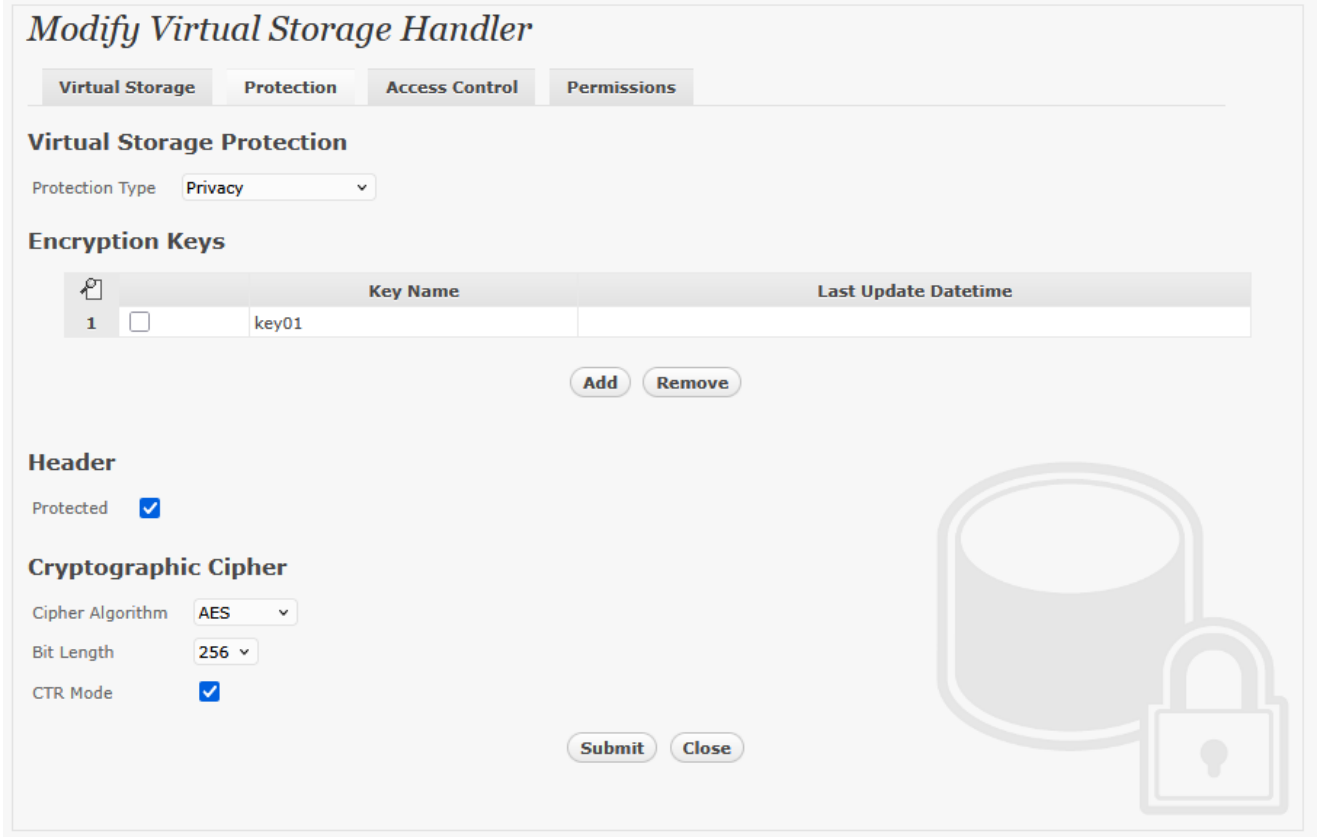
and secure the Microsoft Storage Server storage backend using

```
AES 256-bit
```

encryption and encryption key

```
key01
```

managed at IBM GKLM.

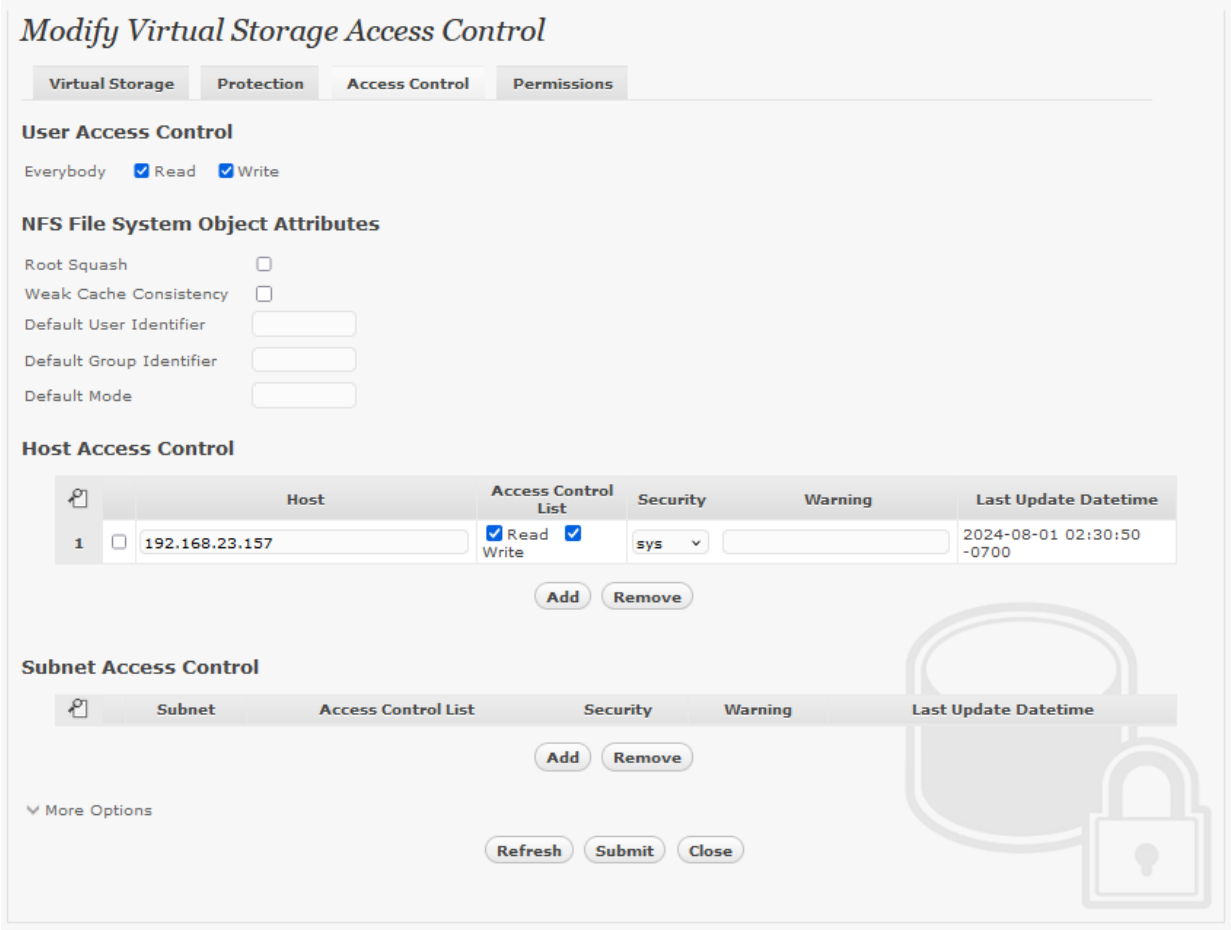


NFS storage protocol relies mainly on UID/GID and networking for access control. In this test, the Bloombase StoreSafe secure storage resource

```
nfs01
```

is provisioned for client IP

```
192.168.23.157
```

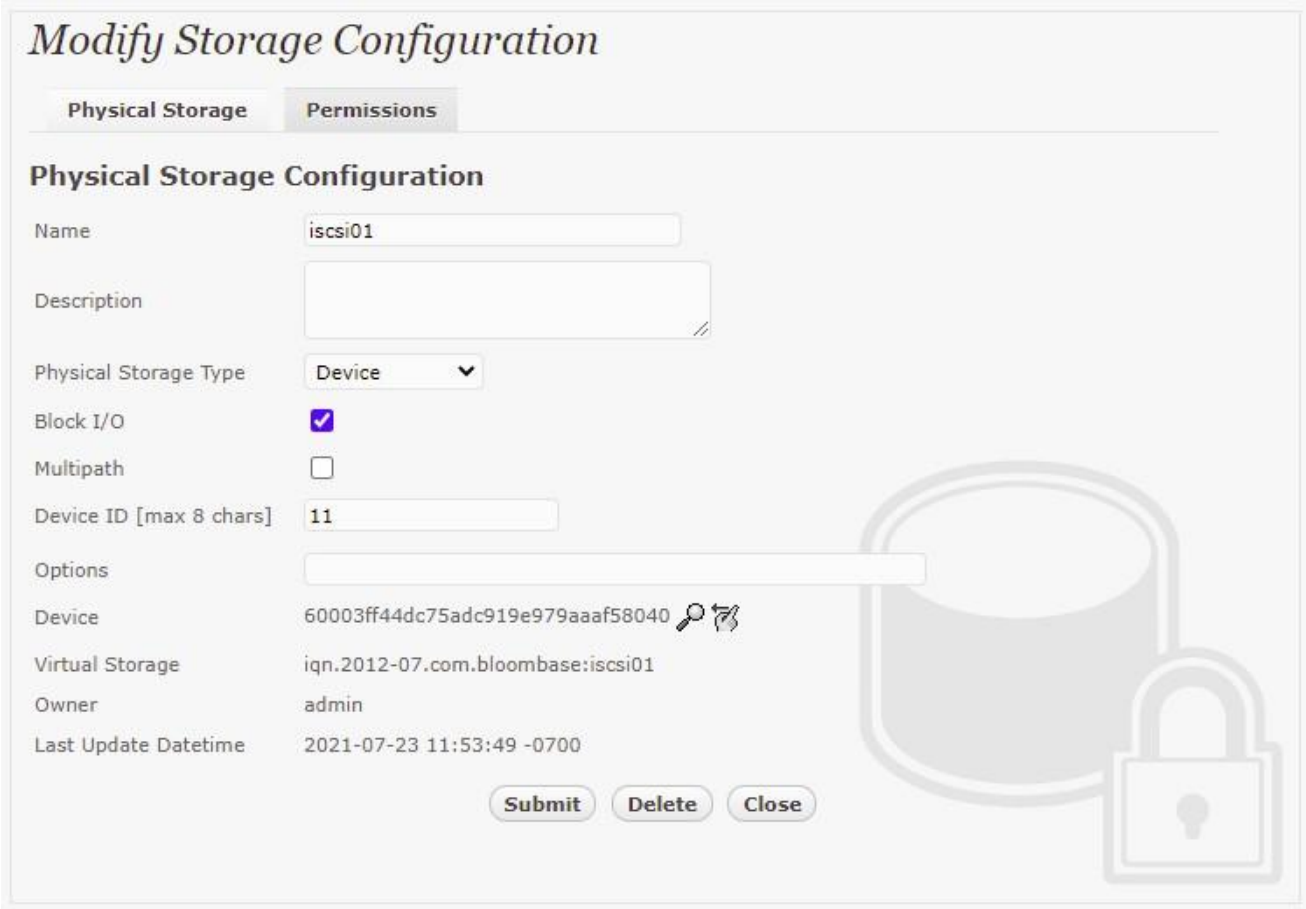


Bloombase StoreSafe Data-at-Rest Encryption for iSCSI Configuration

Physical storage namely

```
iscsi01
```

is configured to be secured by Bloombase StoreSafe using encryption.



