

Bloombase
StoreSafe

Integration Guide

u.trust GP HSM

v4.80.0.0



Imprint

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1 Purpose and Scope

This document describes the steps to integrate u.trust GP HSM 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 u.trust GP HSM
- Integrate Microsoft Windows 11 and Ubuntu 22.04 client systems with Bloombase StoreSafe and u.trust GP HSM data-at-rest encryption security solutions 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.

2 Assumptions

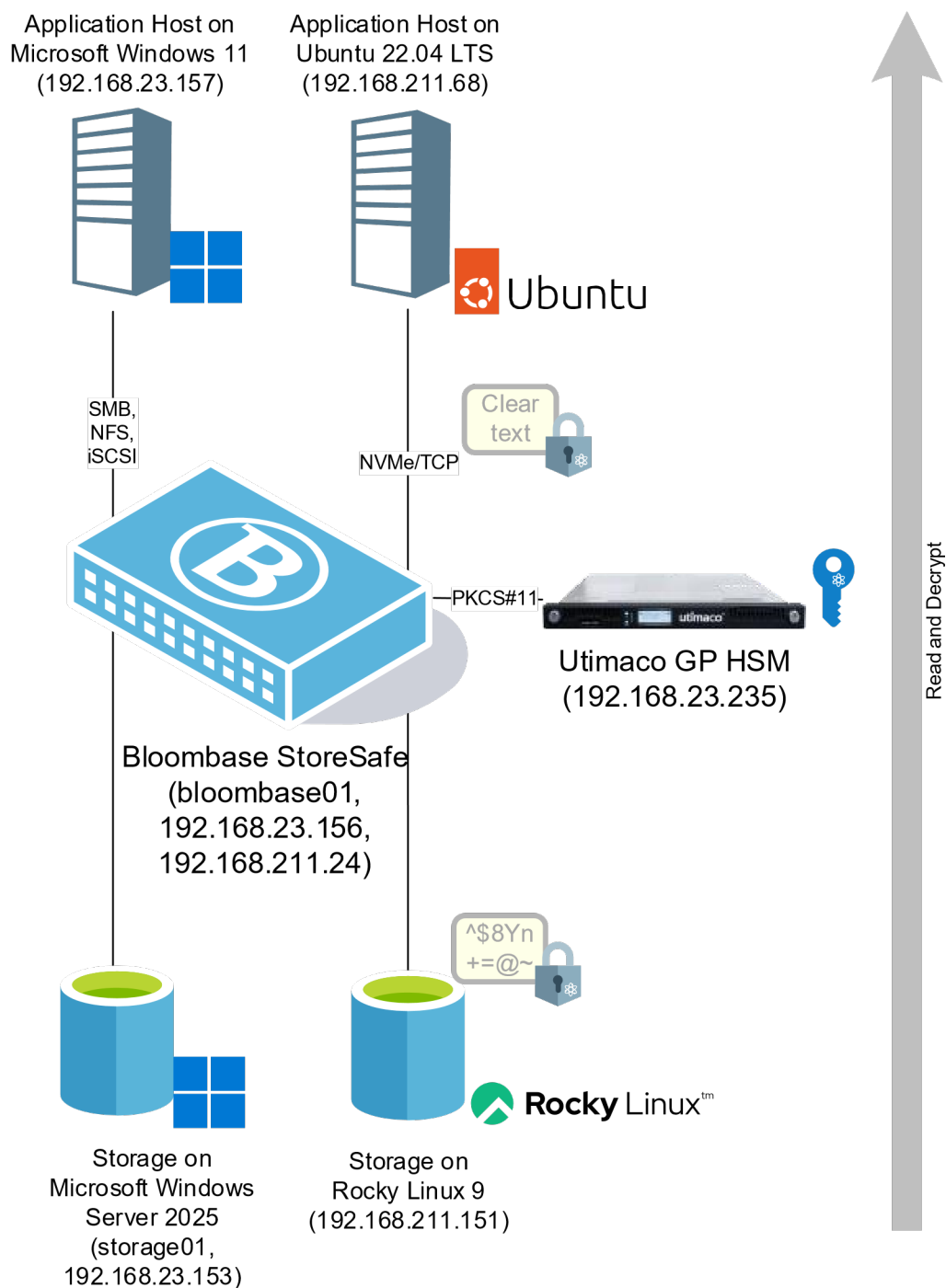
This document describes the integration of u.trust GP HSM with Bloombase StoreSafe. It is assumed that you are familiar with operation of u.trust GP HSM, storage systems, and major operating systems including Linux, Microsoft Windows, IBM AIX, HP-UX and Oracle Sun Solaris. It is also assumed that you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

As u.trust GP HSM 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 u.trust GP HSM 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>.

3 Infrastructure

3.1 Setup

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



3.2 Storage Encryption

Storage Encryption	Bloombase StoreSafe Intelligent Storage Firewall Software Appliance v4.0
Server	VMware ESXi 6.5
Processor	4x Virtual CPU (vCPU)
Memory	8GB
Network Interface Card	NVIDIA ConnectX-5

3.3 Key Management System

Key Management System	u.trust General Purpose Hardware Security Module (GP HSM) v4.80.0.0
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3.4 Storage Systems

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

Client Hosts	Microsoft Windows 11	Ubuntu 22.04 LTS
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3.6 Networking

Ethernet Switch	Celestica Seastone DX010 32-port 100GbE ONIE Switch
Network Interface Card	NVIDIA ConnectX-5
Cables	NVIDIA/Mellanox 100GbE QSFP28 DAC Cables

4 Configuration Overview

4.1 u.trust General Purpose Hardware Security Module (u.trust GP HSM)

u.trust GP HSM is a hardware security module that secures cryptographic key material for servers and applications. It includes integration software that supports the industry standards (e.g. PKCS#11, Microsoft CSP/CNG, JCE...) which are used in many application scenarios, e.g., Enterprise PKI application and database encryption. The General Purpose HSM is available as PCIe embedded card or as network attached appliance. The key management and cryptographic functionalities provided by u.trust GP HSM are used by Bloombase StoreSafe for encryption protection of data-at-rest for general-purpose use cases.

In order to utilize the PKCS#11 functionality, the token must be initialized.

```
[root@cassfl156 ~]# /opt/utimaco/Administration/csadm GetState
mode      = Operational Mode
state     = INITIALIZED (0x00100004)
temp      = 30.0 [C]
alarm     = OFF
bl_ver    = 5.01.10.0          (Model: Se-Series Gen2)
hw_ver    = 0.00.8.15
uid       = ca534d32 34347053 | SM244pS |
adm1      = 5554494d 41434f20 53493030 33303031 |UTIMACO SI003001|
adm2      = 53696d75 6c61746f 72000000 00000000 |Simulator |
adm3      = 696e6974 5f646576 5f707562 00000000 |init dev pub |
```

As an example, the u.trust GP HSM is assigned a token label as follows

```
p11tool2 slot=0 Label=CryptoServer Login=ADMIN,ADMIN.key InitToken=<so pin>
```

A user pin will be needed for PKCS#11. To setup the user pin, run the following command,

```
p11tool2 slot=0 LoginSO=<so pin> InitPin=<user pin>
```

To check if u.trust GP HSM is initialized, run

```
p11tool2 slot=0 ListSlots=status
```

```
[root@cassf156 ~]# /opt/utimaco/bin/plltool2 ListSlots=status
  slot ID   token init.   PIN init.
-----
0: 00000000 yes           yes
1: 00000001 no            no
2: 00000002 no            no
3: 00000003 no            no
4: 00000004 no            no
5: 00000005 no            no
6: 00000006 no            no
7: 00000007 no            no
8: 00000008 no            no
9: 00000009 no            no
```

4.1.1 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-5 NICs via DAC cables as shown in the SONiC console below.

```
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
```

VLAN ID	IP Address	Ports	Port Tagging	Proxy ARP	DHCP Helper Address
210		Ethernet24	untagged	disabled	
		Ethernet28	untagged		

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
```

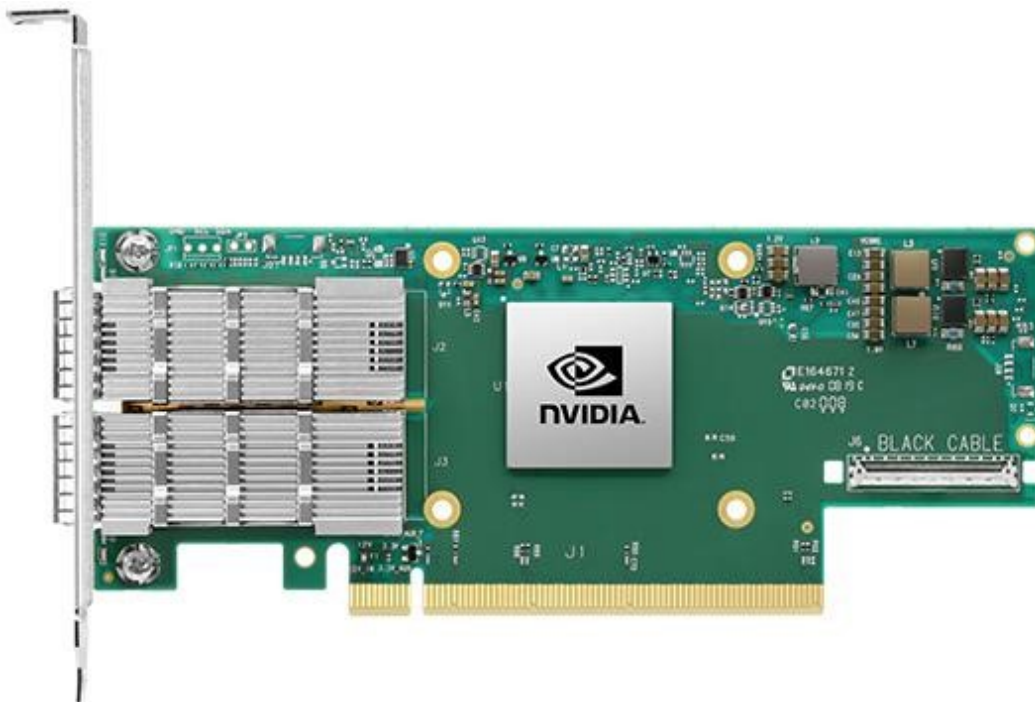
4.1.2 Direct Attach Copper (DAC) Cable

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



4.1.3 Network Interface Card (NIC)

NVIDIA ConnectX-5 NIC has been used in this integration testing.



Install and configure NVIDIA ConnectX-5 NIC using the install image or the driver available from your distribution's repo.

```
user@ubuntu67:~$ lspci |grep mellanox -i
0b:00.0 Ethernet controller: Mellanox Technologies MT27800 Family [ConnectX-5 Virtual Function]
```

