Microsoft SQL Server: Integration Guide

THALES LUNA HSM AND DPOD LUNA CLOUD HSM

Document Information

Document Part Number	007-011108-001
Revision	AT
Release Date	27 January 2022

Trademarks, Copyrights, and Third-Party Software

CONTENTS

Overview

This document contains instructions for integrating Microsoft SQL Server with Luna HSM devices or Luna Cloud HSM services. Microsoft SQL Server uses the Extensible Key Management (EKM) feature to enable the use of HSM devices for key storage and cryptographic operations such as key creation, deletion, encryption, and decryption. Luna HSM provides access to Luna EKM, including EKM provider library. To use the HSM devices with SQL server, you must configure the EKM provider option. You must have the basic knowledge of SQL Server and HSM concepts to make full use of the instructions in this document. Using Luna HSMs with Microsoft SQL Server provides the following benefits:

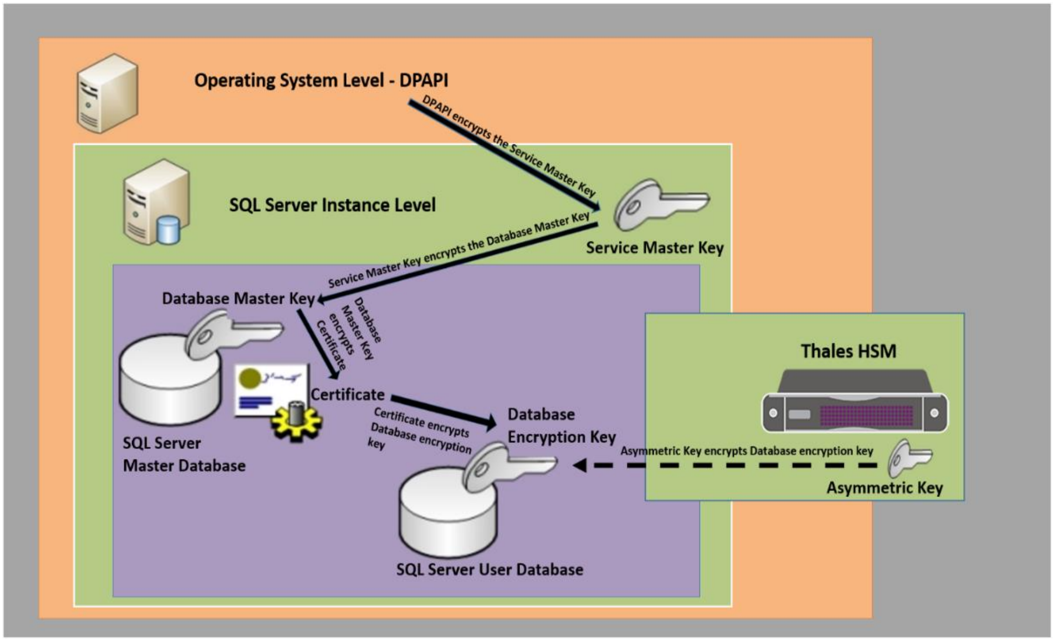
- Secure generation, storage and protection of the identity signing private key on FIPS 140-2 level 3 validated hardware.
- Full life cycle management of the keys.
- HSM audit trail*.
- Significant performance improvements by off-loading cryptographic operations from application servers

*Luna Cloud HSM service does not have access to the secure audit trail

Third Party Application Details

This integration uses the following third party applications:

Microsoft SQL Server


Operating System Level - DPAPI
DPAPI encrypts the Service Master Key
SQL Server Instance Level
Service Master Key
Service Master Key encrypts the Database Master Key
Database Master Key
Database Master Key encrypts Certificate
Certificate
SQL Server Master Database
Certificate encrypts Database encryption key
Database Encryption Key
Thales HSM
Asymmetric Key encrypts Database encryption key
Asymmetric Key
SQL Server User Database

Microsoft SQL Server is a database platform for large-scale online transaction processing (OLTP), data warehousing, and e-commerce applications. It is also a business intelligence platform for data integration, analysis, and reporting solutions. The above diagram shows the relationships between the database master key and the HSM in a Microsoft SQL configuration.

Microsoft SQL Server High Availability (Always On)

The Always On Availability group feature is a high-availability and disaster recovery solution that provides an enterprise-level alternative to database mirroring. An availability group supports a failover environment for a discrete set of user databases, known as availability databases that fail over together. An availability group supports a set of read-write primary databases and one to eight sets of corresponding secondary databases. Optionally, secondary databases can be made available for read-only access and/or some backup operations.

Certified Platforms

This integration is certified on the following platforms:

Luna HSM: Luna HSM appliances are purposefully designed to provide a balance of security, high performance, and usability that makes them an ideal choice for enterprise, financial, and government organizations. Luna HSMs physically and logically secure cryptographic keys and accelerate cryptographic processing. The Luna HSM on premise offerings include the Luna Network HSM, Luna PCIe HSM, and Luna USB HSMs. Luna HSMs are also available for access as an offering from cloud service providers such as IBM cloud HSM and AWS cloud HSM classic.