Virtual storage namely

```
iqn.2012-07.com.bloombase:iscsi01
```

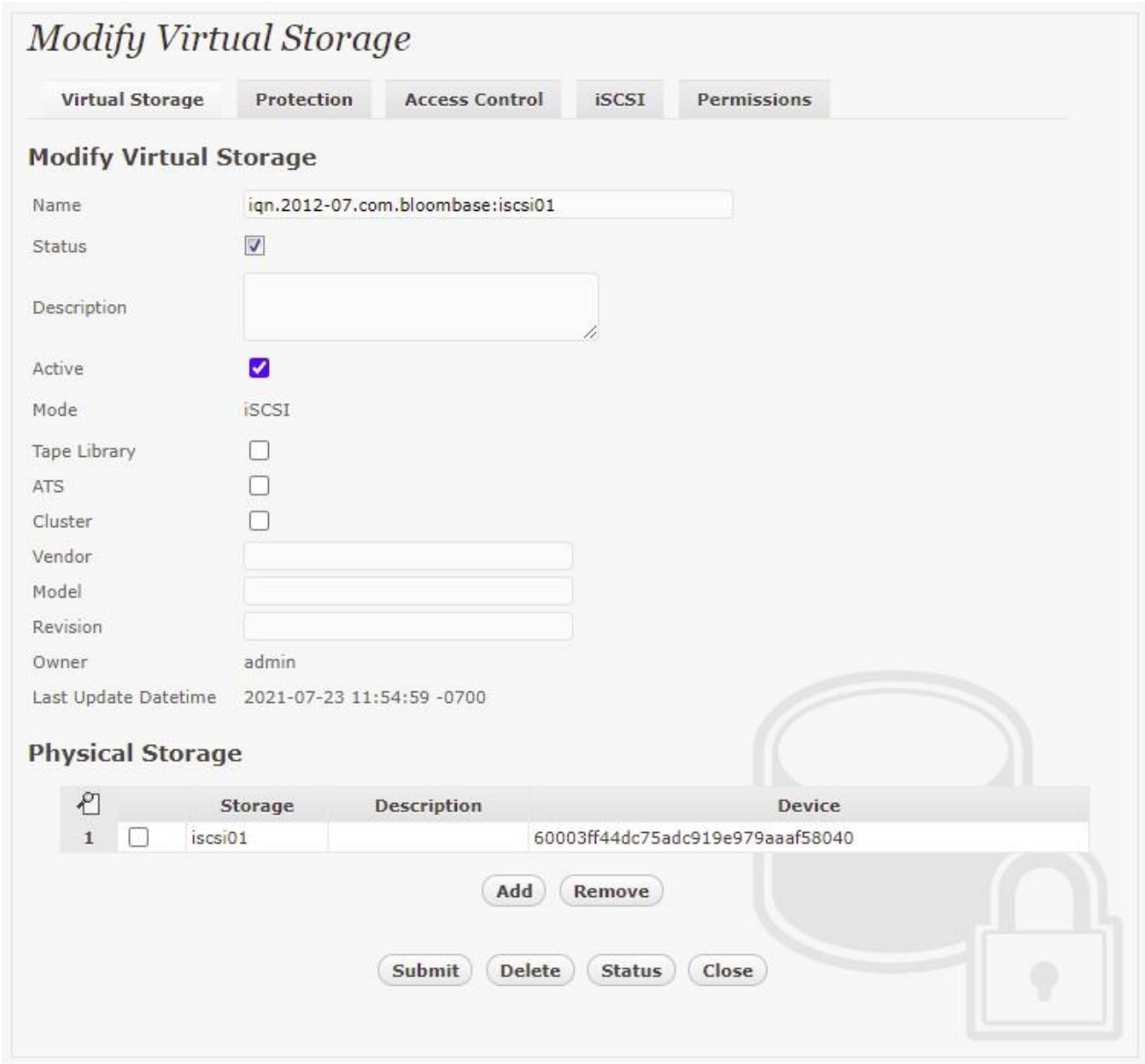
of type

```
iSCSI
```

is created to virtualize physical storage

```
iscsi01
```

for application transparent encryption protection over network file protocols including iSCSI.



Protection type is specified as

```
Privacy
```

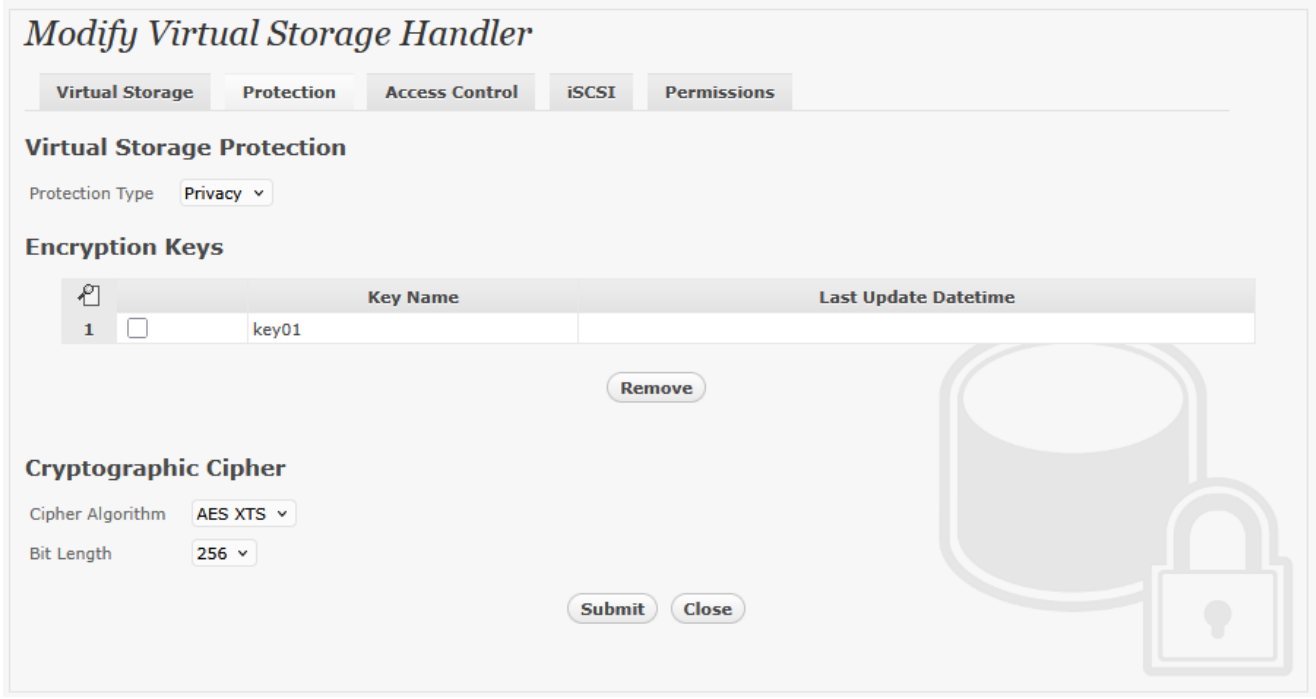
and secure the Microsoft Storage Server storage backend using

```
AES XTS 256-bit
```

encryption and encryption key

```
key01
```

managed at IBM GKLM.



iSCSI storage protocol relies mainly on CHAP, IQN, and networking for access control. In this test, the Bloombase StoreSafe secure storage resource

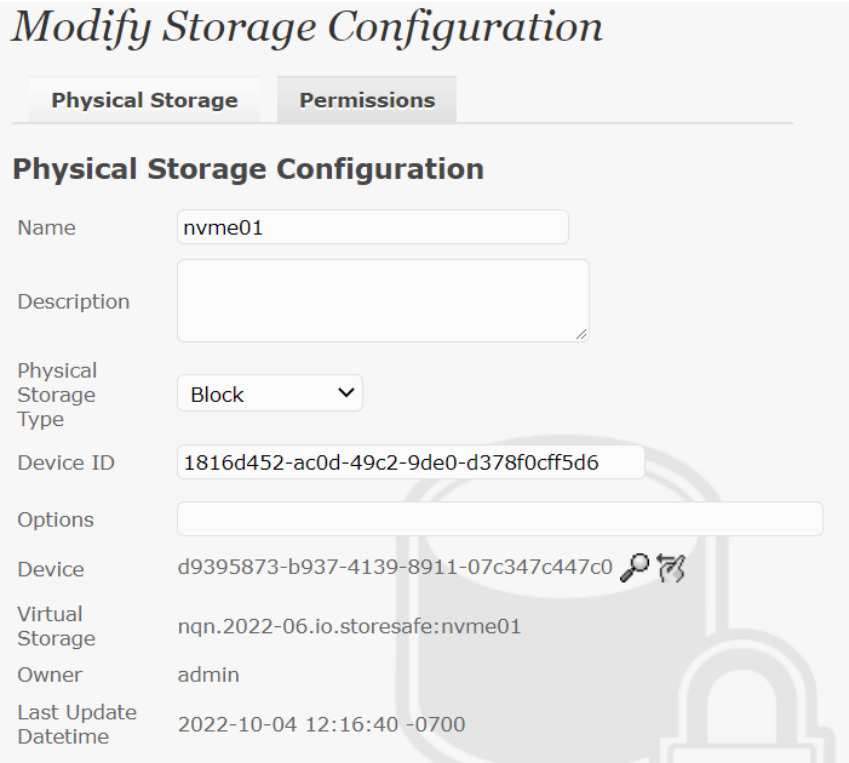
```
iqn.2012-07.com.bloombase:iscsi01
```

is provisioned for initiator

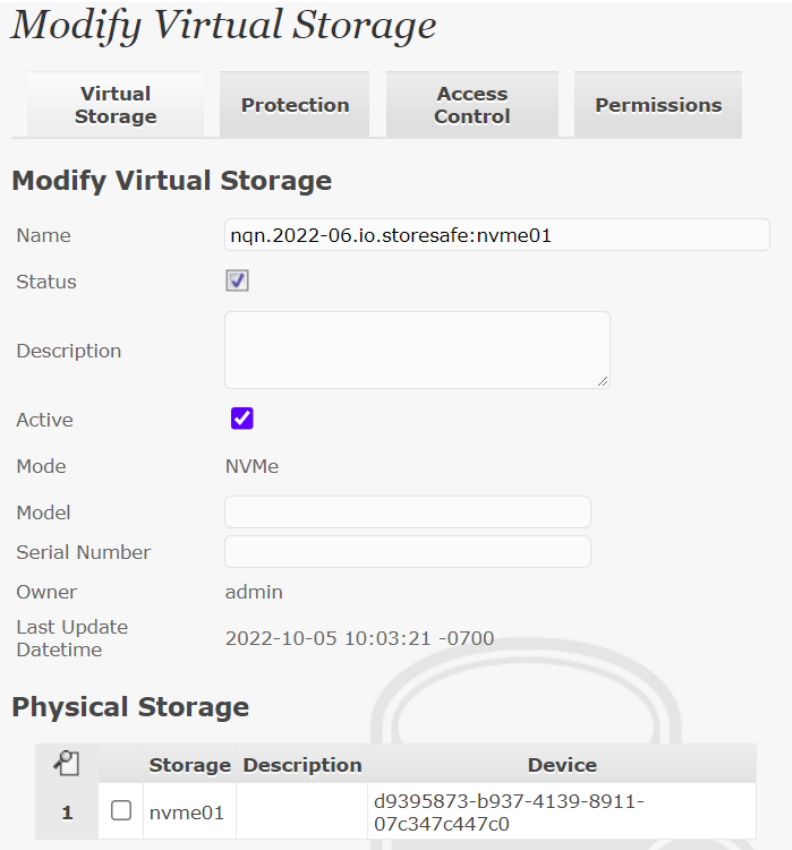
```
iqn.1991-05.com.microsoft:windows11
```

Bloombase StoreSafe Data-at-Rest Encryption for NVMe/TCP Configuration

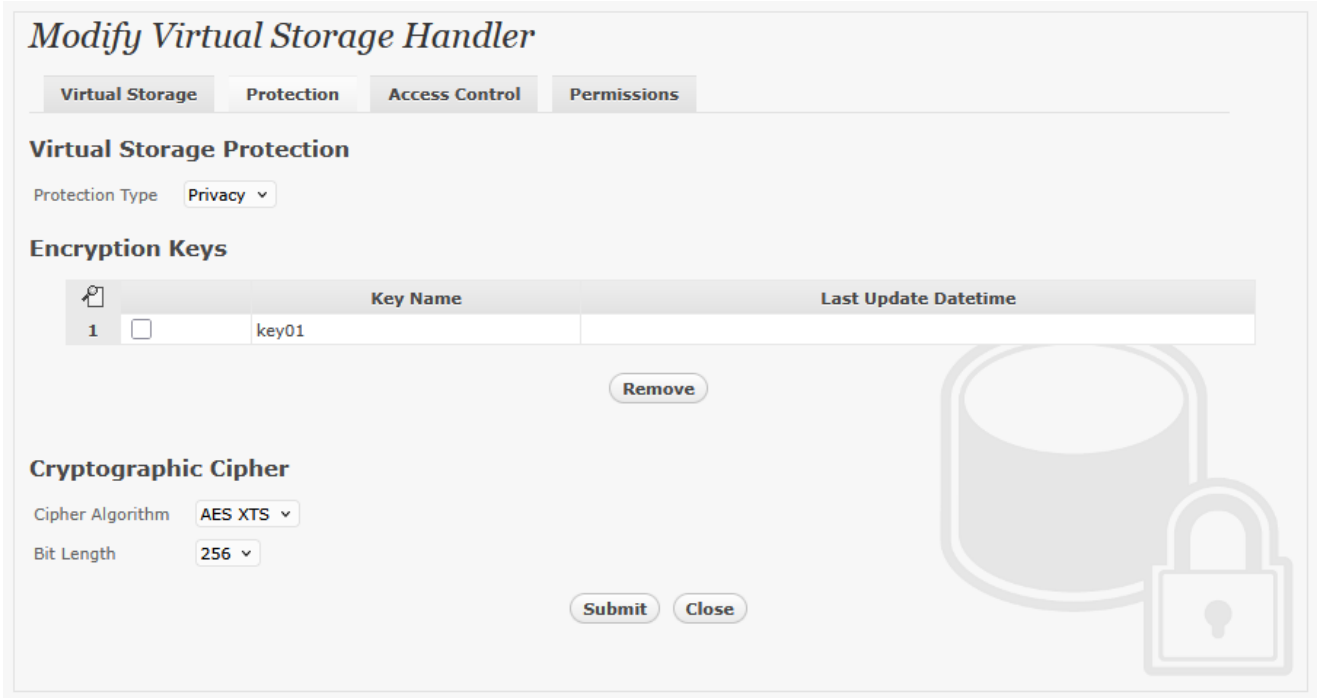
Physical storage with Intel Solid State Drive DC P3600 Series PCIe NVMe SSDs is configured to be secured by Bloombase StoreSafe Intelligent Storage Firewall.