```
user@ubuntu67:~$ ibstat
CA 'mlx5_0'
    CA type: MT4120
    Number of ports: 1
    Firmware version: 16.35.2000
    Hardware version: 0
    Node GUID: 0x000c29ffffe1dfb26
    System image GUID: 0xb8cef60300f2cc66
    Port 1:
        State: Active
        Physical state: LinkUp
        Rate: 100
        Base lid: 0
        LMC: 0
        SM lid: 0
        Capability mask: 0x00010000
        Port GUID: 0x020c29ffffe1dfb26
        Link layer: Ethernet
```

4.2 Microsoft Storage Server on Microsoft Windows Server 2025 Storage Backends

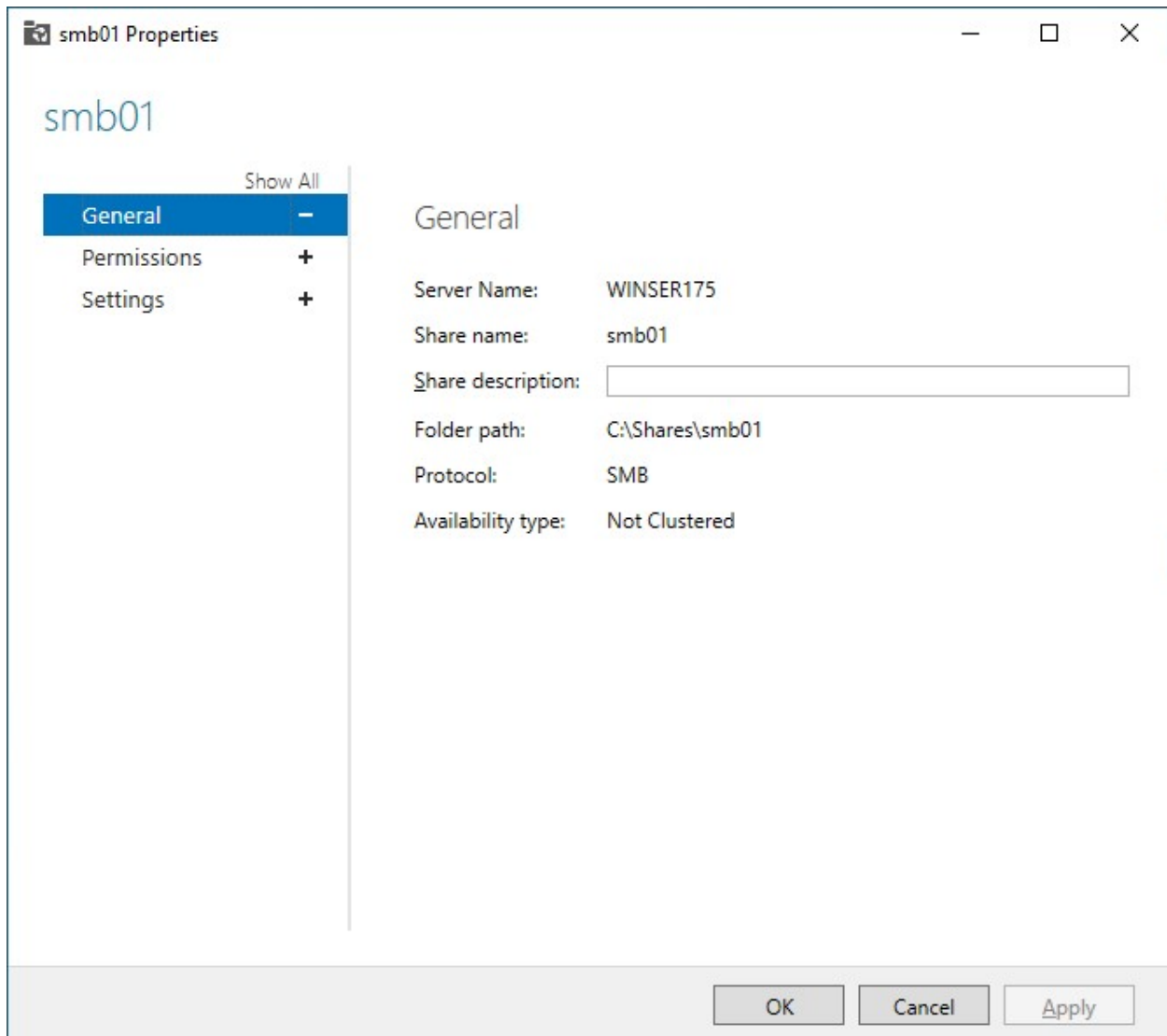
Microsoft Storage Server on Microsoft Windows Server 2025 running on VMware ESXi is used in this interoperability test which is able to provide storage services over network storage protocols including iSCSI, NFS, SMB, CIFS, REST, etc.

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

4.2.1 SMB Services Configuration

The screenshot displays the Windows Server Manager interface, specifically the 'Shares' section under 'File and Storage Services'. The left-hand navigation pane shows a tree structure with 'Servers', 'Volumes', 'Disks', 'Storage Pools', 'Shares', 'iSCSI', and 'Work Folders'. The 'Shares' section is currently selected. The main area is divided into two panes. The left pane, titled 'SHARES', shows a list of shares for the server 'WINSER175 (2)'. The list has columns for 'Share', 'Local Path', 'Protocol', and 'Availability Type'. Two shares are listed: 'smb01' with local path 'C:\Shares\smb01' and protocol 'SMB', and 'nfs01' with local path 'C:\Shares\nfs01' and protocol 'NFS'. Both are marked as 'Not Clustered'. The right pane, titled 'VOLUME', shows details for the 'smb01' volume on 'WINSER175'. It indicates a capacity of 99.4 GB, with 18% used (17.9 GB) and 81.5 GB free space. A 'Go to Volumes Overview >' link is present. Below the volume details, a 'QUOTA' section states: 'To use quotas, File Server Resource Manager must be installed. To install File Server Resource Manager, start the Add Roles and Features Wizard.'

Share	Local Path	Protocol	Availability Type
smb01	C:\Shares\smb01	SMB	Not Clustered
nfs01	C:\Shares\nfs01	NFS	Not Clustered



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

4.2.2 NFS Services Configuration

The screenshot displays the Windows Server Manager interface, specifically the 'Shares' section under 'File and Storage Services'. The left-hand navigation pane shows 'Shares' selected. The main area is divided into two panes: 'SHARES' and 'VOLUME'.

SHARES
All shares | 2 total

Share	Local Path	Protocol	Availability Type
WINSER175 (2)			
smb01	C:\Shares\smb01	SMB	Not Clustered
nfs01	C:\Shares\nfs01	NFS	Not Clustered

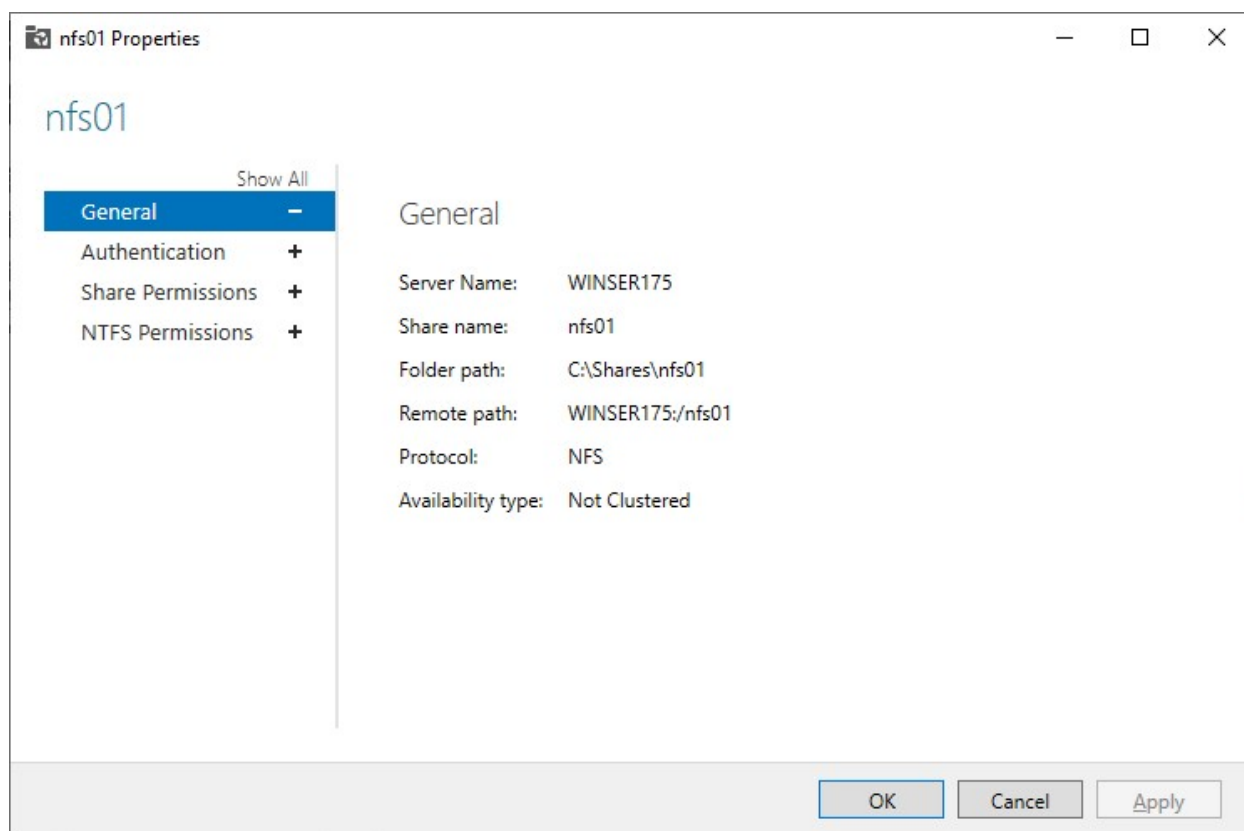
VOLUME
smb01 on WINSER175

Capacity: 99.4 GB

18% Used (17.9 GB Used Space, 81.5 GB Free Space)

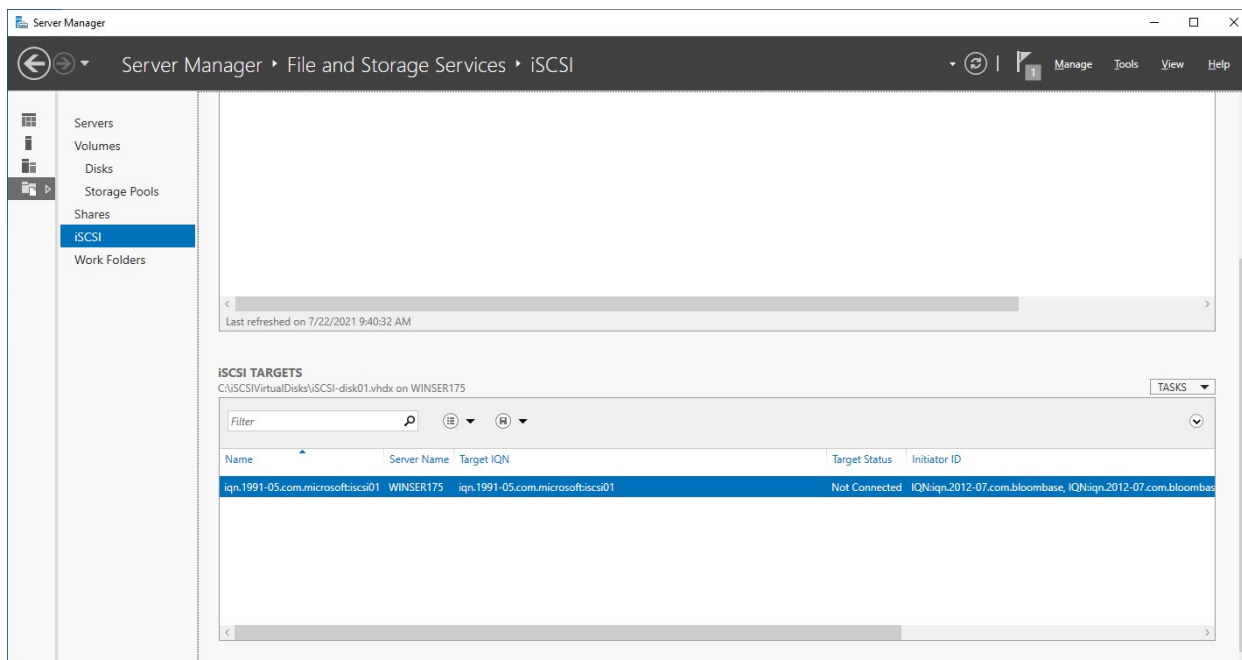
QUOTA
smb01 on WINSER175

To use quotas, File Server Resource Manager must be installed.
To install File Server Resource Manager, start the Add Roles and Features Wizard.



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

4.2.3 iSCSI Services Configuration



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

4.3 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.

```

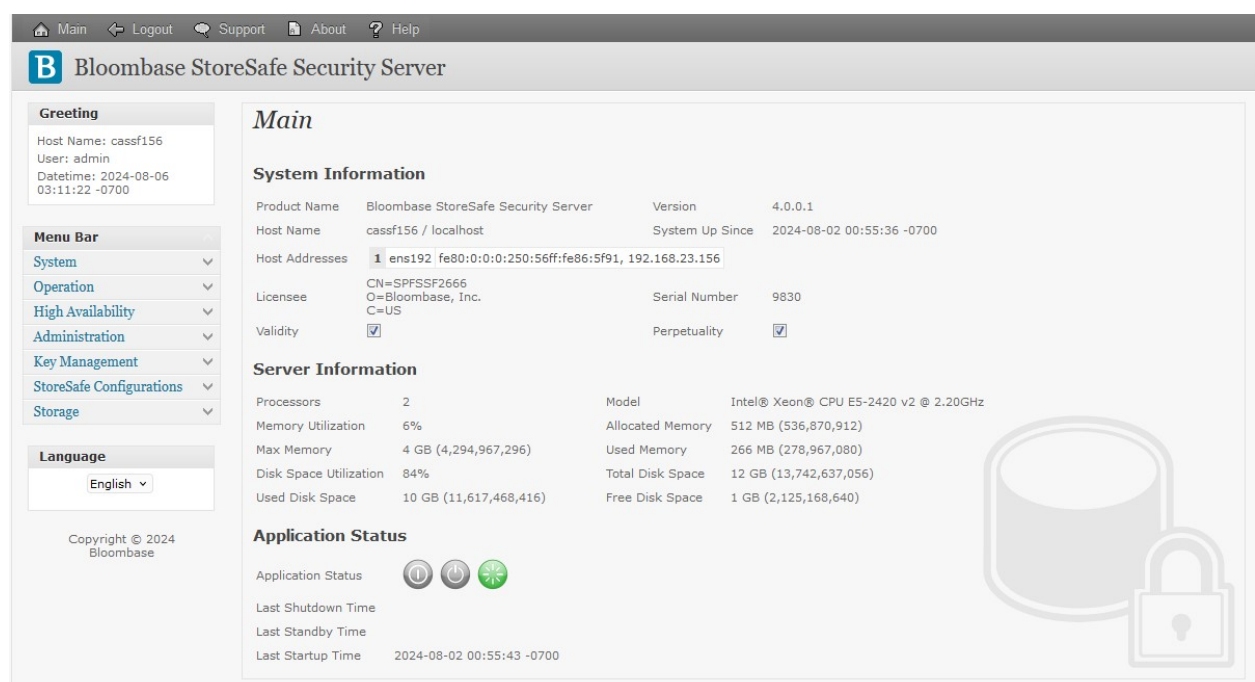
[root@carocky151 ~]# nmctcli
> ls
o- /
o- hosts ..... [..]
  | o- nqn.2014-08.org.nvmeexpress:uuid:4af97520-1bfe-4c8d-9069-5fb9ab632709 ..... [..]
o- ports ..... [..]
  | o- 1 ..... [trtype=tcp, traddr=192.168.211.151, trsvcid=4420, inline_data_size=16384]
  | | o- ana_groups ..... [..]
  | | | o- 1 ..... [state=optimized]
  | o- referrals ..... [..]
  | o- subsystems ..... [..]
  | | o- nqn.2014-08.org.nvmeexpress:NUMA: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.nvmeexpress:NUMA:uuid:7079993e-7413-4338-9b9b-a3af82259b18 ..... [..]
  | | | | o- subsystems ..... [..]
  | | | | o- nqn.2014-08.org.nvmeexpress:NUMA: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, grpuid=1, disabled]

```

4.4 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 u.trust GP HSM.

Bloombase StoreSafe Intelligent Storage Firewall software appliance is deployed as a virtual appliance (VA).



Bloombase StoreSafe Security Server

Greeting
Host Name: cassf156
User: admin
Datetime: 2024-08-06 03:11:22 -0700

Menu Bar
System
Operation
High Availability
Administration
Key Management
StoreSafe Configurations
Storage

Language
English

Main

System Information

Product Name	Bloombase StoreSafe Security Server	Version	4.0.0.1
Host Name	cassf156 / localhost	System Up Since	2024-08-02 00:55:36 -0700
Host Addresses	1 ens192 fe80:0:0:0:250:56ff:fe86:5f91, 192.168.23.156		
Licensee	CN=SPFSSF2666 O=Bloombase, Inc. C=US	Serial Number	9830
Validity	☒	Perpetuality	☒

Server Information

Processors	2	Model	Intel® Xeon® CPU E5-2420 v2 @ 2.20GHz
Memory Utilization	6%	Allocated Memory	512 MB (536,870,912)
Max Memory	4 GB (4,294,967,296)	Used Memory	266 MB (278,967,080)
Disk Space Utilization	84%	Total Disk Space	12 GB (13,742,637,056)
Used Disk Space	10 GB (11,617,468,416)	Free Disk Space	1 GB (2,125,168,640)

Application Status

Application Status: 

Last Shutdown Time
Last Standby Time
Last Startup Time: 2024-08-02 00:55:43 -0700

4.4.1 u.trust General Purpose Hardware Security Module (u.trust GP HSM) and Bloombase StoreSafe Integration

The Utimaco provided PKCS#11 libraries and tools need to be installed on the Bloombase Operating System (BloombaseOS). To modify files on the Bloombase StoreSafe OS filesystem, the administrator can access the TTY2 console (ALT+F2) and login as root or another user.