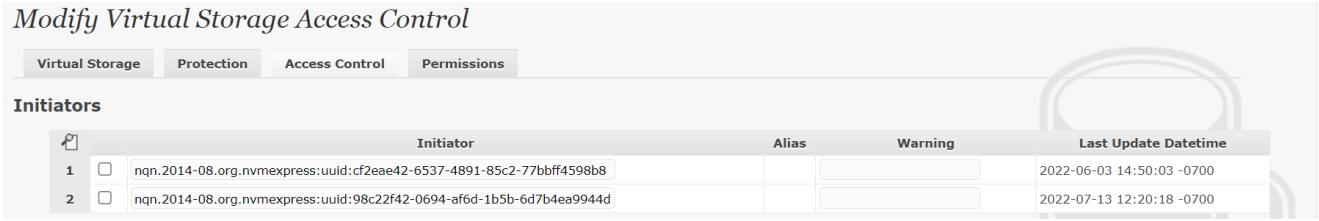
Virtual storage with “NVMe” mode is created to secure the just configured physical storage.



Select “Privacy” for protection type and select the encryption key. Choose the cipher algorithm and bit length.



Add clients' NVMe Qualified Name (NQN) that can access Bloombase StoreSafe virtual storage.

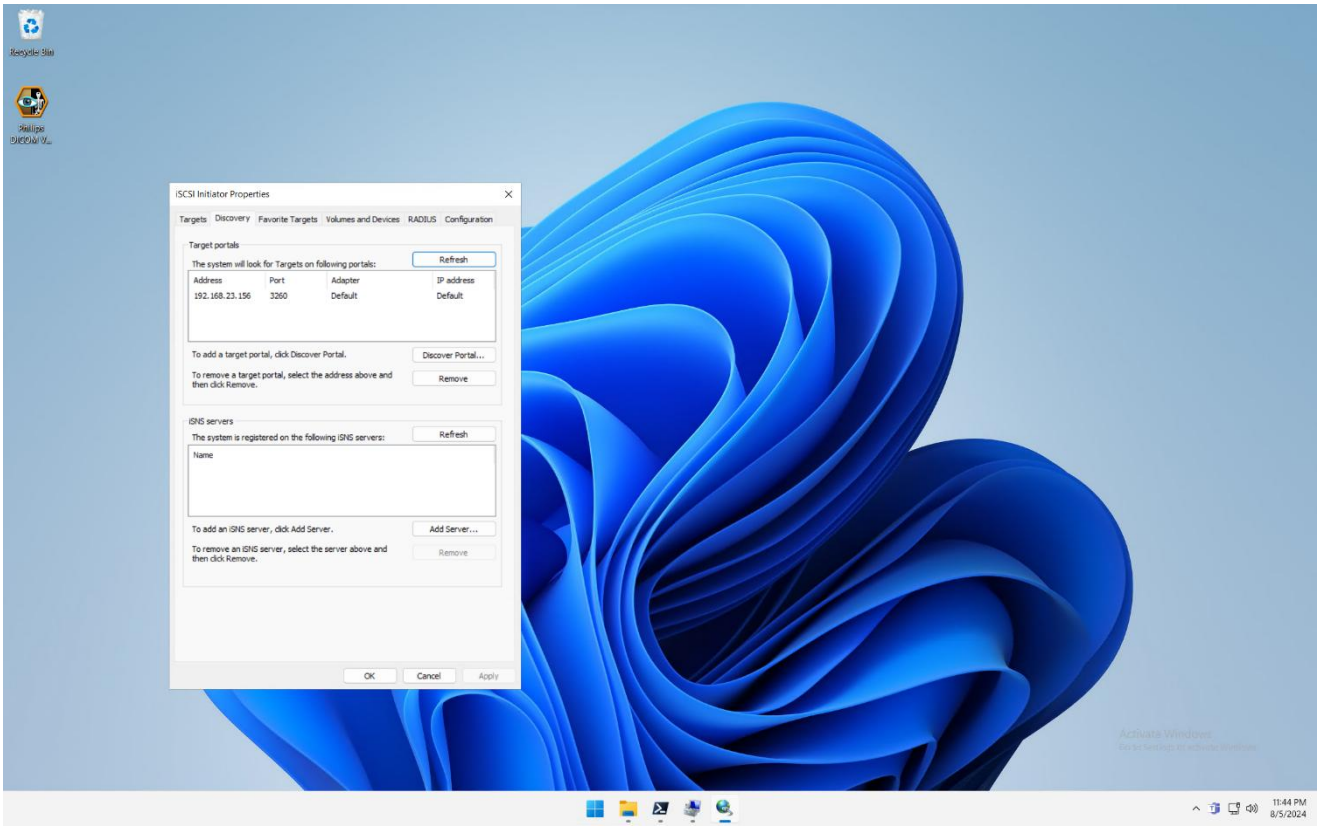


Start Bloombase StoreSafe virtual storage.

Storage Clients

Microsoft Windows 11

Client host running Microsoft Windows 11 is used to access Bloombase StoreSafe Intelligent Storage Firewall virtual storage.



Ubuntu 22.04 LTS

Client host running Ubuntu 22.04 LTS is used to access Bloombase StoreSafe Intelligent Storage Firewall virtual storage.

```
user@ubuntu68:~$ lsb_release -a
No LSB modules are available.
Distributor ID: Ubuntu
Description:    Ubuntu 22.04.2 LTS
Release:        22.04
Codename:       jammy
```

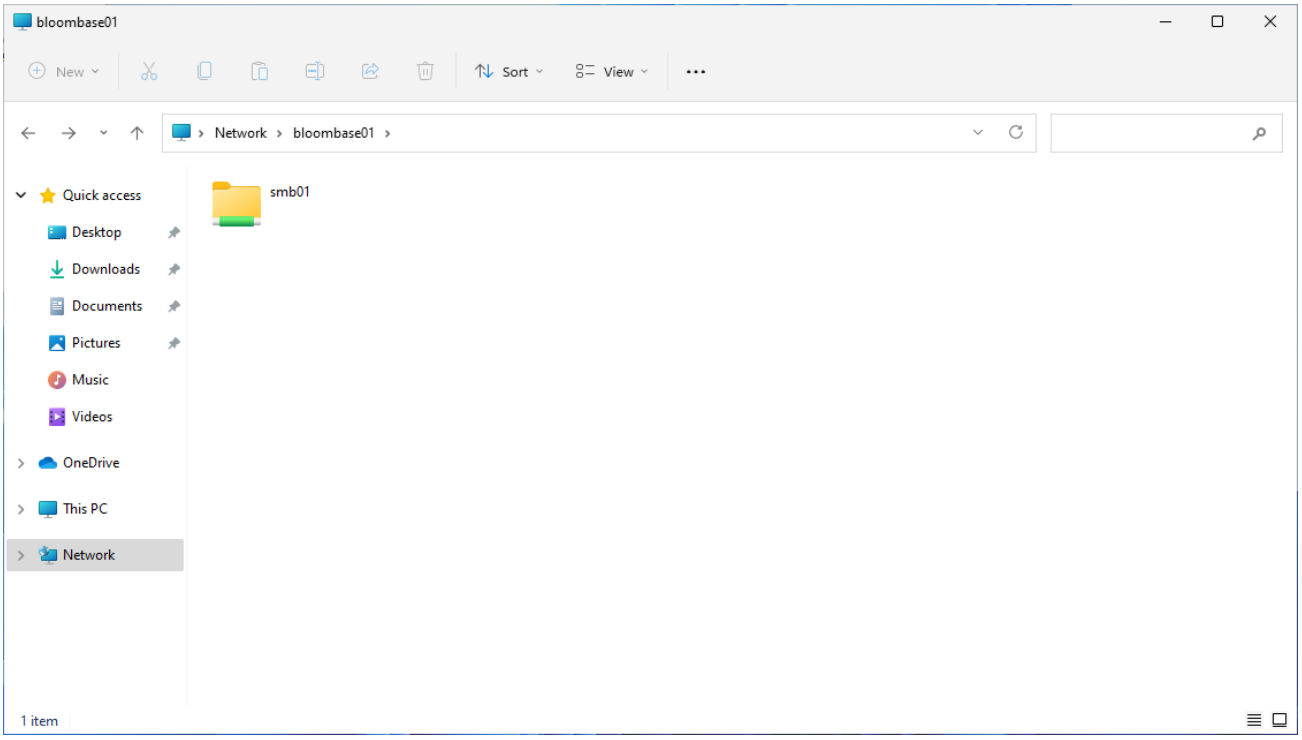
The client will need nvme initiator software installed.

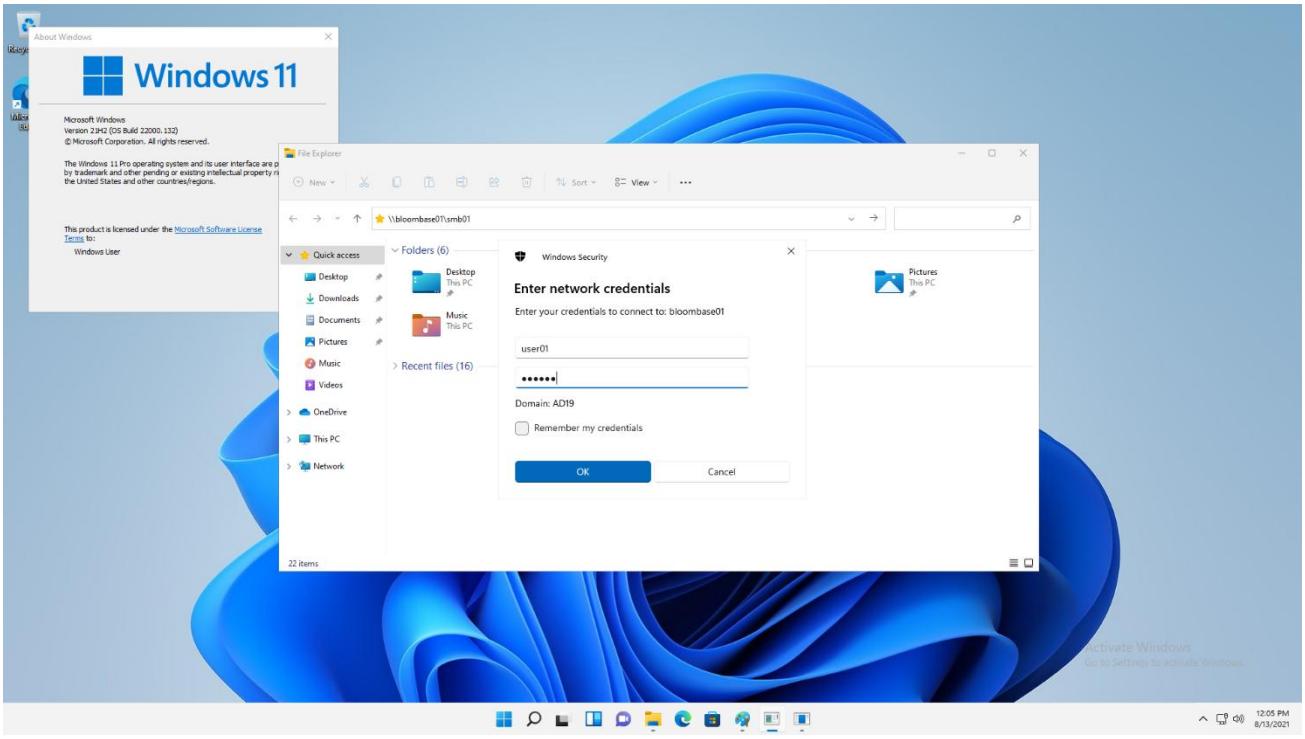
```
user@ubuntu68:~$ nvme --version
nvme version 1.16
```

Test Cases

Tests for Data-at-Rest Encryption over SMB

SMB shares are an example from the many protocols Bloombase StoreSafe supports for encryption. A share from a Windows Server 2025 system that is accessible by domain users is created to act as backend storage. Bloombase StoreSafe creates a virtual encrypted share on its own hostname path that is accessed from a client software system.