```
BloombaseOS 8.8  
localhost login: _
```

The following files need to be installed in their specific paths:

```
/opt/utimaco/bin/p11tool2
```

```
/opt/utimaco/conf/cs_pkcs11_R3.cfg
```

```
/opt/utimaco/lib/libcs_pkcs11_R3.so
```

Additionally: the following two environment variables need to be declared at the set environment parameter script of Bloombase StoreSafe:

```
/spitfire/spitfire-storesafe/bin/setenv.sh
```

```
### Utimaco HSM  
  
export CS_PKCS11_R3_CFG=/opt/utimaco/conf/cs_pkcs11_R3.cfg  
  
export LD_LIBRARY_PATH=$LD_LIBRARY_PATH:/opt/utimaco/lib
```

Ensure the

```
cs_pkcs11_R3.cfg
```

file is correctly configured to Utimaco instructions. The device ID or network IP needs to be specified in the file as such:

[CryptoServer]

Device specifier (here: internal PCI device : cHSM on local u.trust Anchor device - last number represents cHSM slot (1))

Device = /dev/cs2.0.1

Device specifier (here: cluster of remote devices - first with IP address, others using format <port>@<ip>)

Device = { 192.168.23.235 288@192.168.23.236 4001@192.168.23.237 }

To enable the built-in Bloombase KeyCastle to utilize keys managed in the u.trust GP HSM, the hardware security module service configuration at Bloombase web management console has to be set up. This is done by clicking “Hardware Security Module” under “Key Management”.

List Hardware Security Module

List Hardware Security Module

	Label	Present	Slot	Token	Module	Manufacturer	Model	Serial Number	Version	Status
										

Input a name for the configuration, and select Model as

Utimaco

Input the token label of the u.trust GP HSM, and the token user pin.

Modify Hardware Security Module

Modify Hardware Security Module

Module:

Label / Username:

Pin:

Confirm Pin:

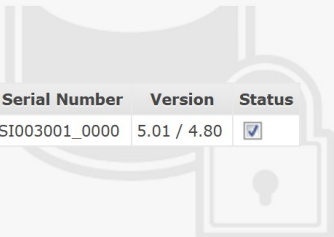


Click 'Submit' to commit the configuration. If the token is properly initialized and connected the "Present" and "Status" boxes will be checked.

List Hardware Security Module

List Hardware Security Module

	Label	Present	Slot	Token	Module	Manufacturer	Model	Serial Number	Version	Status
1	CryptoServer PKCS11 Token	☒	0	0	utimaco	Utimaco IS Gmb H	CryptoServer	SI003001_0000	5.01 / 4.80	☒



4.4.2 Encryption Key Provisioning

To generate key in attached u.trust GP HSM, select Key Source Type as

Hardware Security Module

and the assigned Key Manager token, in this case

CryptoServer PKCS11 Token

Select "Add Key" and "generate" to create a new key on the HSM.

Modify Key Wrapper

Key Wrapper **Permissions**

Modify Key Wrapper

Name	hsmkey01
Key Source	Hardware Security Module
Type	Asymmetric
Active	☒
Module	utimaco
Label	CryptoServer PKCS11 Token
Alias	
Algorithm	RSA ▾
Key Bit Length	2048 ▾
Signature Algorithm	SHA256 ▾
Key Usage	☐ Digital Signature
	☐ Non Repudiation
	☐ Key Encipherment
	☐ Data Encipherment
	☐ Key Agreement
	☐ Key Cert Sign
	☐ CRL Sign
	☐ Encipher Only
	☐ Decipher Only
	Extended Key Usage
Owner	
Last Update Datetime	



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

Modify Key Wrapper

Key Wrapper **Permissions**

Modify Key Wrapper

Key Source	Hardware Security Module ▾
Module	utimaco ▾
Token	CryptoServer PKCS11 Token ▾
Key	hsmkey01 ▾



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

Find Key Wrapper

Find Key Wrapper

Name Type **Asymmetric** Active ☐ CA

▼ More Options

Find **Reset** **Add**

	Name	Type	Key Source Type	Active	Status	CA	Subject DN	Issuer DN	Effective Datetime	Expiry Datetime	Last Update Datetime
1	hsmkey01	Asymmetric	Hardware Security Module	☒	Valid	☐	CN=hsmkey01	CN=hsmkey01	2024-07-30 10:44:26 -0700	2044-07-25 10:44:26 -0700	2024-07-30 10:44:29 -0700

1-4 of 4

The new key can be found on the GP HSM as an object using the

`p11tool2`

tool.

```
[root@cassf156 ~]# /opt/utimaco/bin/p11tool2 slot=0 LoginUser=1234567890 ListObjects

CKO_CERTIFICATE:
+ 1.1
  CKA_CERTIFICATE_TYPE      = CKC_X_509
  CKA_UNIQUE_ID             = DA7F0FD0-2278-4DC1-8677-4C78047E95FB
  CKA_LABEL                 = hsmkey01
  CKA_ID                   = 0x68736D6B 65793031 (hsmkey01)
  CKA_SUBJECT               =
    0x30133111 300F0603 5504030C 0868736D |0 1 0   U   hsm|
    6B657930 31          |key01   |

CKO_PRIVATE_KEY:
+ 2.1
  CKA_KEY_TYPE              = CKK_RSA
  CKA_UNIQUE_ID             = 8EC8F145-A68E-454A-AFE2-291CE5FB4EE3
  CKA_SENSITIVE              = CK_FALSE
  CKA_EXTRACTABLE           = CK_TRUE
  CKA_LABEL                 =
  CKA_ID                   = 0x68736D6B 65793031 (hsmkey01)
```

4.4.3 Bloombase StoreSafe Data-at-Rest Encryption for SMB Configuration

Physical storage namely

smb01

is configured to be secured by Bloombase StoreSafe using encryption.

Modify Storage Configuration

Physical Storage**Permissions**

Physical Storage Configuration

Name	smb01		
Description			
Physical Storage Type	Remote ▾		
Type	Common Internet File System (CIFS) ▾		
Host	storage01		
Share Name	smb01		
Read Size	65536	bytes	
Write Size	65536	bytes	
Mount Hard	☐		
User	user01		
Password			
Options			
Virtual Storage	smb01		
Owner	admin		
Last Update Datetime	2021-07-22 08:32:00 -0700		

Submit**Delete****Close**



Virtual storage namely

smb01

of type

File

is created to virtualize physical storage

smb01

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

Modify Virtual Storage

Virtual StorageProtectionAccess ControlPermissions

Modify Virtual Storage

Name	smb01
Status	☒
Description	
Active	☒
Mode	File
Protocol	SMB
Owner	admin
Last Update Datetime	2021-07-22 04:33:45 -0700

Settings

Offline Setting **Disabled** ▼

Physical Storage

Storage	smb01 🔍 ⚙️
Description	
Physical Storage Type	Remote
Type	cifs
Host	storage01
Share	smb01

Submit**Delete****Status****Close**



Protection type is specified as

Privacy

and secure the Microsoft Storage Server storage backend using

AES 256-bit

encryption and encryption key

hsmkey01

managed at u.trust GP HSM.

Modify Virtual Storage Handler

Virtual Storage

Protection

Access Control

Permissions

Virtual Storage Protection

Protection Type

Privacy

Encryption Keys

		Key Name	Last Update Datetime
1	☐	hsmkey01	2024-08-01 02:05:35 -0700

Add

Remove

Header

Protected ☒

Cryptographic Cipher

Cipher Algorithm

AES

Bit Length

256

CTR Mode ☒

Submit

Close



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 integration for user-password authentication and single sign-on.

Modify Virtual Storage Access Control

Virtual Storage Protection Access Control Permissions

User Access Control

Warning: Deny access will override allow access

Everybody ☐ Read ☐ Write
☐ Deny Read ☐ Deny Write

User Repository **Local**

		User	Access Control List	Deny Access Control List	Warning	Last Update Datetime
1	☐	user01	☒ Read ☒ Write	☐ Deny Read ☐ Deny Write		2021-07-22 04:33:45 -0700

Add Remove

More Options

Refresh Submit Close

4.4.4 Bloombase StoreSafe Data-at-Rest Encryption for NFS Configuration

Physical storage namely

nfs01

is configured to be secured by Bloombase StoreSafe using encryption.

Modify Storage Configuration

Physical Storage | Permissions

Physical Storage Configuration

Name	nfs01		
Description			
Physical Storage Type	Remote ▾		
Type	Network File System (NFS) ▾		
Host	storage01		
Share Name	nfs01		
Read Size	65536	bytes	
Write Size	65536	bytes	
Synchronous	☐		
Mount Hard	☐		
Options	vers=4.1		
Virtual Storage	nfs01		
Owner	admin		
Last Update Datetime	2021-07-23 04:47:41 -0700		

Submit **Delete** **Close**



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.

Modify Virtual Storage

Virtual Storage

Protection

Access Control

Permissions

Modify Virtual Storage

Name	nfs01
Status	☒
Description	
Active	☒
Mode	File
Protocol	NFS
Owner	admin
Last Update Datetime	2021-07-22 09:55:37 -0700

Settings

Offline Setting Disabled

Physical Storage

Storage	nfs01
Description	
Physical Storage Type	Remote
Type	nfs
Host	storage01
Share	nfs01

Submit

Delete

Status

Close



Protection type is specified as

Privacy

and secure the Microsoft Storage Server storage backend using

AES 256-bit

encryption and encryption key

hsmkey01

managed at u.trust GP HSM.

Modify Virtual Storage Handler

Virtual Storage

Protection

Access Control

Permissions

Virtual Storage Protection

Protection Type

Privacy

Encryption Keys

		Key Name	Last Update Datetime
1	☐	hsmkey01	2024-08-01 02:05:35 -0700

Add

Remove

Header

Protected ☒

Cryptographic Cipher

Cipher Algorithm

AES

Bit Length

256

CTR Mode ☒

Submit

Close



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

Modify Virtual Storage Access Control

Virtual Storage Protection Access Control Permissions

User Access Control

Everybody ☒ Read ☒ Write

NFS File System Object Attributes

Root Squash ☐
Weak Cache Consistency ☐
Default User Identifier
Default Group Identifier
Default Mode

Host Access Control

		Host	Access Control List	Security	Warning	Last Update Datetime
1	☐	192.168.23.157	☒ Read ☒ Write	sys		2024-08-01 02:30:50 -0700

Add Remove

Subnet Access Control

	Subnet	Access Control List	Security	Warning	Last Update Datetime
--	--------	---------------------	----------	---------	----------------------

Add Remove

More Options

Refresh Submit Close

4.4.5 Bloombase StoreSafe Data-at-Rest Encryption for iSCSI Configuration

Physical storage namely

`iscsi01`

is configured to be secured by Bloombase StoreSafe using encryption.

Modify Storage Configuration

Physical Storage | Permissions

Physical Storage Configuration

Name	iscsi01		
Description			
Physical Storage Type	Device		
Block I/O	☒		
Multipath	☐		
Device ID [max 8 chars]	11		
Options			
Device	60003ff44dc75adc919e979aaaf58040  		
Virtual Storage	iqn.2012-07.com.bloombase:iscsi01		
Owner	admin		
Last Update Datetime	2021-07-23 11:53:49 -0700		



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.

Modify Virtual Storage

Virtual StorageProtectionAccess ControliSCSIPermissions

Modify Virtual Storage

Nameiqn.2012-07.com.bloombase:iscsi01

Status☒

Description

Active☒

ModeiSCSI

Tape Library☐

ATS☐

Cluster☐

Vendor

Model

Revision

Owneradmin

Last Update Datetime2021-07-23 11:54:59 -0700

Physical Storage

		Storage	Description	Device
1	☐	iscsi01		60003ff44dc75adc919e979aaaf58040

AddRemove

SubmitDeleteStatusClose

Protection type is specified as

Privacy

and secure the Microsoft Storage Server storage backend using

AES XTS 256-bit

encryption and encryption key

hsmkey01

managed at u.trust GP HSM.

Modify Virtual Storage Handler

Virtual Storage

Protection

Access Control

iSCSI

Permissions

Virtual Storage Protection

Protection Type

Privacy

Encryption Keys

		Key Name	Last Update Datetime
1	☐	hsmkey01	2024-08-02 00:45:46 -0700

Remove

Cryptographic Cipher

Cipher Algorithm

AES XTS

Bit Length

256

SubmitClose



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

Modify Virtual Storage Access Control

Virtual Storage Protection Access Control iSCSI Permissions

Allowed Portal

Portal IP

Add **Remove**

Incoming Users

User	Warning	Last Update Datetime
------	---------	----------------------

Add **Remove**

Initiators

Initiator	Alias	Warning	Last Update Datetime
1 ☐ iqn.1991-05.com.microsoft:windows11			2021-07-23 12:19:08 -0700

Add **Remove**

Refresh **Alias** **Submit** **Close**

▼ List Initiators

4.4.6 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.

Modify Storage Configuration

Physical Storage**Permissions**

Physical Storage Configuration

Name	nvme01
Description	
Physical Storage Type	Block ▼
Device ID	1816d452-ac0d-49c2-9de0-d378f0cff5d6
Options	
Device	d9395873-b937-4139-8911-07c347c447c0 🔍 ↗
Virtual Storage	nqn.2022-06.io.storesafe:nvme01
Owner	admin
Last Update Datetime	2022-10-04 12:16:40 -0700

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

Modify Virtual Storage

**Virtual
Storage****Protection****Access
Control****Permissions**

Modify Virtual Storage

Name	nqn.2022-06.io.storesafe:nvme01
Status	☒
Description	
Active	☒
Mode	NVMe
Model	
Serial Number	
Owner	admin
Last Update Datetime	2022-10-05 10:03:21 -0700

Physical Storage

	Storage	Description	Device
1	☐ nvme01		d9395873-b937-4139-8911-07c347c447c0

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

Modify Virtual Storage Handler

Virtual Storage Protection Access Control Permissions

Virtual Storage Protection

Protection Type **Privacy** ▾

Encryption Keys

		Key Name	Last Update Datetime
1	☐	hsmkey01	2024-05-24 05:09:46 +0000

Remove

Cryptographic Cipher

Cipher Algorithm **AES XTS** ▾

Bit Length **256** ▾

Submit **Close**



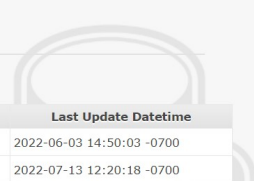
Add clients' NVMe Qualified Name (NQN) that can access Bloombase StoreSafe virtual storage.

Modify Virtual Storage Access Control

Virtual Storage Protection **Access Control** Permissions

Initiators

		Initiator	Alias	Warning	Last Update Datetime
1	☐	nqn.2014-08.org.nvmexpress:uuid:cf2eae42-6537-4891-85c2-77bbff4598b8			2022-06-03 14:50:03 -0700
2	☐	nqn.2014-08.org.nvmexpress:uuid:98c22f42-0694-af6d-1b5b-6d7b4ea9944d			2022-07-13 12:20:18 -0700



Start Bloombase StoreSafe virtual storage.

Virtual Storage Status

Virtual Storage

Name	nqn.2022-06.io.storesafe:nvme01
Status	☒
Active	☒
Type	NVMe

Physical Storage

Name	nvme01
Type	Unknown

Active Share Status

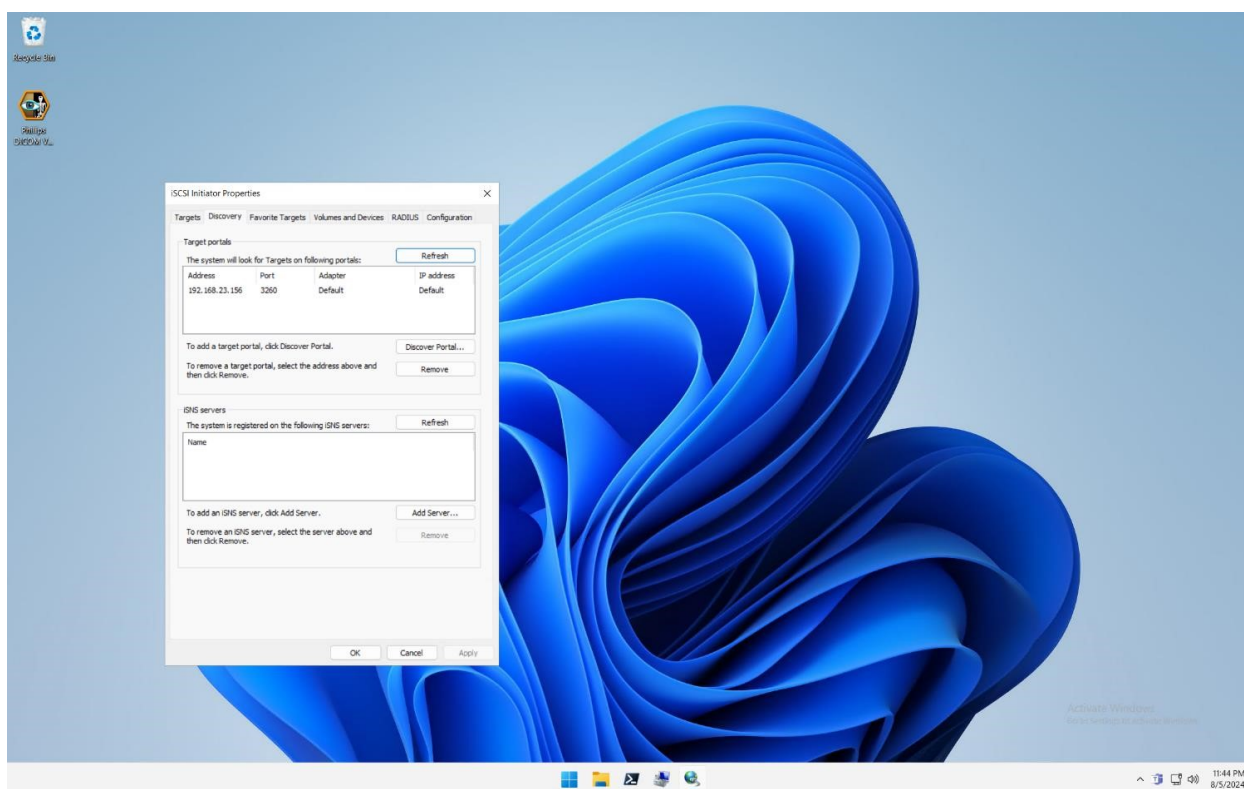
Share Name	nqn.2022-06.io.storesafe:nvme01
Storage Type	Unknown
Storage Path	Target : nqn.2022-06.io.storesafe:nvme01 LUN 1:[_SS_nvme33n1__];
Sessions	2 

[Refresh](#)[Stop](#)[Start](#)[Close](#)

4.5 Storage Clients

4.5.1 Microsoft Windows 11

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



4.5.2 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
```

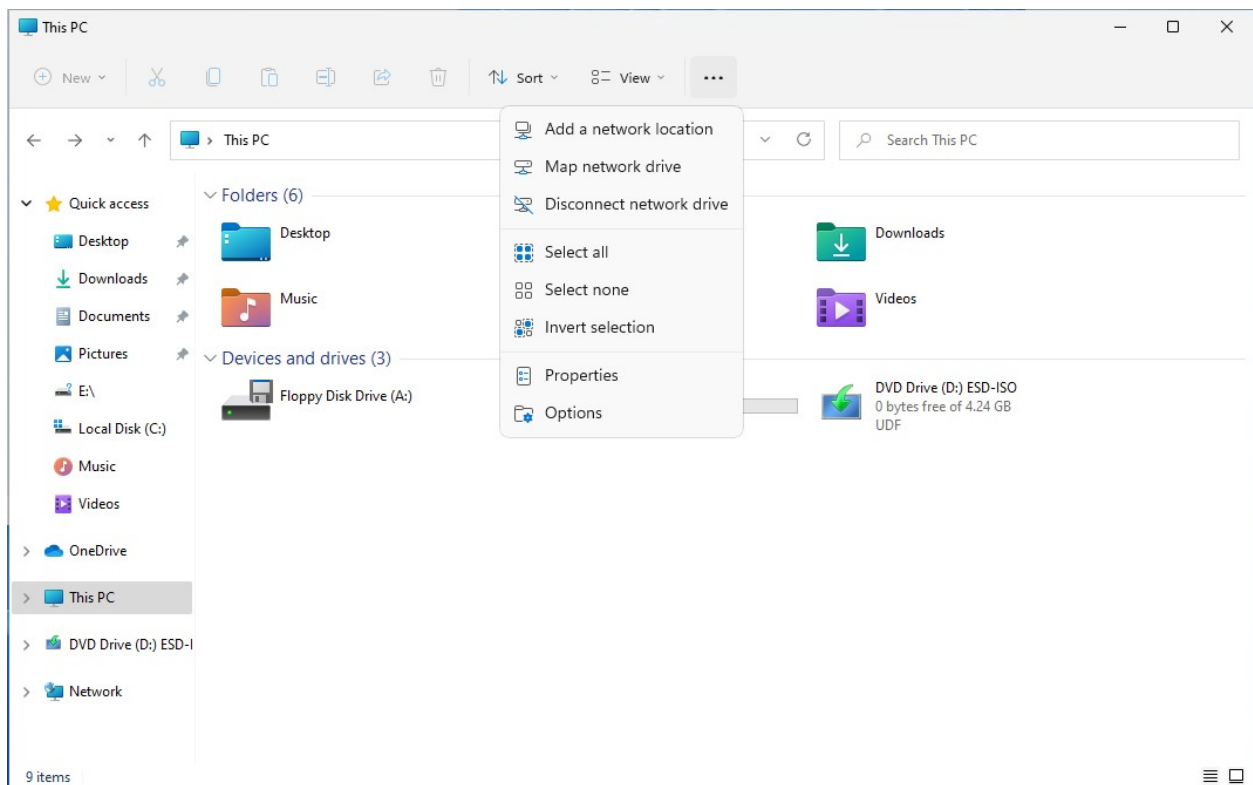
The client will need nvme initiator software installed.

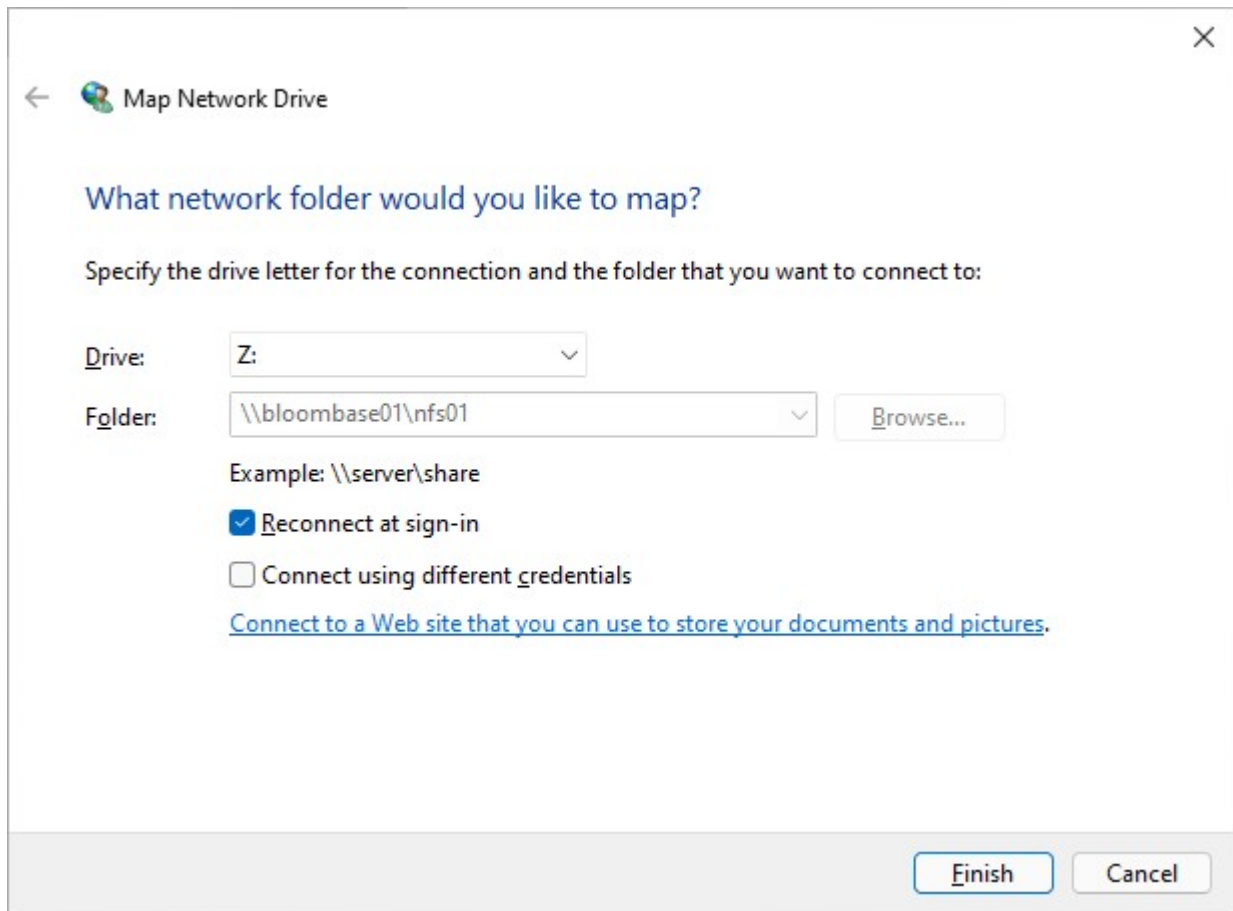
```
user@ubuntu68:~$ nvme --version
nvme version 1.16
```