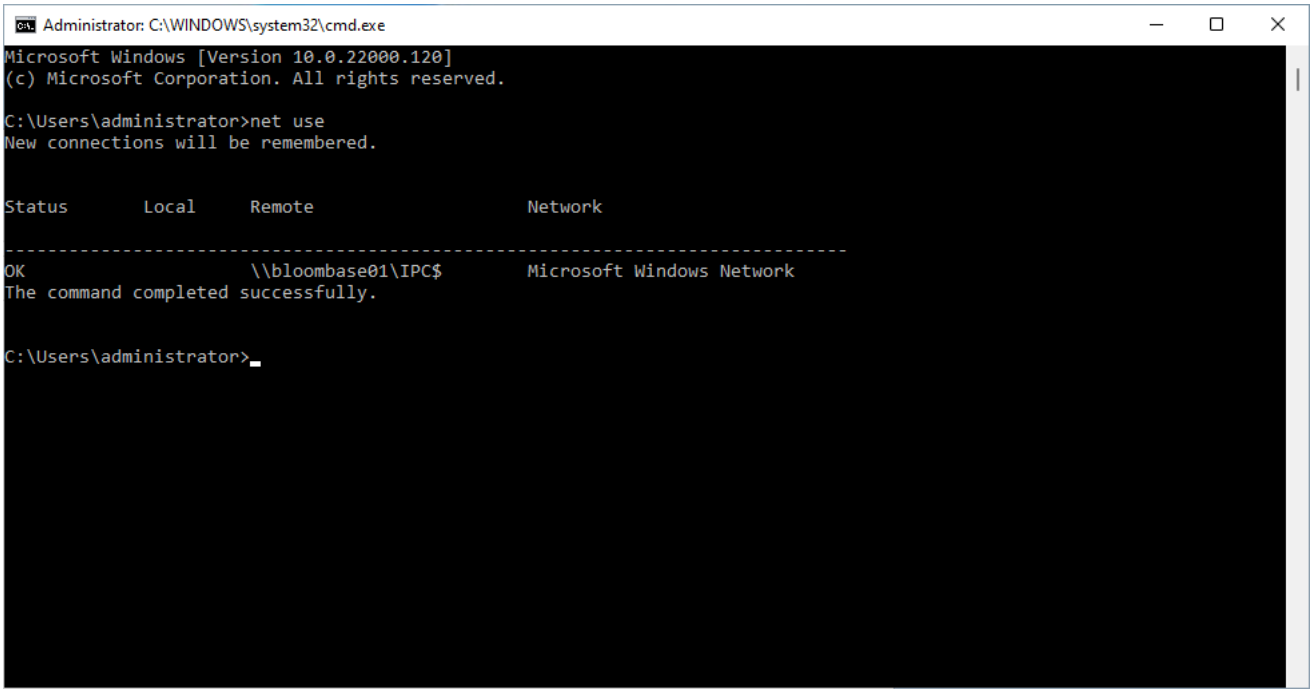




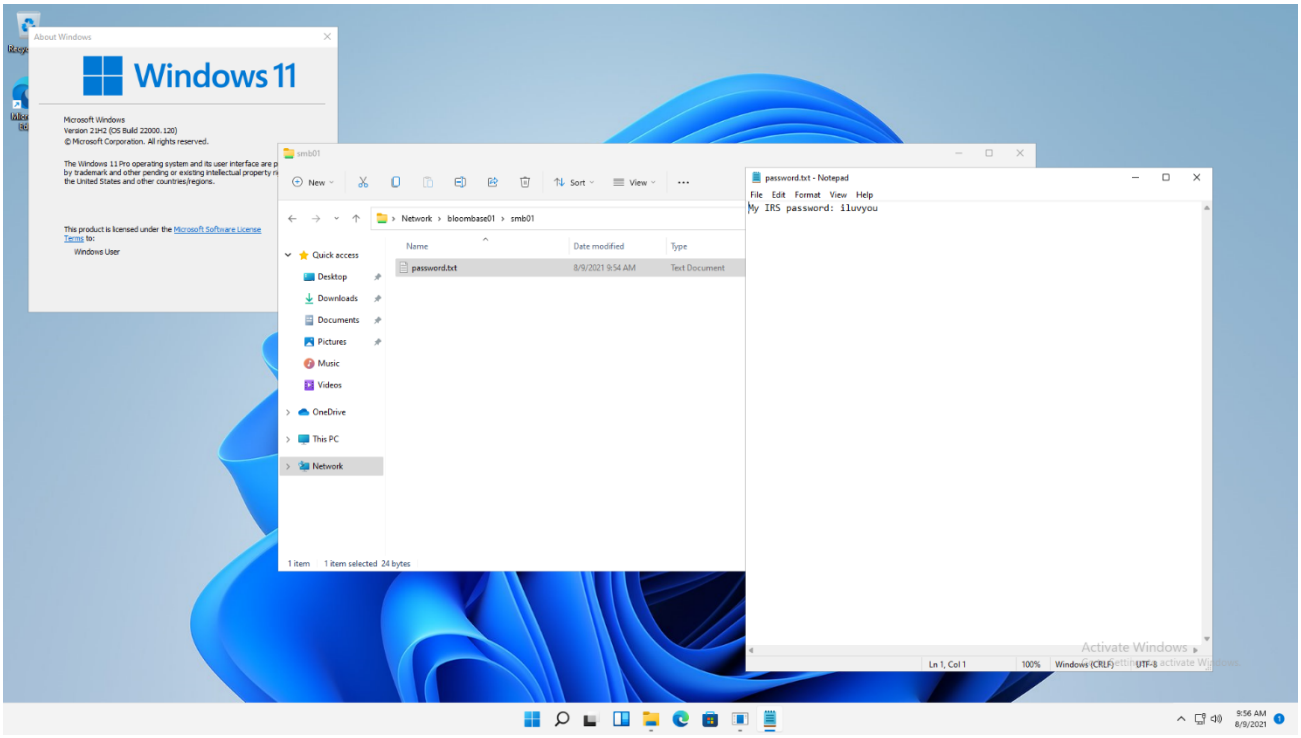
Microsoft Windows 11 clients can use the included network share on file manager to access the SMB share presented by Bloombase StoreSafe Intelligent Storage Firewall. Data owners can alternatively use the

```
net use
```

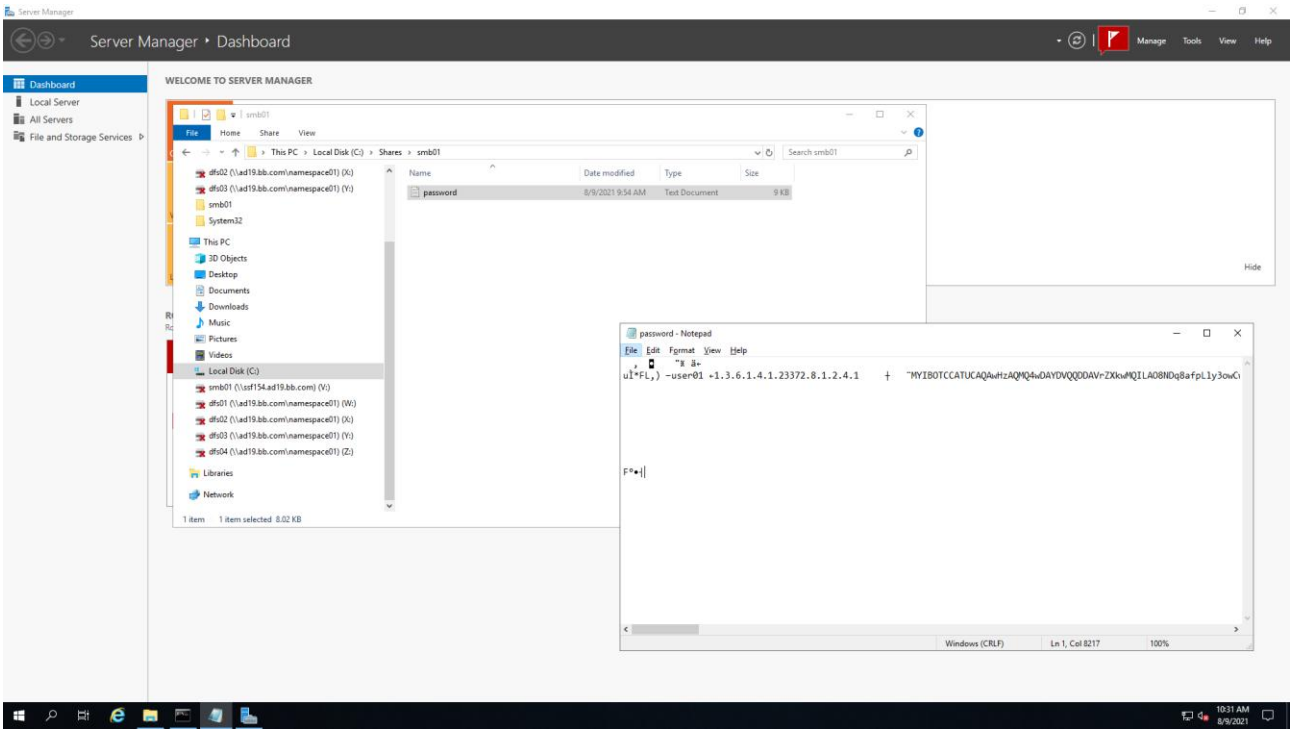
command to specify additional mounting options.



On the virtual encrypted SMB share, a sample plaintext file is created by the client and saved. The file is transparently encrypted by the Bloombase StoreSafe encryption engine with encryption keys managed by IBM GKLM and stored on the Windows Server 2025 backend share.