5 Test Cases

5.1 Tests for Data-at-Rest Encryption over NFS

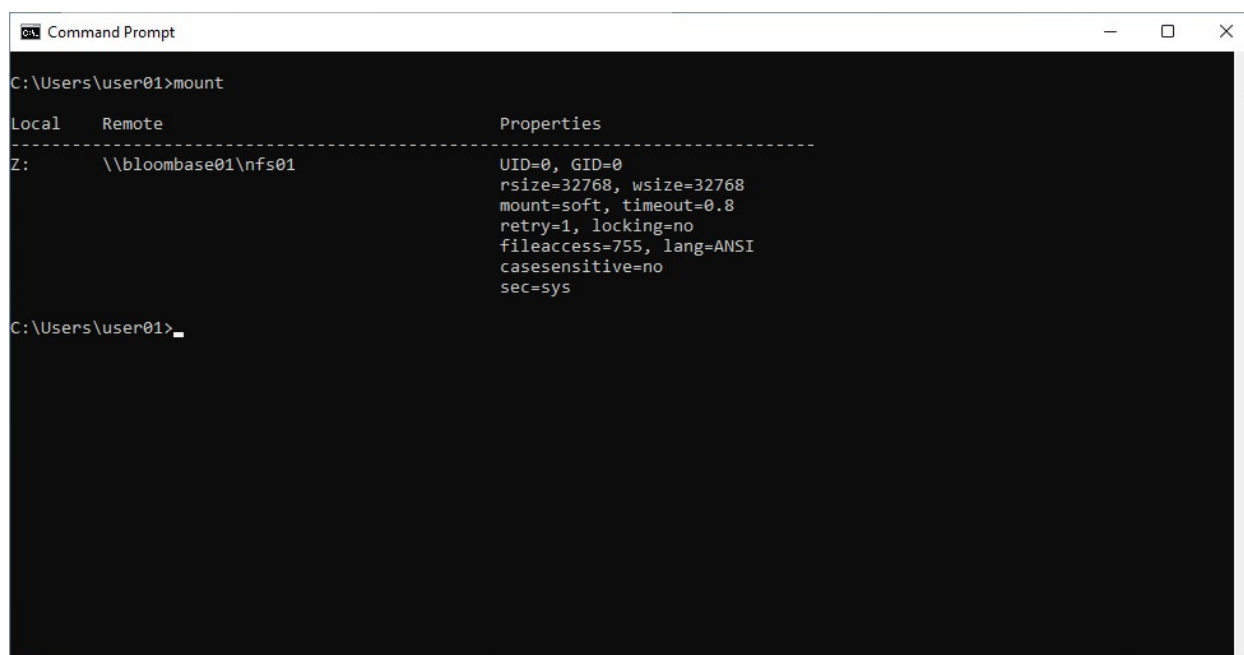
NFS shares are an example from the many protocols Bloombase StoreSafe supports for encryption. A share from a Windows Server 2025 system that is accessible by configure clients is created to act as backend storage. Bloombase StoreSafe creates a virtual encrypted share on its own hostname path that is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

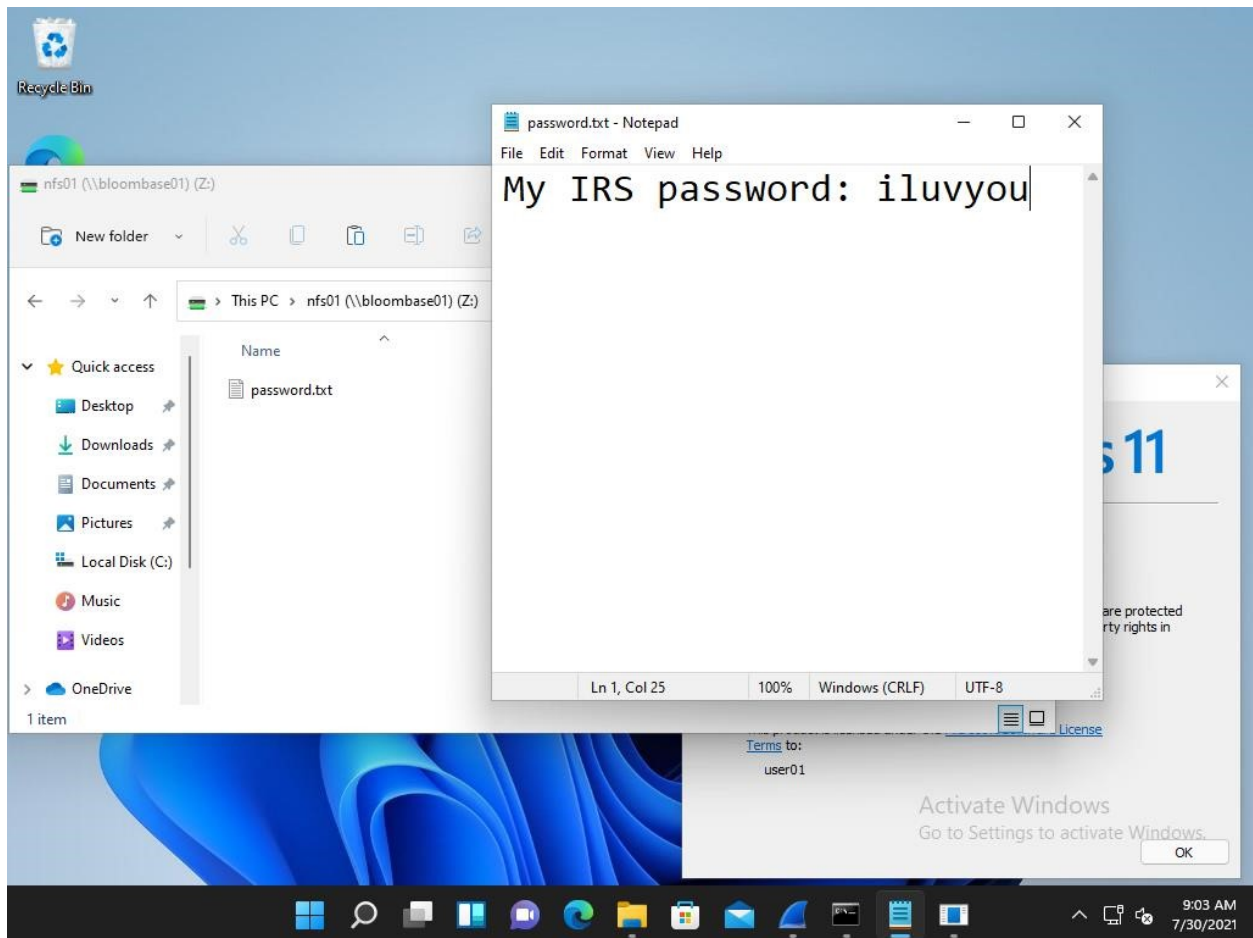


```
Command Prompt
C:\Users\user01>mount

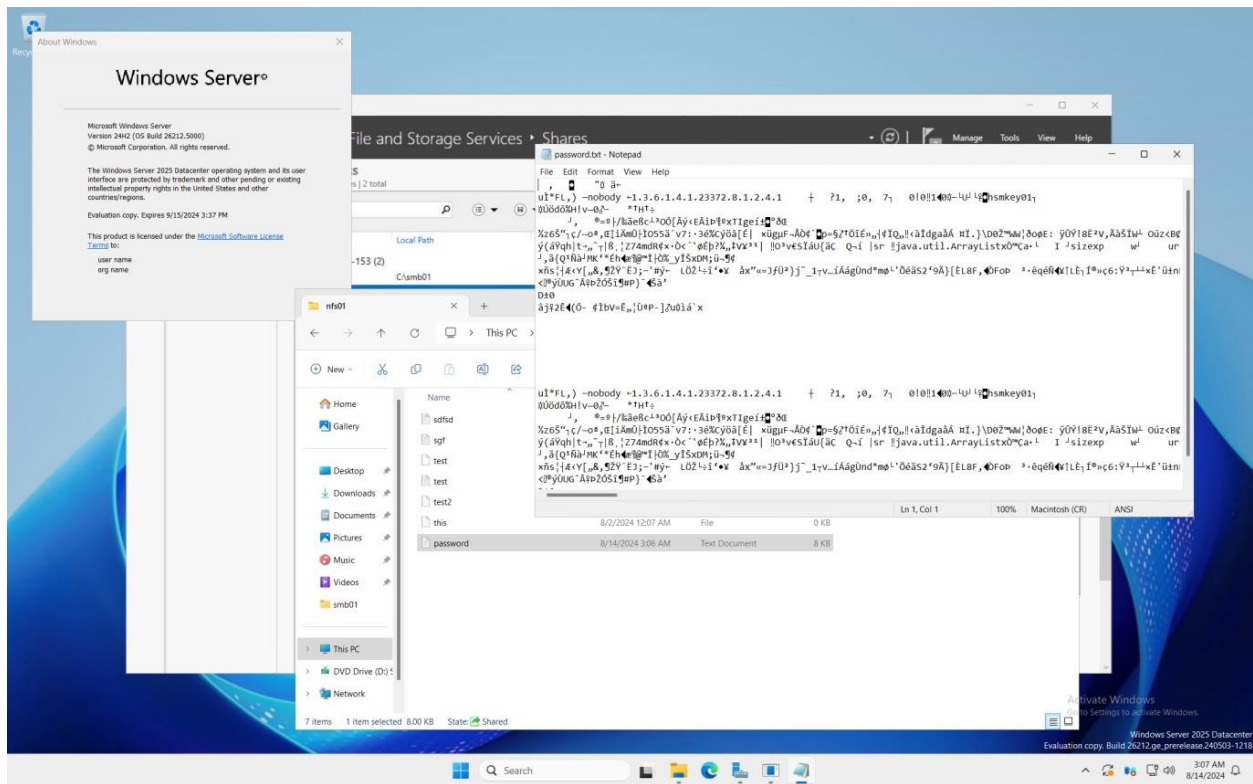
Local      Remote      Properties
-----
Z:         \\bloombase01\nfs01
           UID=0, GID=0
           rsize=32768, wsize=32768
           mount=soft, timeout=0.8
           retry=1, locking=no
           fileaccess=755, lang=ANSI
           casesensitive=no
           sec=sys

C:\Users\user01>
```

On the demo 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 and stored on the Microsoft Windows Server 2025 backend share.



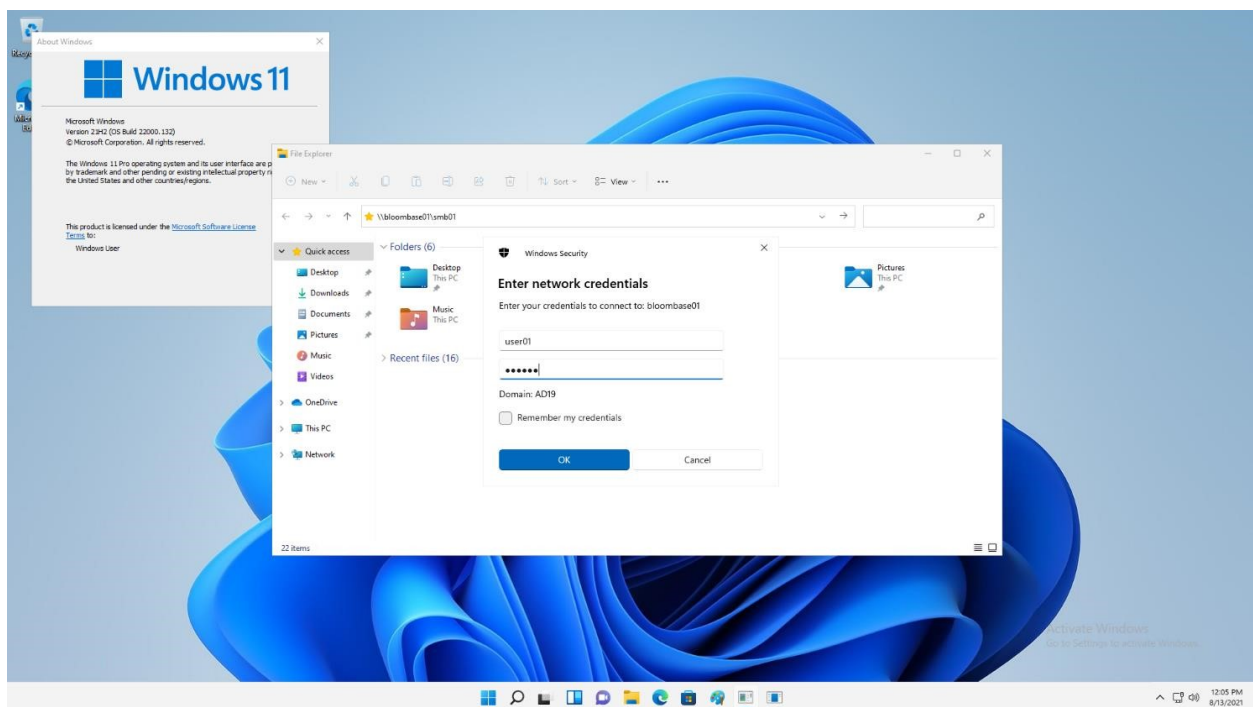
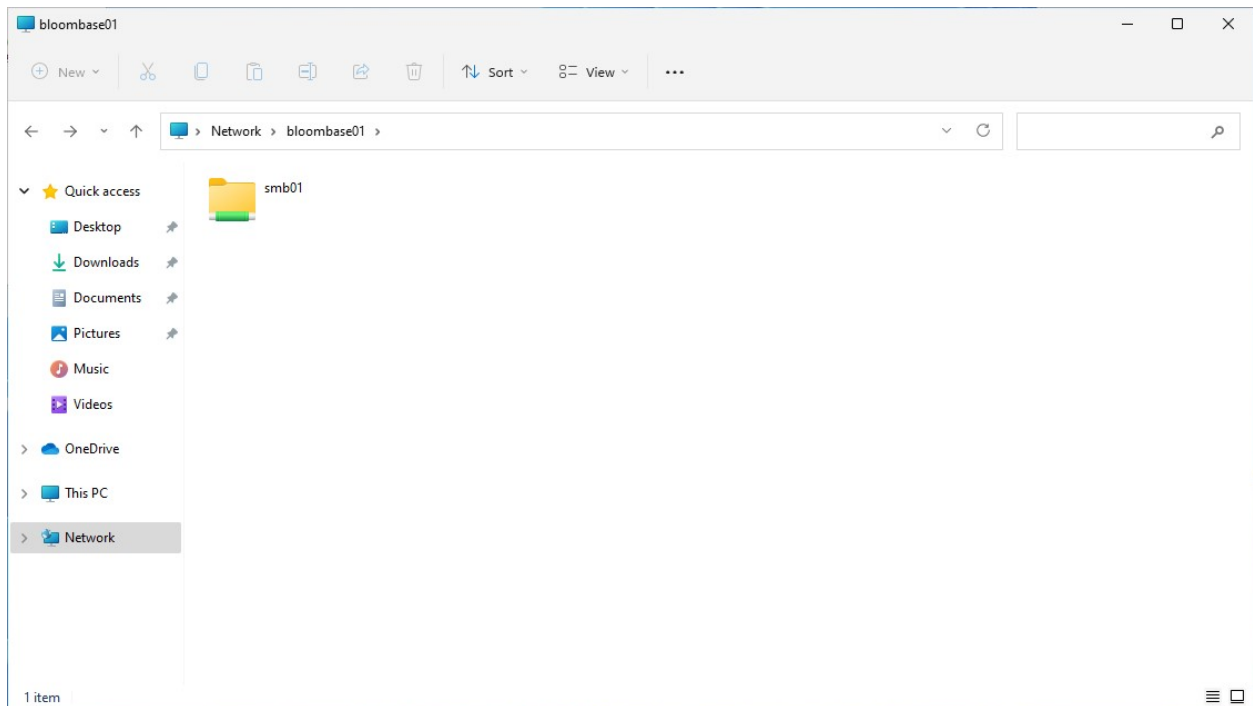
If the application data is attempted to be accessed directly on the backend without going through the Bloombase StoreSafe encryption engine, only ciphertext can be read as expected.



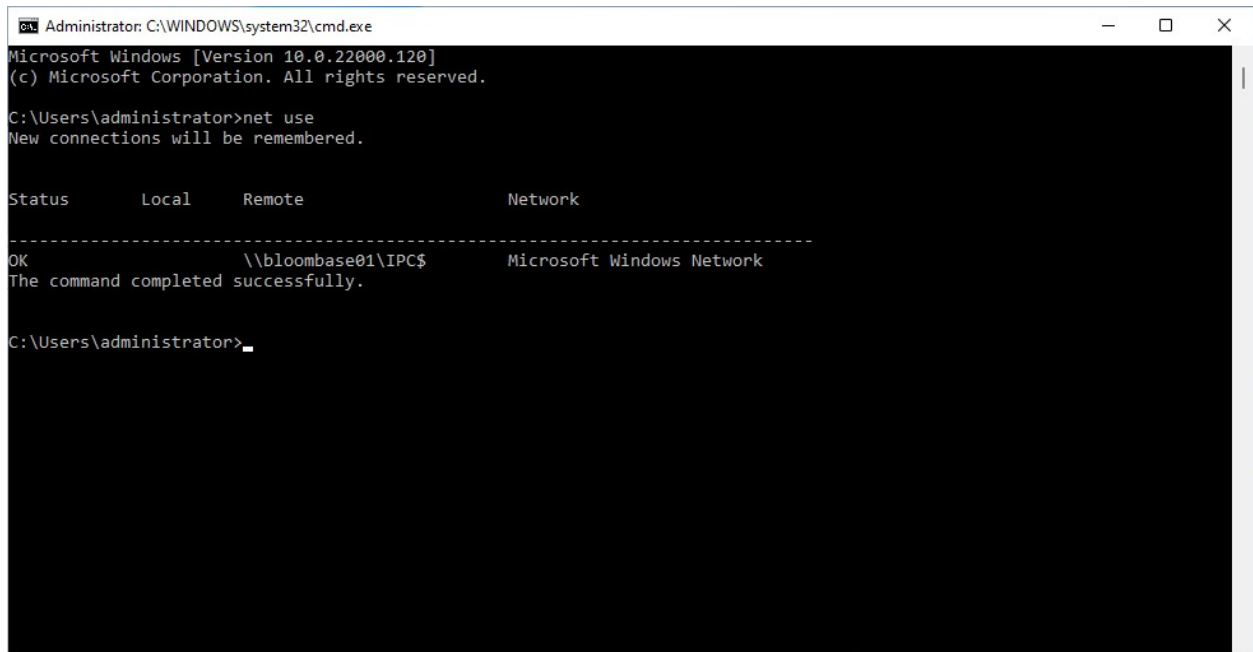
5.2 Tests for Data-at-Rest Encryption over SMB

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.



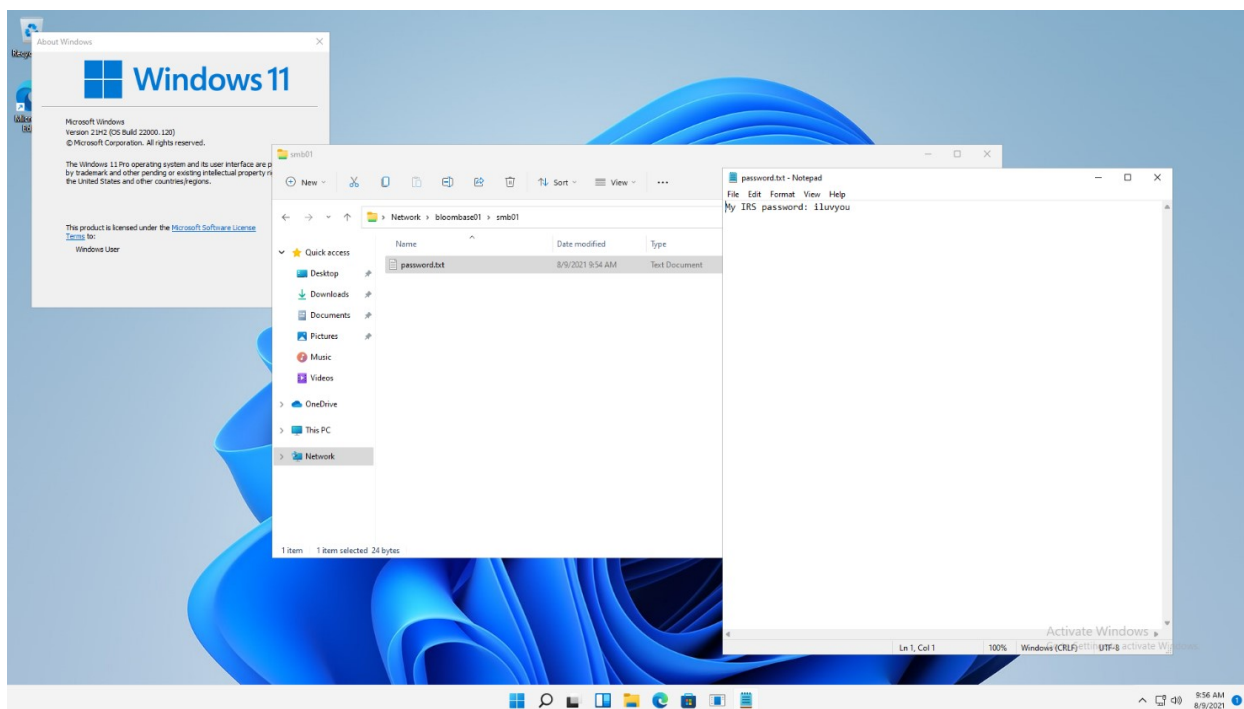
```
Administrator: C:\WINDOWS\system32\cmd.exe
Microsoft Windows [Version 10.0.22000.120]
(c) Microsoft Corporation. All rights reserved.

C:\Users\administrator>net use
New connections will be remembered.

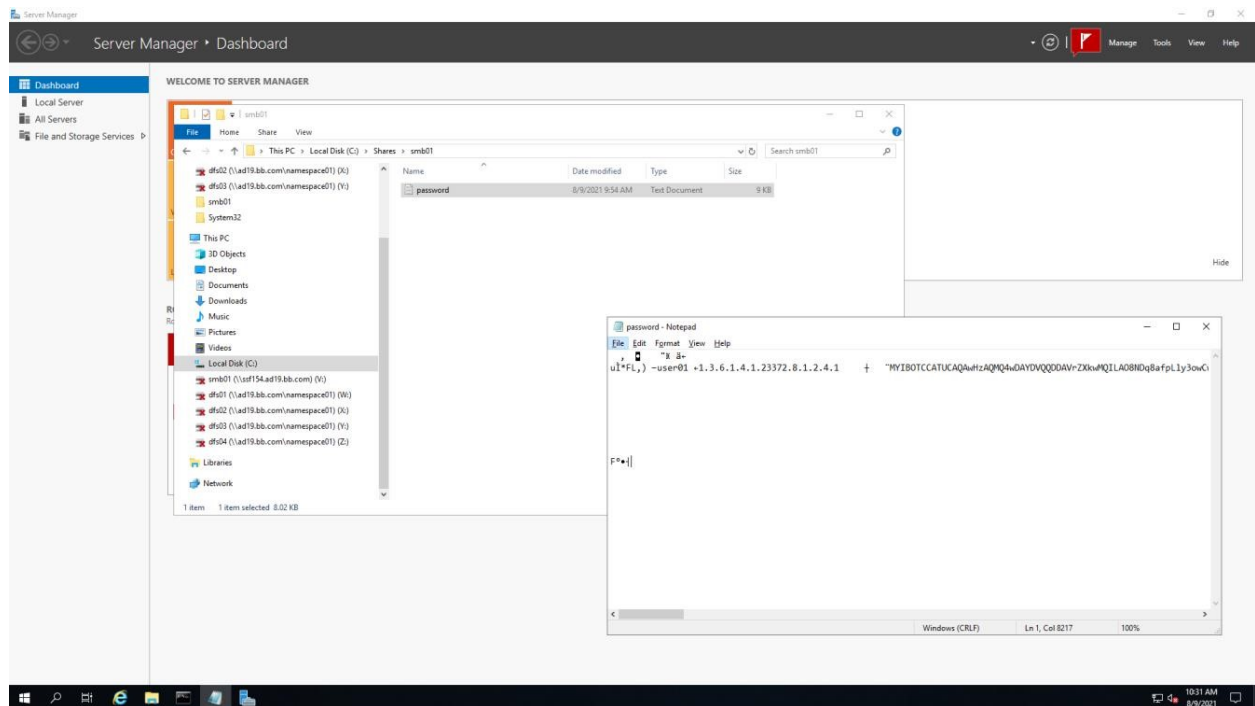
Status          Local          Remote          Network
-----
OK              \\bloombase01\IPC$  Microsoft Windows Network
The command completed successfully.

C:\Users\administrator>
```

On the demo 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 and stored on the Windows Server 2025 backend share.