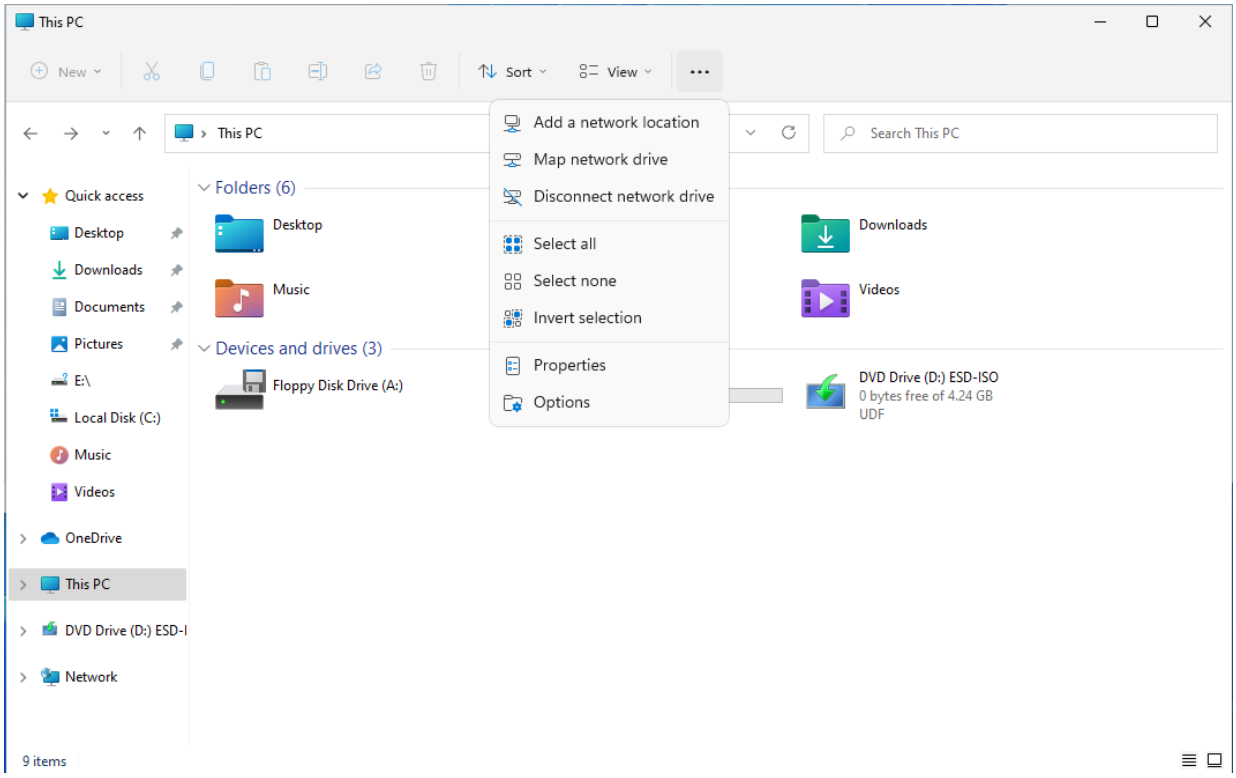


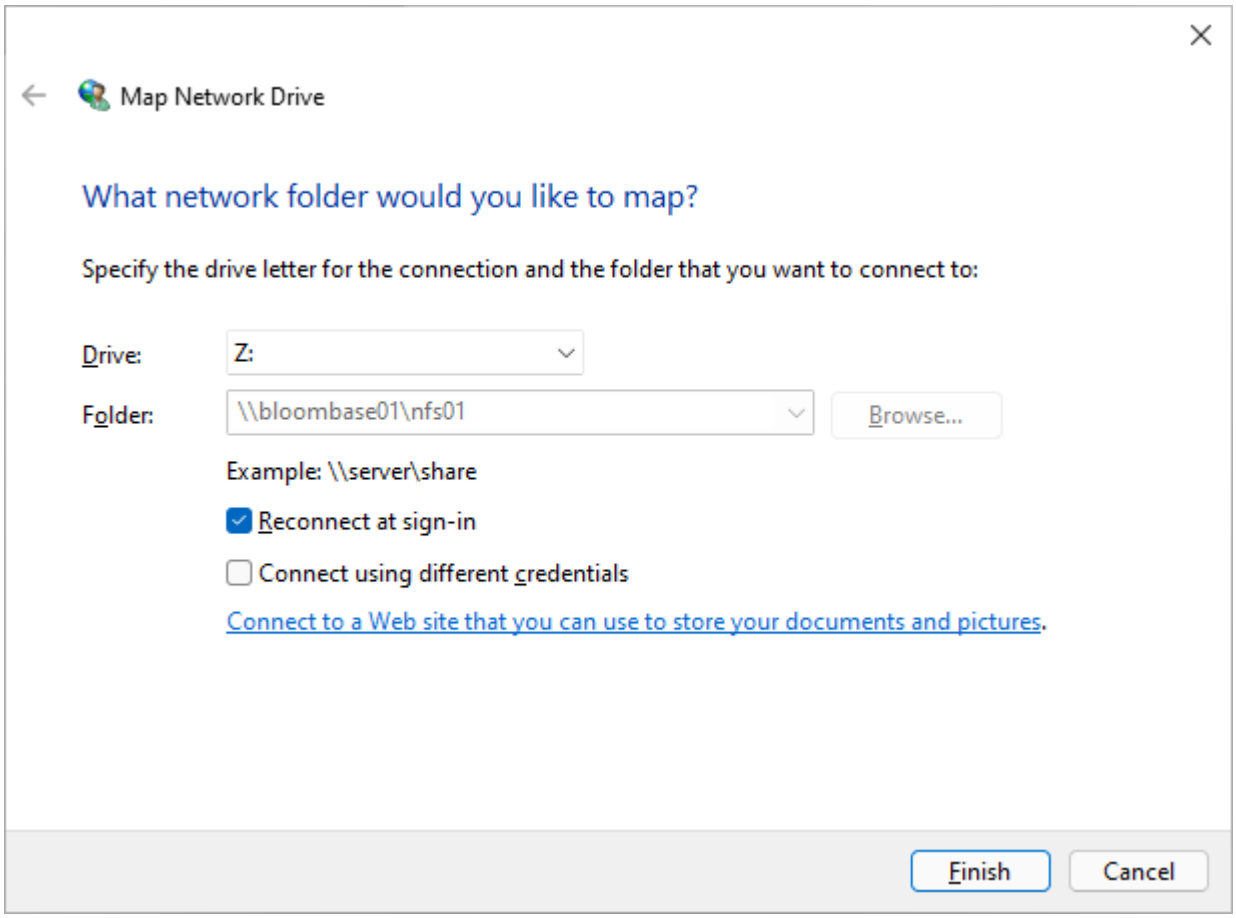
If the application data is attempted to be accessed directly on the backend without going through the Bloombase StoreSafe encryption engine, only ciphertext can be read as expected.



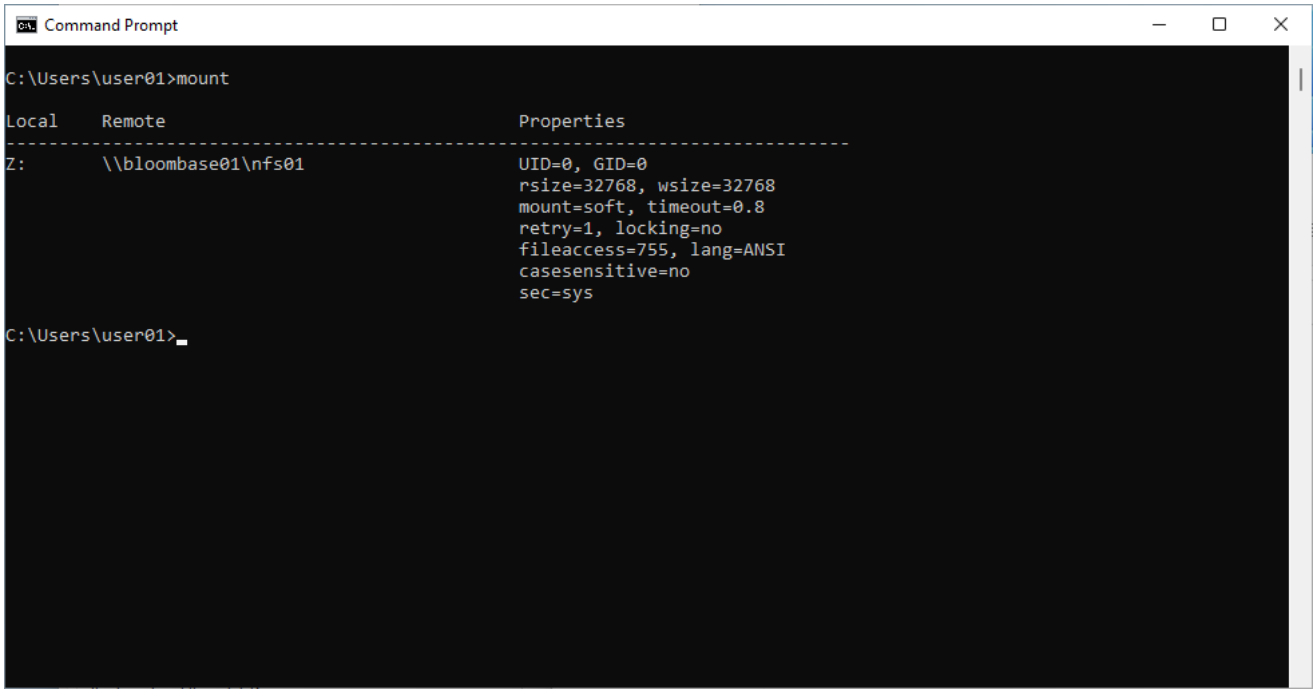
Tests for Data-at-Rest Encryption over NFS

NFS shares are an example from the many protocols Bloombase StoreSafe supports for encryption. A share from a Microsoft Windows Server 2025 system that is accessible by configure clients is created to act as backend storage. Bloombase StoreSafe creates a virtual encrypted share on its own hostname path that is accessed from a client software system.