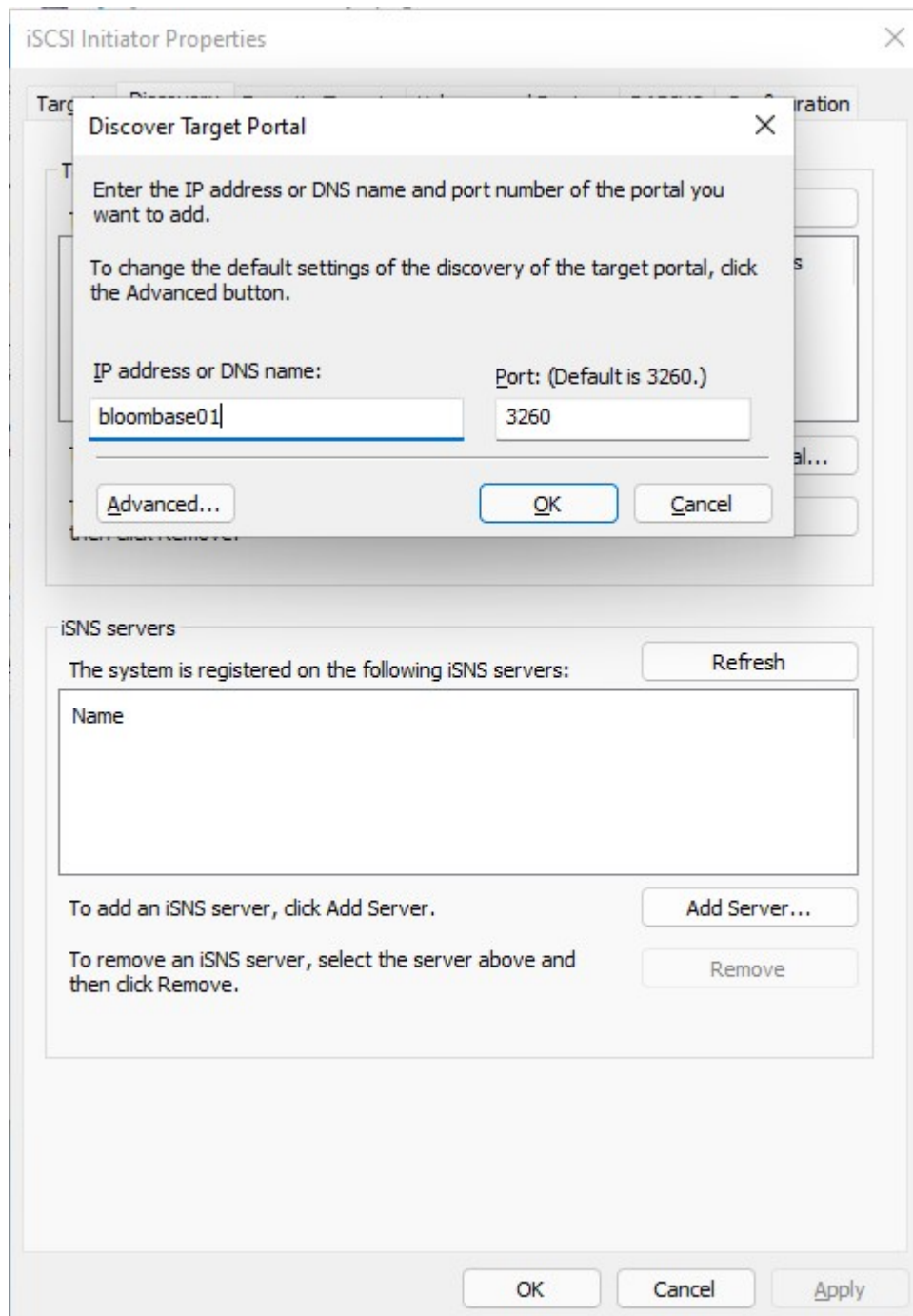


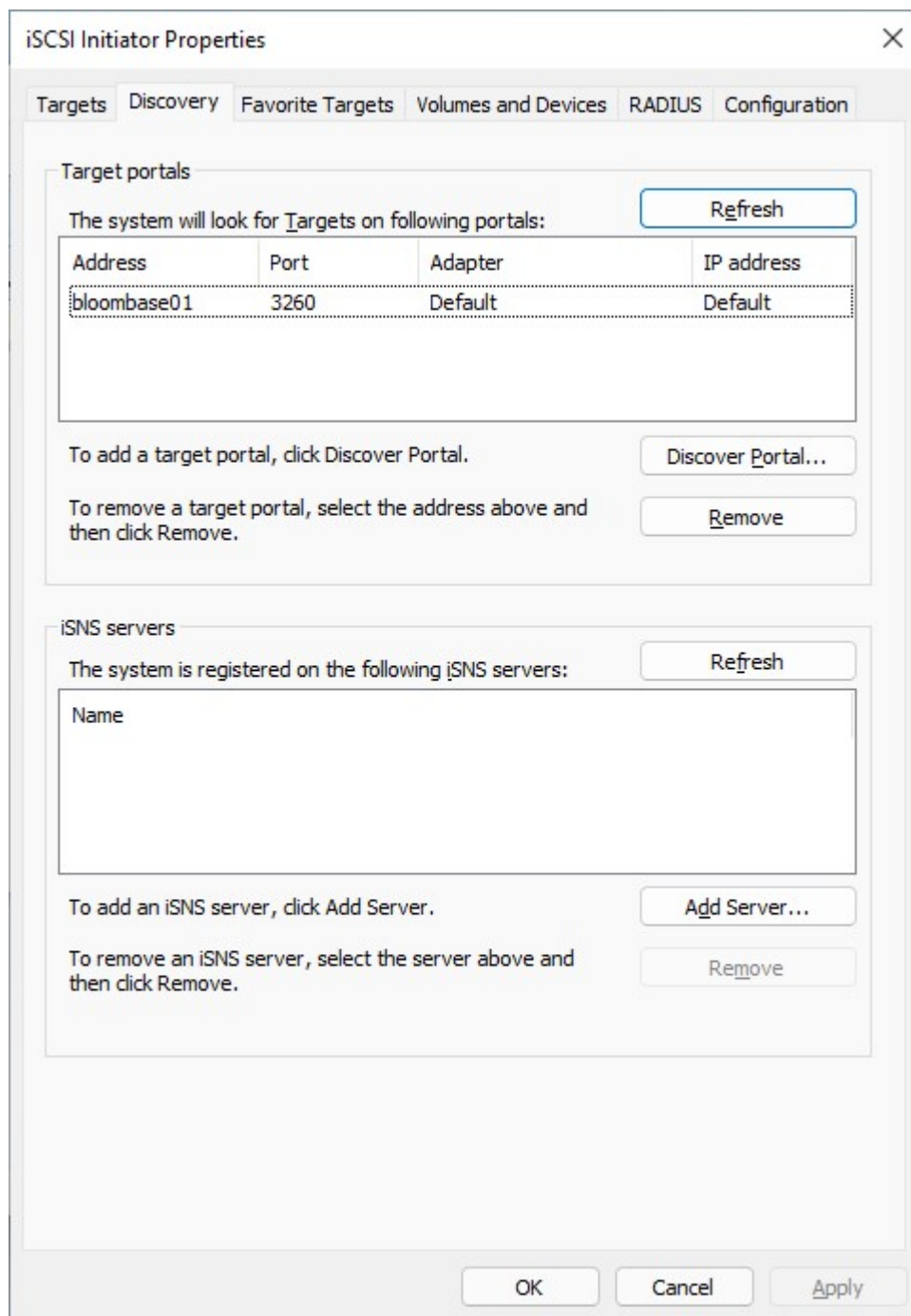
If the application data is attempted to be accessed directly on the backend without going through the Bloombase StoreSafe encryption engine, only ciphertext can be read as expected.



5.3 Tests for Data-at-Rest Encryption over iSCSI

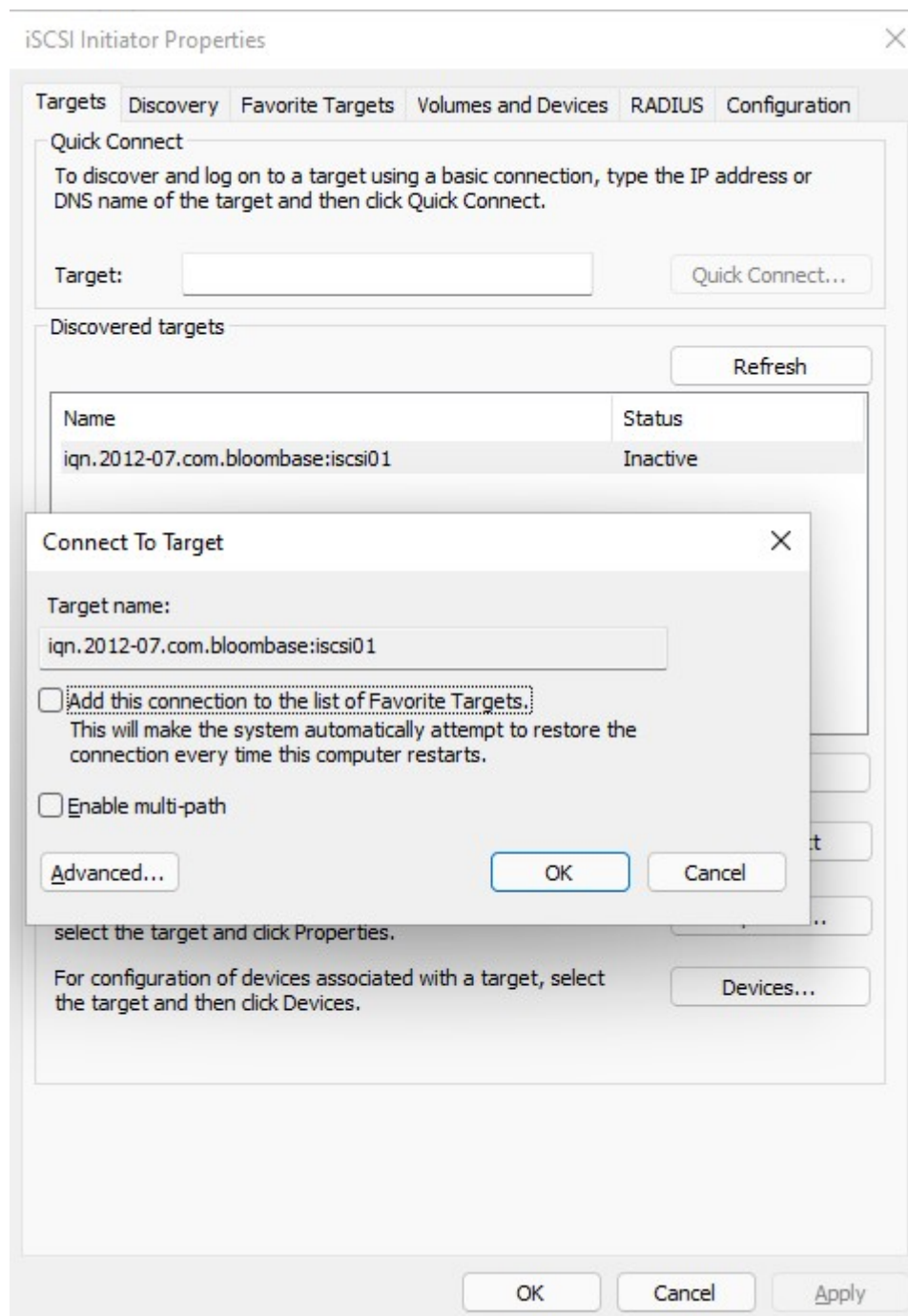
iSCSI targets are an example from the many protocols Bloombase StoreSafe supports for encryption. A target from a Microsoft Windows Server 2025 system that is accessible by configure clients is created to act as backend storage. Bloombase StoreSafe creates a virtual encrypted share on its own hostname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