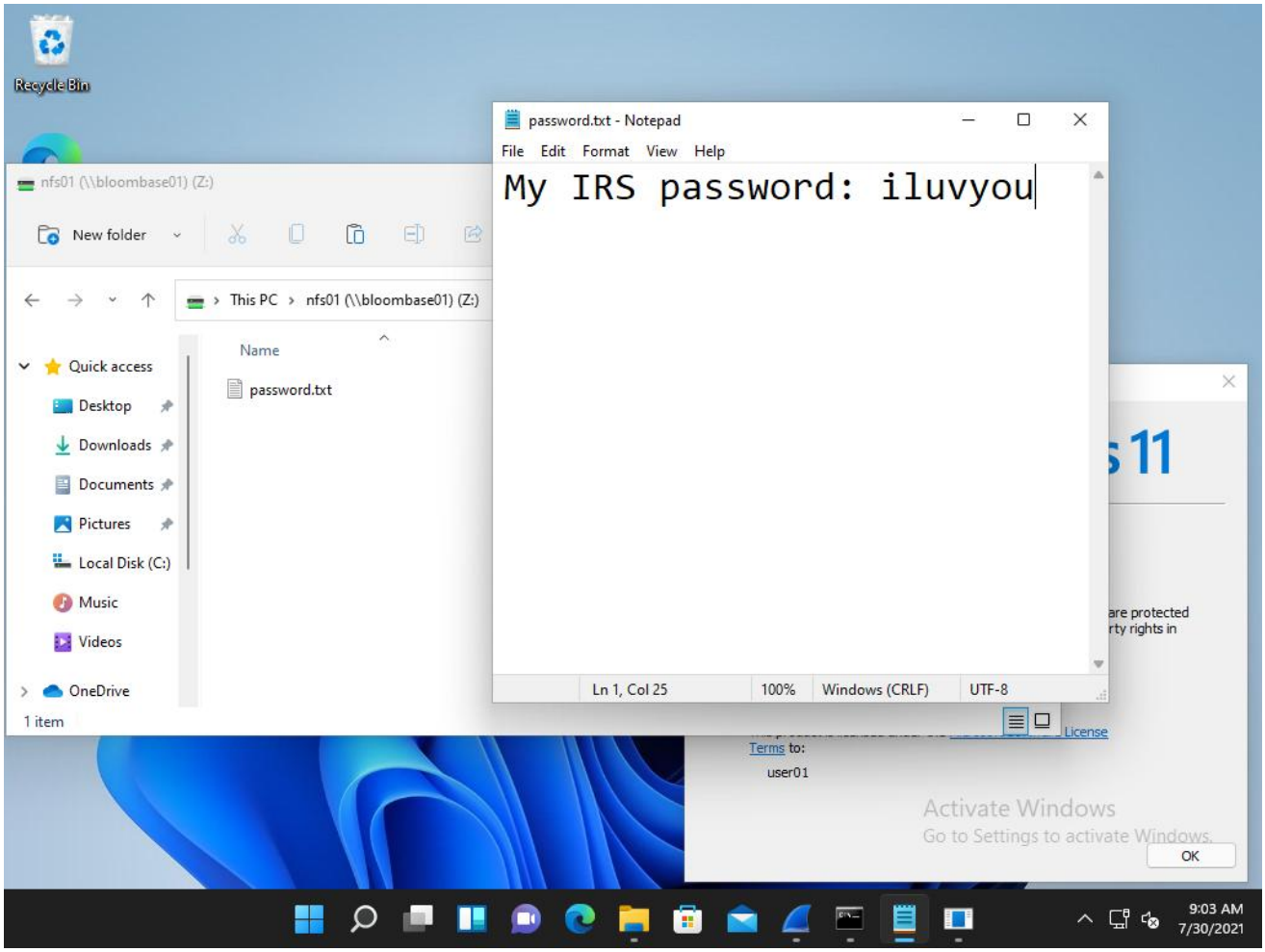




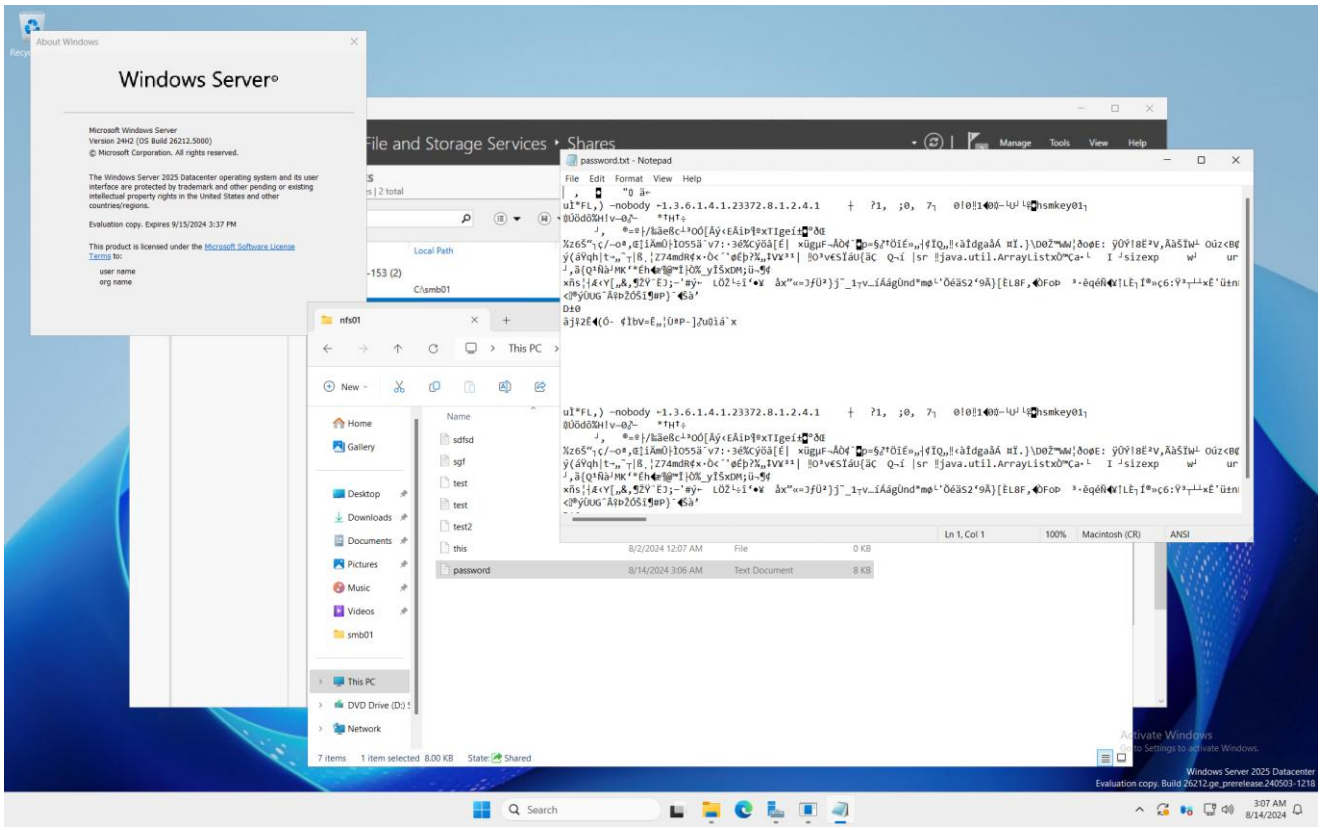
Microsoft Windows 11 clients can use the included map network drive option to add the NFS share presented by Bloombase StoreSafe Intelligent Storage Firewall with a drive letter. Data owners can alternatively use the mount command to specify additional mounting options.



On the virtual encrypted NFS share, a sample plaintext file is created by the client and saved. The file is transparently encrypted by the Bloombase StoreSafe encryption engine with keys managed by IBM GKLM and stored on the Microsoft Windows Server 2025 backend share.

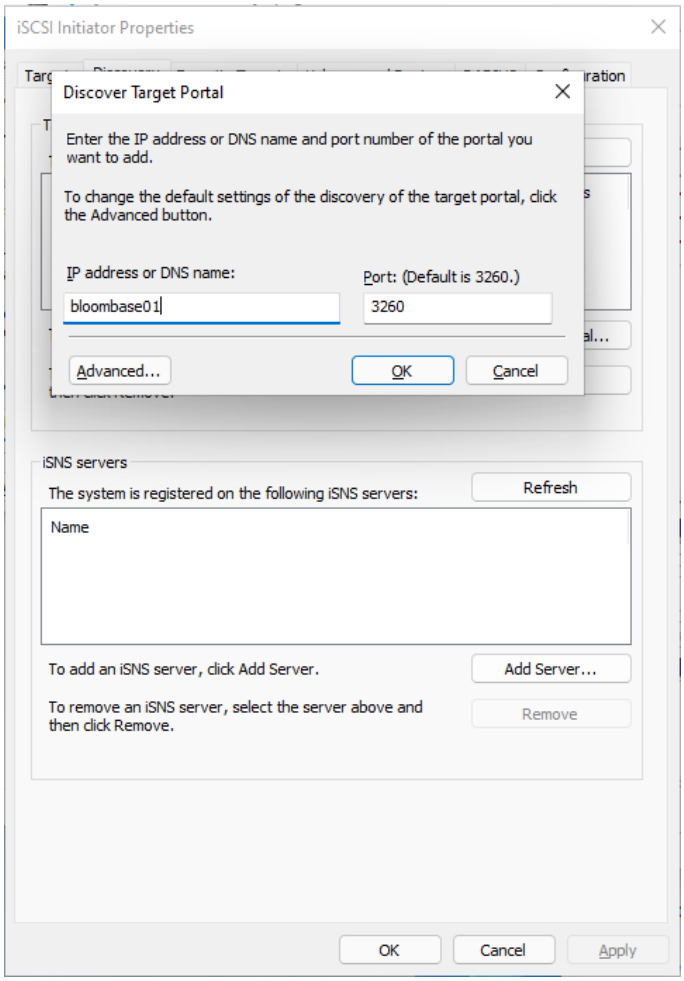


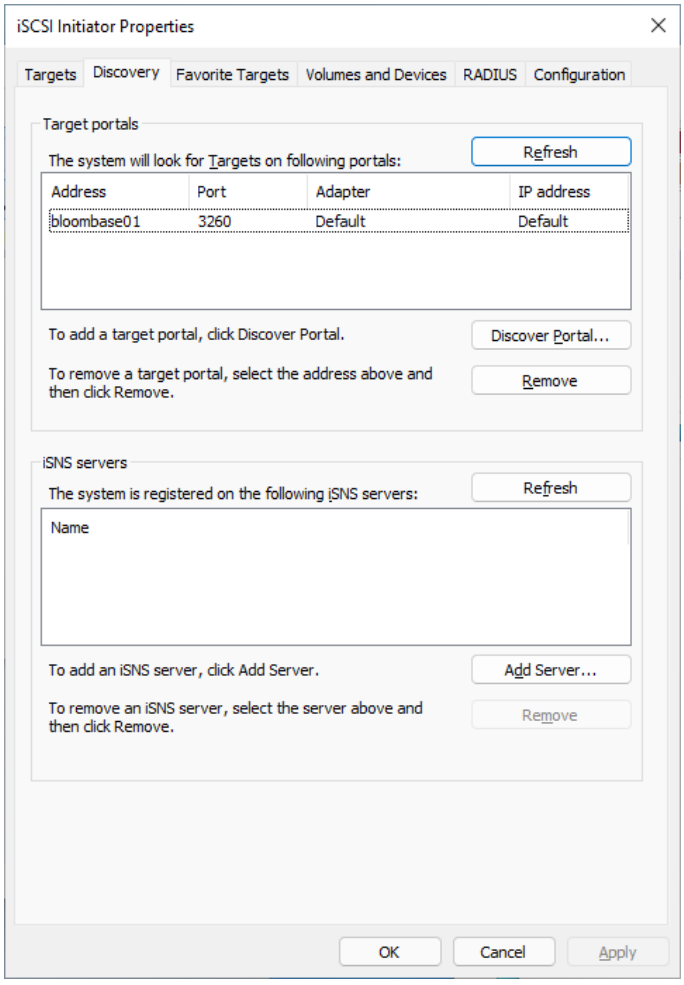
If the application data is attempted to be accessed directly on the backend without going through the Bloombase StoreSafe encryption engine, only ciphertext can be read as expected.



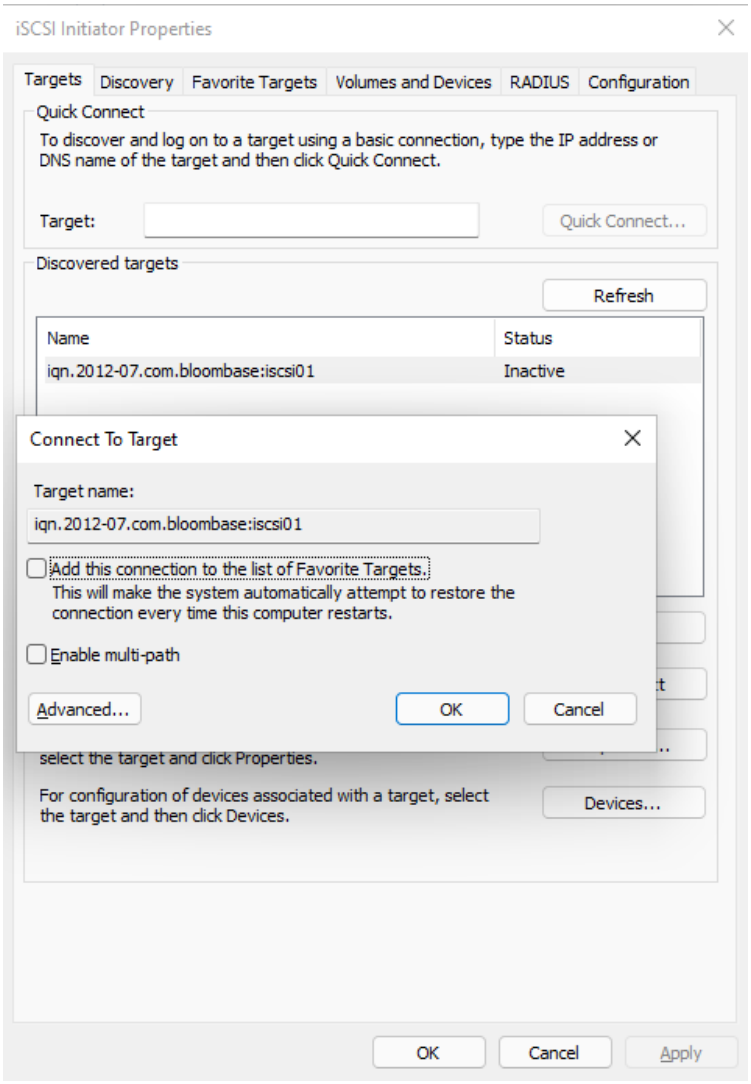
Tests for Data-at-Rest Encryption over iSCSI

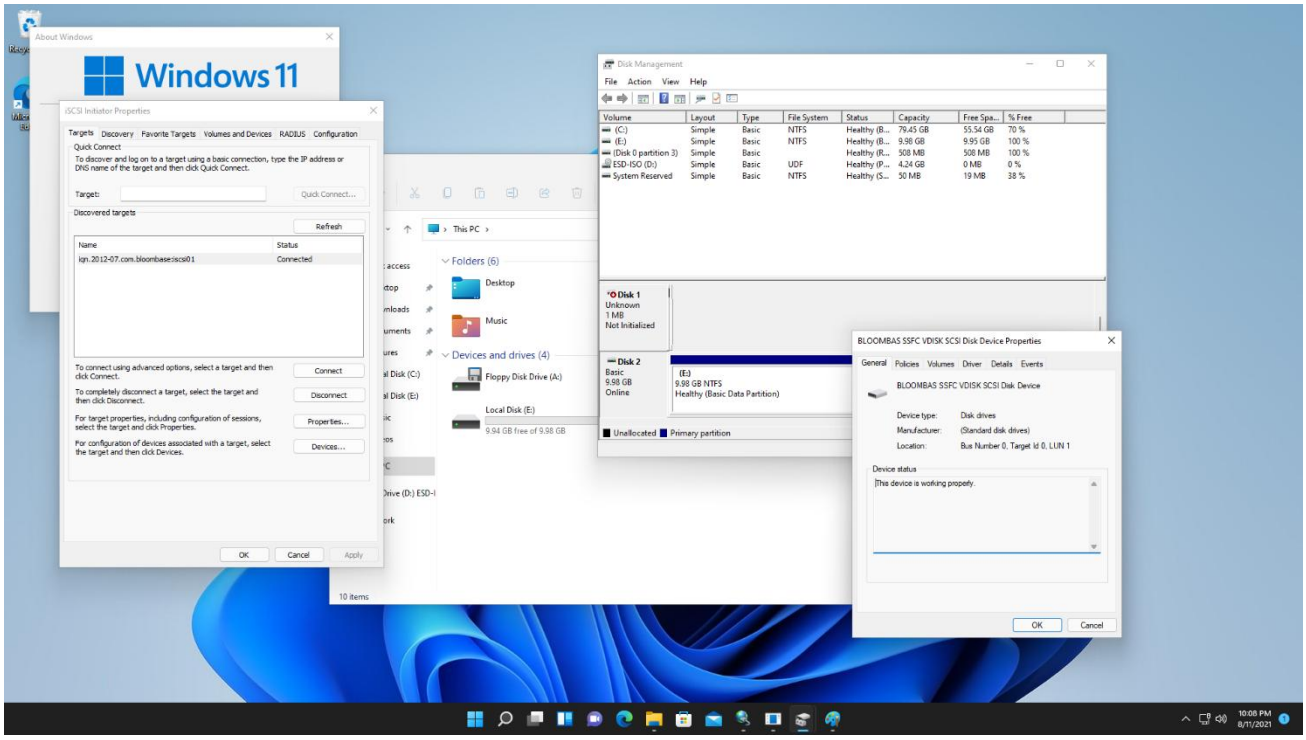
iSCSI targets are an example from the many protocols Bloombase StoreSafe supports for encryption. A target from a Microsoft Windows Server 2025 system that is accessible by configure clients is created to act as backend storage. Bloombase StoreSafe creates a virtual encrypted share on its own hostname path that is accessed from a client software system.



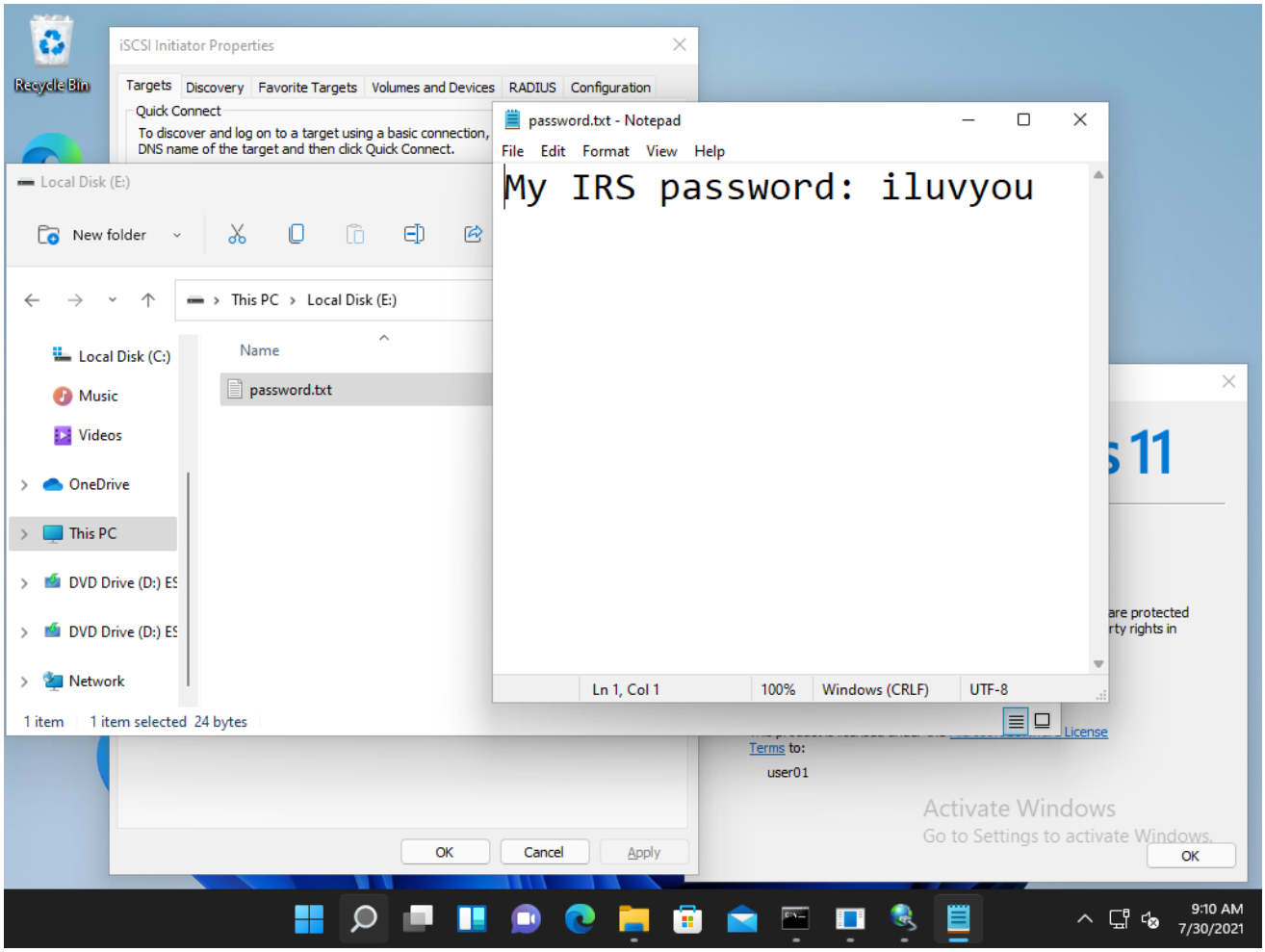


Microsoft Windows 11 clients can attach the virtual encrypted share with the default iSCSI initiator tool. Add the hostname and port to the discover tab, then connect to the iSCSI storage target presented by Bloombase StoreSafe Intelligent Storage Firewall. To access the Bloombase StoreSafe iSCSI disk, make sure the client IQN is be added the Bloombase StoreSafe configuration. The disk will be mounted to the client operating system and it can be formatted with a filesystem, in this case, NTFS.

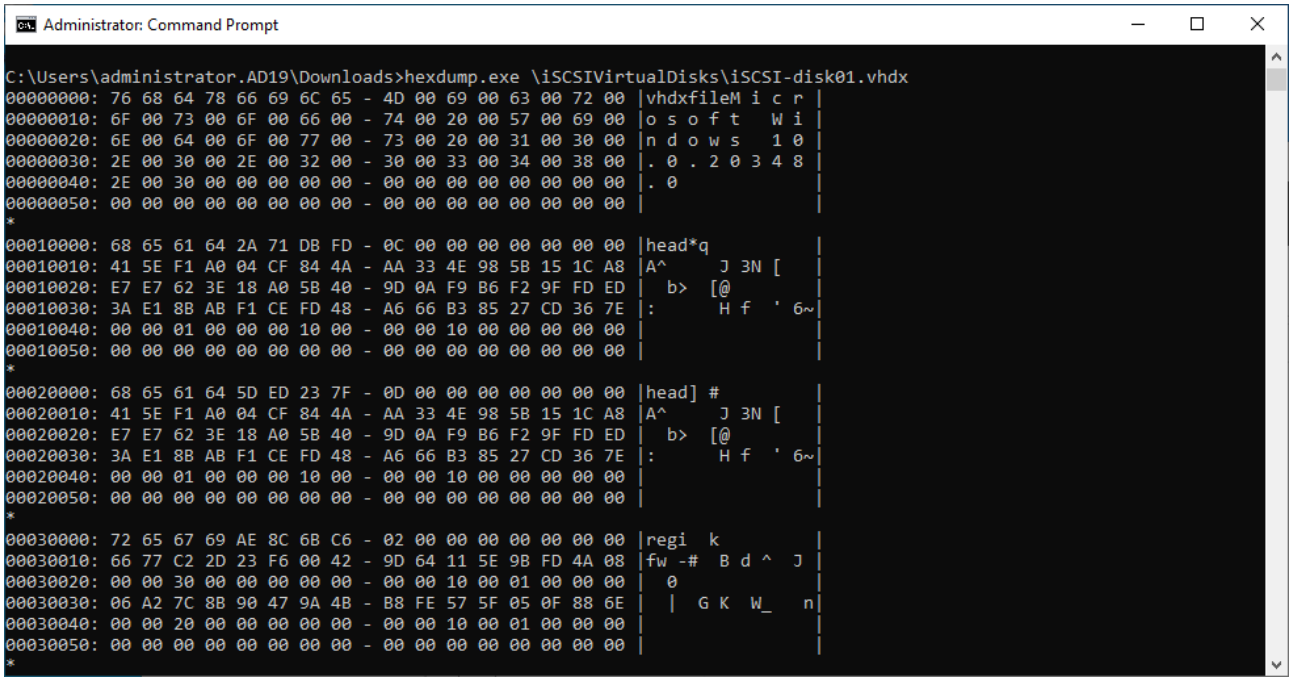


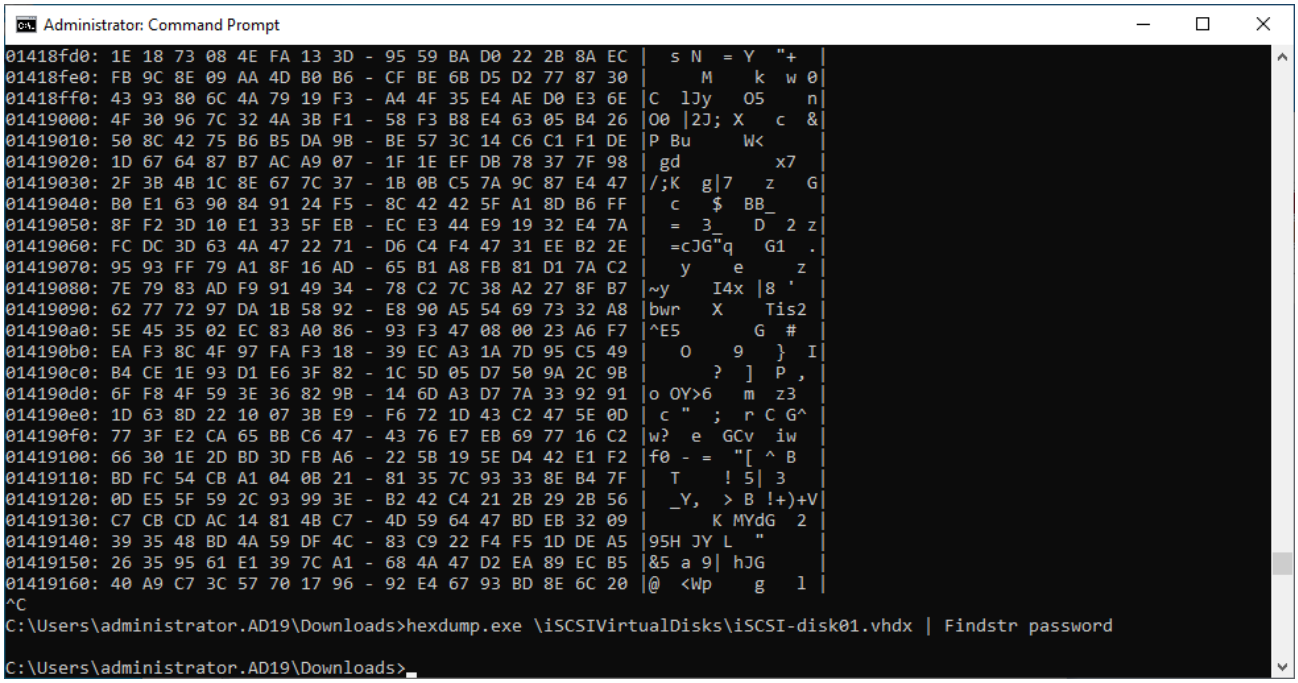


On the virtual encrypted iSCSI target, a sample plaintext file is created by the client and saved. The file is transparently encrypted by the Bloombase StoreSafe encryption engine with encryption keys managed by IBM GKLM and stored on the Microsoft Windows Server 2025 storage backend.



If the application data is attempted to be accessed directly on the backend without going through the Bloombase StoreSafe encryption engine, only ciphertext can be read as expected.