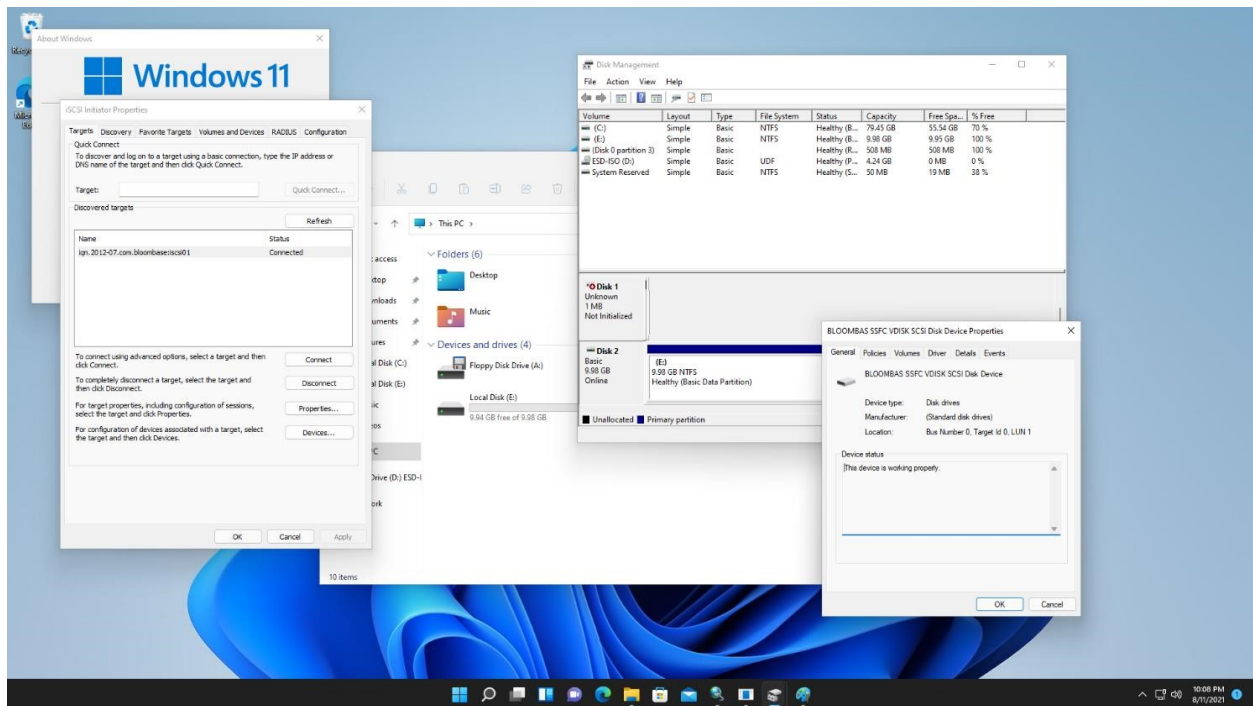




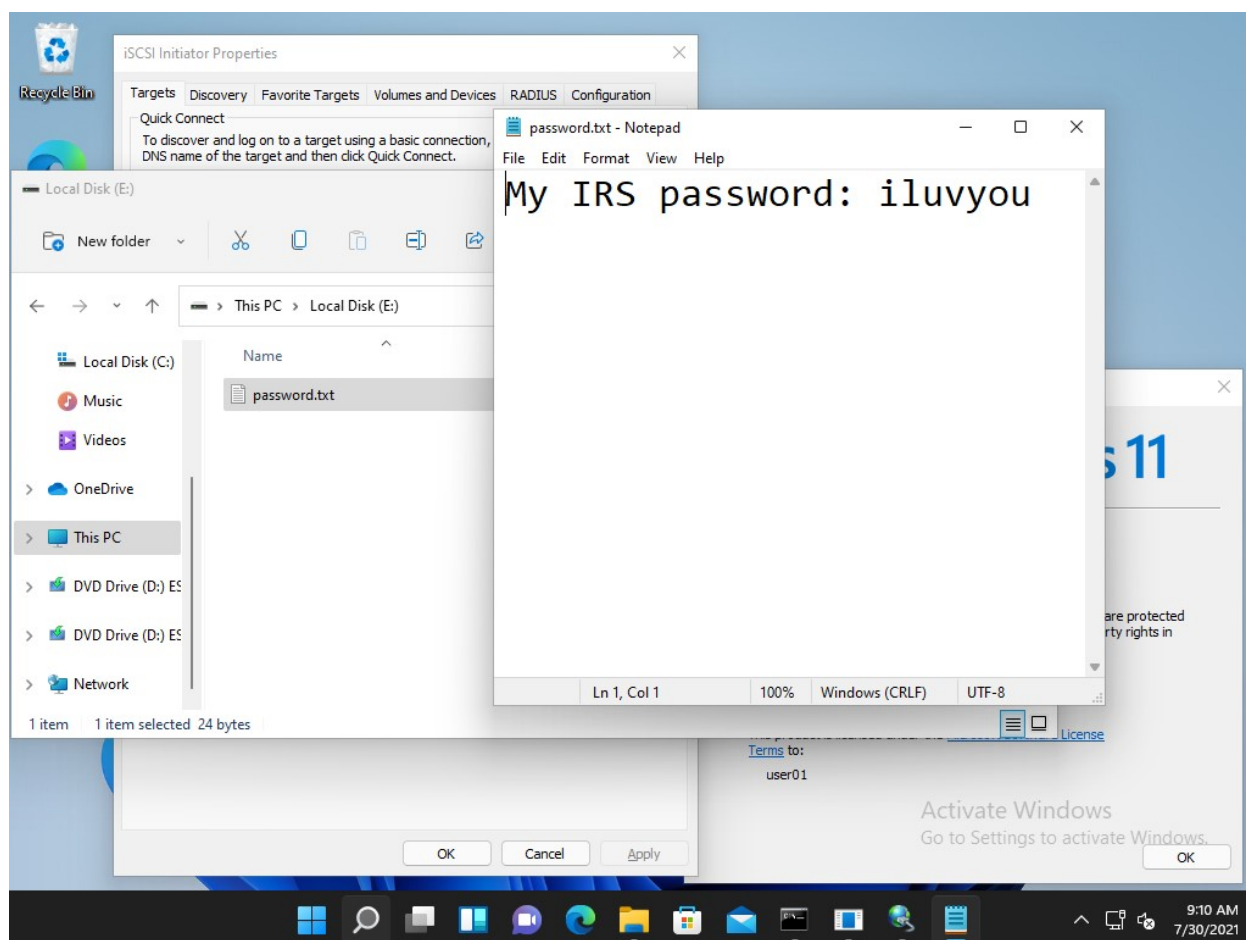
Microsoft Windows 11 clients can attach the virtual encrypted share with the default iSCSI initiator tool. Add the hostname and port to the discover tab, then connect to the iSCSI storage target presented by Bloombase StoreSafe Intelligent Storage Firewall. To access the Bloombase

StoreSafe iSCSI disk, make sure the client IQN is be added the Bloombase StoreSafe configuration. The disk will be mounted to the system and it can be formatted with a filesystem.





On the demo 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 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.

```
Administrator: Command Prompt

C:\Users\administrator.AD19\Downloads>hexdump.exe \iscsiVirtualDisks\iscsi-disk01.vhdx
00000000: 76 68 64 78 66 69 6C 65 - 4D 00 69 00 63 00 72 00 |vhdxfileM i c r|
00000010: 6F 00 73 00 6F 00 66 00 - 74 00 20 00 57 00 69 00 |o s o f t W i|
00000020: 6E 00 64 00 6F 00 77 00 - 73 00 20 00 31 00 30 00 |n d o w s 1 0|
00000030: 2E 00 30 00 2E 00 32 00 - 30 00 33 00 34 00 38 00 |. 0 . 2 0 3 4 8|
00000040: 2E 00 30 00 00 00 00 00 - 00 00 00 00 00 00 00 00 |. 0|
00000050: 00 00 00 00 00 00 00 00 - 00 00 00 00 00 00 00 00 |
*
00010000: 68 65 61 64 2A 71 DB FD - 0C 00 00 00 00 00 00 00 |head*q|
00010010: 41 5E F1 A0 04 CF 84 4A - AA 33 4E 98 5B 15 1C A8 |A^ J 3N [|
00010020: E7 E7 62 3E 18 A0 5B 40 - 9D 0A F9 B6 F2 9F FD ED |b> [ @|
00010030: 3A E1 8B AB F1 CE FD 48 - A6 66 B3 85 27 CD 36 7E |: H f ' 6~|
00010040: 00 00 01 00 00 00 10 00 - 00 00 10 00 00 00 00 00 |
00010050: 00 00 00 00 00 00 00 00 - 00 00 00 00 00 00 00 00 |
*
00020000: 68 65 61 64 5D ED 23 7F - 0D 00 00 00 00 00 00 00 |head] #|
00020010: 41 5E F1 A0 04 CF 84 4A - AA 33 4E 98 5B 15 1C A8 |A^ J 3N [|
00020020: E7 E7 62 3E 18 A0 5B 40 - 9D 0A F9 B6 F2 9F FD ED |b> [ @|
00020030: 3A E1 8B AB F1 CE FD 48 - A6 66 B3 85 27 CD 36 7E |: H f ' 6~|
00020040: 00 00 01 00 00 00 10 00 - 00 00 10 00 00 00 00 00 |
00020050: 00 00 00 00 00 00 00 00 - 00 00 00 00 00 00 00 00 |
*
00030000: 72 65 67 69 AE 8C 6B C6 - 02 00 00 00 00 00 00 00 |regi k|
00030010: 66 77 C2 2D 23 F6 00 42 - 9D 64 11 5E 9B FD 4A 08 |fw -# B d ^ J|
00030020: 00 00 30 00 00 00 00 00 - 00 00 10 00 01 00 00 00 |0|
00030030: 06 A2 7C 8B 90 47 9A 4B - B8 FE 57 5F 05 0F 88 6E | G K W_ n|
00030040: 00 00 20 00 00 00 00 00 - 00 00 10 00 01 00 00 00 |
00030050: 00 00 00 00 00 00 00 00 - 00 00 00 00 00 00 00 00 |
*
```

```
Administrator: Command Prompt

01418fd0: 1E 18 73 08 4E FA 13 3D - 95 59 BA D0 22 2B 8A EC | s N = Y "+|
01418fe0: FB 9C 8E 09 AA 4D B0 B6 - CF BE 68 D5 D2 77 87 30 | M k w 0|
01418ff0: 43 93 80 6C 4A 79 19 F3 - A4 4F 35 E4 AE D0 E3 6E |C l3y 05 n|
01419000: 4F 30 96 7C 32 4A 3B F1 - 58 F3 B8 E4 63 05 B4 26 |00 |2J; X c &|
01419010: 50 8C 42 75 B6 B5 DA 9B - BE 57 3C 14 C6 C1 F1 DE |P Bu Wk|
01419020: 1D 67 64 87 B7 AC A9 07 - 1F 1E EF DB 78 37 7F 98 |gd x7|
01419030: 2F 3B 4B 1C 8E 67 7C 37 - 1B 0B C5 7A 9C 87 E4 47 |/;K g|7 z G|
01419040: B0 E1 63 90 84 91 24 F5 - 8C 42 42 5F A1 8D B6 FF |c $ BB_|
01419050: 8F F2 3D 10 E1 33 5F EB - EC E3 44 E9 19 32 E4 7A | = 3_ D 2 z|
01419060: FC DC 3D 63 4A 47 22 71 - D6 C4 F4 47 31 EE B2 2E | =cJG"q G1 .|
01419070: 95 93 FF 79 A1 8F 16 AD - 65 B1 A8 FB 81 D1 7A C2 |y e z|
01419080: 7E 79 83 AD F9 91 49 34 - 78 C2 7C 38 A2 27 8F B7 |~y I4x |8 '|
01419090: 62 77 72 97 DA 1B 58 92 - E8 90 A5 54 69 73 32 A8 |bwr X Tis2|
014190a0: 5E 45 35 02 EC 83 A0 86 - 93 F3 47 08 00 23 A6 F7 |^E5 G #|
014190b0: EA F3 8C 4F 97 FA F3 18 - 39 EC A3 1A 7D 95 C5 49 | O 9 } I|
014190c0: B4 CE 1E 93 D1 E6 3F 82 - 1C 5D 05 D7 50 9A 2C 9B | ? ] P ,|
014190d0: 6F F8 4F 59 3E 36 82 9B - 14 6D A3 D7 7A 33 92 91 |o OY>6 m z3|
014190e0: 1D 63 8D 22 10 07 3B E9 - F6 72 1D 43 C2 47 5E 0D |c " ; r C G^|
014190f0: 77 3F E2 CA 65 BB C6 47 - 43 76 E7 EB 69 77 16 C2 |w? e GCv iw|
01419100: 66 30 1E 2D BD 3D FB A6 - 22 5B 19 5E D4 42 E1 F2 |f0 - = "[ ^ B|
01419110: BD FC 54 CB A1 04 0B 21 - 81 35 7C 93 33 8E B4 7F | T ! 5| 3|
01419120: 0D E5 5F 59 2C 93 99 3E - B2 42 C4 21 2B 29 2B 56 | _Y, > B !+)+V|
01419130: C7 CB CD AC 14 81 4B C7 - 4D 59 64 47 BD EB 32 09 | K MYdG 2|
01419140: 39 35 48 BD 4A 59 DF 4C - 83 C9 22 F4 F5 1D DE A5 |95H JY L "|
01419150: 26 35 95 61 E1 39 7C A1 - 68 4A 47 D2 EA 89 EC B5 |&5 a 9| hJG|
01419160: 40 A9 C7 3C 57 70 17 96 - 92 E4 67 93 BD 8E 6C 20 |@ <Wp g 1|
^C
C:\Users\administrator.AD19\Downloads>hexdump.exe \iscsiVirtualDisks\iscsi-disk01.vhdx | Findstr password
C:\Users\administrator.AD19\Downloads>
```

5.4 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:cf2eae42-6537-4891-85c2-77bbff4598b8
```

```
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:cf2eae42-6537-4891-85c2-77bbff4598b8 -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 110.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.

```
1/
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 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 ~]#
```

6 Conclusion

In this integration guide, we have shown how to set up Bloombase StoreSafe Intelligent Storage Firewall with u.trust GP HSM 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,

- u.trust GP HSM 4.80.0.0

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	u.trust GP HSM 4.80.0.0

7 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.

8 Acknowledgement

Bloombase InteropLab would like to thank Utimaco team for supporting the integration of Bloombase StoreSafe with u.trust GP HSM.

9 Reference

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