Tests for Data-at-Rest Encryption over NVMe/TCP

Client that has appropriate access can discover Bloombase StoreSafe Intelligent Storage Firewall virtual storage over NVMe/TCP protocol.

```
[root@bb027 ~]# nvme discover -t tcp -a 192.168.211.24 -s 4420 -q nqn.2014-08.org.nvmexpress:uuid:cf
2eae42-6537-4891-85c2-77bbff4598b8
```

```
trtype:  tcp
adrfam:  ipv4
subtype: nvme subsystem
treq:    not required
portid:  1
trsvcid: 4420
subnqn:  nqn.2022-06.io.storesafe:nvme01
traddr:  192.168.211.24
sectype: none
```

Connect client to Bloombase StoreSafe Intelligent Storage Firewall NVMe/TCP virtual storage.

```
[root@bb027 ~]# nvme connect -t tcp -a 192.168.211.24 -s 4420 -q nqn.2014-08.org.nvmexpress:uuid:cf2
eae42-6537-4891-85c2-77bbff4598b8 -n nqn.2022-06.io.storesafe:nvme01
```

Ensure that Bloombase StoreSafe Intelligent Storage Firewall virtual storage is attached to the client after successful discovery and connection.

```
[root@bb027 ~]# lsblk
NAME        MAJ:MIN RM  SIZE RO TYPE MOUNTPOINT
sda           8:0    0  1.8T  0 disk
├─sda1        8:1    0  600M  0 part /boot/efi
├─sda2        8:2    0    1G  0 part /boot
└─sda3        8:3    0  1.8T  0 part
  ├─rl-root 253:0    0   70G  0 lvm  /
  ├─rl-swap 253:1    0 15.7G  0 lvm  [SWAP]
  └─rl-home 253:2    0  1.8T  0 lvm  /home
nvme0n1     259:0    0  1.1T  0 disk
```

Format and mount Bloombase Storesafe Intelligent Storage Firewall NVMe/TCP virtual storage.

```
[root@bb027 ~]# mount /dev/nvme0n1 /nvme01
[root@bb027 ~]# mount | grep nvme01
/dev/nvme0n1 on /nvme01 type xfs (rw,relatime,seclabel,attr2,inode64,logbufs=8,logbsize=32k,noquota)
[root@bb027 ~]# cd /nvme01/
```

Sample plaintext files have been pre-added into Bloombase StoreSafe Intelligent Storage Firewall NVMe/TCP virtual storage.

```
[root@bb027 nvme01]# ls -l
total 261336
-rw-r--r--. 1 root root      3285 Aug 13  2021  0.seq
-rw-r--r--. 1 root root      3201 Aug 13  2021  100.seq
-rw-r--r--. 1 root root      3066 Aug 13  2021  101.seq
-rw-r--r--. 1 root root      3191 Aug 13  2021  102.seq
-rw-r--r--. 1 root root      3362 Aug 13  2021  103.seq
-rw-r--r--. 1 root root      3275 Aug 13  2021  104.seq
-rw-r--r--. 1 root root      3192 Aug 13  2021  105.seq
-rw-r--r--. 1 root root      3204 Aug 13  2021  106.seq
-rw-r--r--. 1 root root      3200 Aug 13  2021  107.seq
-rw-r--r--. 1 root root      3184 Aug 13  2021  108.seq
-rw-r--r--. 1 root root      3155 Aug 13  2021  109.seq
-rw-r--r--. 1 root root      2993 Aug 13  2021  10.seq
-rw-r--r--. 1 root root      3044 Aug 13  2021  110.seq
-rw-r--r--. 1 root root      3287 Aug 13  2021  111.seq
```

Trusted client is able to access and read the Bloombase StoreSafe encrypted files as if they are in clear-text.

```
//
LOCUS       AQ721632               506 bp    DNA     linear   GSS 09-MAY-2010
DEFINITION  HS_5563_B1_B06_T7A RPCI-11 Human Male BAC Library Homo sapiens
            genomic clone Plate=1139 Col=11 Row=D, genomic survey sequence.
ACCESSION   AQ721632
VERSION     AQ721632.1
DBLINK      BioSample: SAMN00183116
KEYWORDS    GSS.
SOURCE      Homo sapiens (human)
  ORGANISM  Homo sapiens
            Eukaryota; Metazoa; Chordata; Craniata; Vertebrata; Euteleostomi;
            Mammalia; Eutheria; Euarchontoglires; Primates; Haplorrhini;
            Catarrhini; Hominidae; Homo.
REFERENCE   1  (bases 1 to 506)
  AUTHORS   Mahairas,G.G., Wallace,J.C., Smith,K., Swartzell,S., Holzman,T.,
            Keller,A., Shaker,R., Furlong,J., Young,J., Zhao,S., Adams,M.D. and
            Hood,L.
  TITLE     Sequence-tagged connectors: A sequence approach to mapping and
            scanning the human genome
  JOURNAL   Proc. Natl. Acad. Sci. U.S.A. 96 (17), 9739-9744 (1999)
   PUBMED   10449764
COMMENT     Contact: Mahairas GG, Wallace JC, Hood L
            High Throughput Sequencing Center
            University of Washington
            401 Queen Anne Avenue North, Seattle, WA 98109, USA
            Tel: (206) 616-3618
            Fax: (206) 616-3887
            Email: jwallace@u.washington.edu
"100.seq" 60L, 3201C
```

Any file/data stored via Bloombase StoreSafe Intelligent Storage Firewall NVMe/TCP virtual storage is seamlessly encrypted at the storage with zero operational impact to end users, system administrators and software applications.

```
[root@bb024 ~]# hexdump -C /dev/nvme0n1
```

```
00391940  61 cd fa af e1 12 60 48  a0 b9 07 ee 96 c4 58 82  |a.....`H......X.|
00391950  b4 2a 9e 8c 44 ee 9e 93  22 d4 30 88 2e 1f 56 1a  |.*..D..."."0...V.|
00391960  4e 21 56 87 78 a6 3c 5c  1b dd 93 28 d3 a3 c7 fe  |N!V.x.<\...(....|
00391970  02 c7 3f a3 51 2d 2b 7c  2b 32 aa 5a 21 55 06 53  |..?.Q-+|+2.Z!U.S|
00391980  b0 bf dd 43 32 a2 30 49  fc ce c7 e2 8a 51 fe 9d  |...C2.0I.....Q..|
00391990  1c af 55 9e 50 bc 4c a9  39 eb b0 96 bd d6 60 df  |..U.P.L.9.....`.|
003919a0  ed 48 25 bf ae 11 93 90  96 bc 46 5f 6d 18 25 5c  |.H%.......F_m.%\|
003919b0  e9 ea 62 b0 dc a2 45 75  5c ca 0b 22 df 78 fd b3  |..b...Eu\.."."x..|
003919c0  05 19 15 26 0f 1c 70 f4  03 09 33 6d eb 67 e2 7e  |...&..p...3m.g.~|
003919d0  8f 38 fe 6f 5f 99 b3 d3  4f bb 21 71 9e 6b 67 8a  |.8.o_...O.!q.kg.|
003919e0  bb c9 d0 8f c2 10 99 13  fa a3 8d 65 34 36 d1 44  |...........e46.D|
003919f0  96 f0 3f 76 d4 a0 d4 6b  7b 77 c4 1f d8 db 2d db  |..?v...k{w....-.|
00391a00  ab 5f 41 9a d4 bc 00 89  6d 3b bb 1f 10 e0 c4 cb  |._A.....m;......|
00391a10  4d e0 a6 28 ab 3e e6 5a  fa ad fe 20 9a 9d ca cd  |M..(.>.Z... ....|
00391a20  e4 b9 22 fa 61 4a 6e 7b  c1 82 4c ad fe 3a 72 d1  |.."aJn{..L..:r.|
00391a30  16 81 a7 32 f6 8c ab 33  f4 ed a0 5d 78 75 d7 9b  |...2...3...]xu..|
00391a40  fe f8 7a dc 39 9f 87 75  c4 cd f7 3c bd c2 43 7e  |..z.9..u...<..C~|
00391a50  d8 a2 47 6f 98 ea da ed  d5 a2 40 c7 44 94 03 df  |..Go......@.D...|
```

```
[root@bb024 ~]# hexdump -C /dev/nvme0n1 | grep SAMN00183116
[root@bb024 ~]#
```

Create a new file to be secured by Bloombase StoreSafe Intelligent Storage Firewall.

```
[root@bb027 nvme01]# vi password.txt
```

```
My IRS password: iloveyou
My Citibank password: qwertyuiop
~
~
~
```

Trusted client is able to access and write files into Bloombase StoreSafe Intelligent Storage Firewall as if they are plain-text files.

```
[root@bb027 nvme01]# ls -l | grep password.txt
-rw-r--r--. 1 root root        60 Oct  5 08:03 password.txt
```

```
[root@bb027 nvme01]# cat password.txt
My IRS password: iloveyou
My Citibank password: qwertyuiop
```

Any file/data stored via Bloombase StoreSafe Intelligent Storage Firewall virtual storage with IBM GKLM centralize key management is seamlessly encrypted at the storage with zero operational impact to end users, system administrators and software applications.

```
[root@bb024 ~]# hexdump -C /dev/nvme0n1
```

```
00391940  61 cd fa af e1 12 60 48  a0 b9 07 ee 96 c4 58 82  |a.....`H......X.|
00391950  b4 2a 9e 8c 44 ee 9e 93  22 d4 30 88 2e 1f 56 1a  |.*..D..."."0...V.|
00391960  4e 21 56 87 78 a6 3c 5c  1b dd 93 28 d3 a3 c7 fe  |N!V.x.<\...(....|
00391970  02 c7 3f a3 51 2d 2b 7c  2b 32 aa 5a 21 55 06 53  |..?.Q-+|+2.Z!U.S|
00391980  b0 bf dd 43 32 a2 30 49  fc ce c7 e2 8a 51 fe 9d  |...C2.0I.....Q..|
00391990  1c af 55 9e 50 bc 4c a9  39 eb b0 96 bd d6 60 df  |..U.P.L.9.....`.|
003919a0  ed 48 25 bf ae 11 93 90  96 bc 46 5f 6d 18 25 5c  |.H%.......F_m.%\|
003919b0  e9 ea 62 b0 dc a2 45 75  5c ca 0b 22 df 78 fd b3  |..b...Eu\.."."x..|
003919c0  05 19 15 26 0f 1c 70 f4  03 09 33 6d eb 67 e2 7e  |...&..p...3m.g.~|
003919d0  8f 38 fe 6f 5f 99 b3 d3  4f bb 21 71 9e 6b 67 8a  |.8.o_...O.!q.kg.|
003919e0  bb c9 d0 8f c2 10 99 13  fa a3 8d 65 34 36 d1 44  |...........e46.D|
003919f0  96 f0 3f 76 d4 a0 d4 6b  7b 77 c4 1f d8 db 2d db  |..?v...k{w....-.|
00391a00  ab 5f 41 9a d4 bc 00 89  6d 3b bb 1f 10 e0 c4 cb  |._A.....m;......|
00391a10  4d e0 a6 28 ab 3e e6 5a  fa ad fe 20 9a 9d ca cd  |M..(.>.Z... ....|
00391a20  e4 b9 22 fa 61 4a 6e 7b  c1 82 4c ad fe 3a 72 d1  |.."."aJn{..L..:r.|
00391a30  16 81 a7 32 f6 8c ab 33  f4 ed a0 5d 78 75 d7 9b  |...2...3...]xu..|
00391a40  fe f8 7a dc 39 9f 87 75  c4 cd f7 3c bd c2 43 7e  |..z.9..u...<..C~|
00391a50  d8 a2 47 6f 98 ea da ed  d5 a2 40 c7 44 94 03 df  |..Go......@.D...|
```

```
[root@bb024 ~]# hexdump -C /dev/nvme0n1 | grep password
[root@bb024 ~]#
```

Conclusion

In this integration guide, we have shown how to set up Bloombase StoreSafe Intelligent Storage Firewall with IBM Guardium Key Lifecycle Manager (GKLM) to deliver on-the-fly encryption of multiple storage protocols including SMB, NFS, iSCSI and NVMe/TCP. The end result is a high-bandwidth, application-transparent storage encryption solution with centralized key management that locks down sensitive crown-jewel data on disks and helps mitigate information exfiltration threats for mission-critical systems and data services.

As a summary,

- IBM Guardium Key Lifecycle Manager (GKLM) 5.0

has been integrated with Bloombase StoreSafe Intelligent Storage Firewall to deliver encryption security of Microsoft Storage Server on Microsoft Windows Server 2025 over SMB/CIFS, NFS, iSCSI and Rocky Linux 9 via NVMe/TCP network storage protocols for software applications running on Microsoft Windows 11 and Ubuntu 22.04 LTS.

Bloombase Product	Client Systems	Storage Backends	Key Management System

Bloombase StoreSafe Intelligent Storage Firewall 4.0	• Microsoft Windows 11 • Ubuntu 22.04 LTS	• Microsoft Windows Server 2025 • Rocky Linux 9	IBM Guardium Key Lifecycle Manager (GKLM) 5.0

Disclaimer

The integration procedures described in this paper were conducted in the Bloombase InteropLab. Bloombase has not tested this configuration with all the combinations of hardware and software options available. There may be significant difference in your configuration that will change the procedures necessary to accomplish the objectives outlined in this paper. If you find that any of these procedures do not work in your environment, please contact us immediately.

Acknowledgement

Bloombase InteropLab would like to thank IBM team for supporting the integration of Bloombase StoreSafe with IBM Guardium Key Lifecycle Manager (GKLM).

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