Platforms Tested	EKM Software Version	Microsoft SQL Server
Windows Server 2019+CU2 (KB4536075)	EKM v1.5 EKM v1.4	Microsoft SQL Server 2019
Windows Server 2016 Windows Server 2012 R2	EKM v1.4	Microsoft SQL Server 2017 Microsoft SQL Server 2016

> **NOTE:** This integration is tested in both HA and FIPS mode. SQL Server uses CKM_RSA_PKCS mechanism for encryption/decryption, which is now restricted in FIPS from firmware 7.7.2 onwards. This integration is not supported in FIPS mode for Luna HSM firmware 7.7.2 or above.

Luna Cloud HSM: Luna Cloud HSM platform provides on-demand, cloud-based HSM and Key Management services through a simple graphical user interface. With Luna Cloud HSM, security is simple, cost effective and easy to manage because there is no hardware to buy, deploy and maintain. As an Application Owner, you click and deploy services, generate usage reports and maintain just the services you need.

Platforms Tested	EKM Software Version	Microsoft SQL Server
Windows Server 2019+CU2 (KB4536075)	EKM v1.5	Microsoft SQL Server 2019
Windows Server 2016	EKM v1.4	Microsoft SQL Server 2017 Microsoft SQL Server 2016

> **NOTE:** SQL Server uses CKM_RSA_PKCS mechanism for encryption which is not allowed by Luna Cloud HSM in FIPS mode. Therefore, SQL Server integration with Luna Cloud HSM will work in Non-FIPS mode only.

Prerequisites

Before you proceed with the integration, complete the following tasks:

Configuring Luna HSM

If you are using Luna HSM:

1. Verify the HSM is set up, initialized, provisioned and ready for deployment.
2. Create a partition that will be later used by SQL Server.
3. If using a Luna Network HSM, register a client for the system and assign the client to the partition to create an NTLS connection. Initialize the Crypto Officer and Crypto User roles for the registered partition.
4. Ensure that the partition is successfully registered and configured. The command to see the registered partitions is:

   ```
   C:\Program Files\SafeNet\LunaClient>lunacm.exe

   lunacm.exe (64-bit) v10.3.0-273. Copyright (c) 2020 SafeNet. All rights
   reserved.

   Available HSMs:

       Slot Id ->                  0

       Label ->                    SQL

       Serial Number ->            1238696044952

       Model ->                    LunaSA 7.4.0

       Firmware Version ->         7.4.0

       Configuration ->            Luna User Partition With SO (PW) Key Export With
       Cloning Mode

       Slot Description ->         Net Token Slot

       FM HW Status ->             Non-FM
   ```

5. For PED-authenticated HSM, enable partition policies 22 and 23 to allow activation and auto-activation.

   > **NOTE:** Refer to Luna HSM documentation for detailed steps on creating NTLS connection, initializing the partitions, and assigning various user roles.

Set up Luna HSM High-Availability

Refer to the Luna HSM documentation for HA steps and details regarding configuring and setting up two or more HSM boxes on host systems. You must enable the HAOnly setting in HA for failover to work so that if the primary goes down due to any reason, all calls automatically route to the secondary until the primary recovers and starts up.

Set up Luna HSM in FIPS Mode

> **NOTE:** This setting is not required for Universal Client. This setting is applicable only for Luna Client 7.x.

Under FIPS 186-3/4, the RSA methods permitted for generating keys are 186-3 with primes and 186-3 with aux primes. This means that RSA PKCS and X9.31 key generation is no longer approved for operation in a FIPS-compliant HSM. If you are using the Luna HSM in FIPS mode, you have to make the following change in the configuration file:

```
[Misc]
RSAKeyGenMechRemap=1
```

The above setting redirects the older calling mechanism to a new approved mechanism when Luna HSM is in FIPS mode.

Configure Luna Cloud HSM Service

You can configure Luna Cloud HSM Service in the following ways:

> Standalone Cloud HSM service using minimum client package

> Standalone Cloud HSM service using full Luna client package

> Luna HSM and Luna Cloud HSM service in hybrid mode

> **NOTE:** Luna Client v10.x or higher is required for configuring Luna HSM device and Luna Cloud HSM service in hybrid mode.

Standalone Cloud HSM service using minimum client package

To configure Luna Cloud HSM service using minimum client package:

1. Transfer the downloaded .zip file to your Client workstation using pscp, scp, or other secure means.
2. Extract the .zip file into a directory on your client workstation.
3. Extract or untar the appropriate client package for your operating system. Do not extract to a new subdirectory; place the files in the client install directory.

   ```
   [Windows]

   cvclient-min.zip
   ```

4. Run the **setenv** script to create a new configuration file containing information required by the Luna Cloud HSM service.

   ```
   [Windows]

   Right-click setenv.cmd and select Run as Administrator.
   ```

5. Run the **LunaCM** utility and verify the Cloud HSM service is listed.

Standalone Cloud HSM service using full Luna client package

To configure Luna Cloud HSM service using full Luna client package:

1. Transfer the downloaded .zip file to your Client workstation using pscp, scp, or other secure means.

2. Extract the .zip file into a directory on your client workstation.
3. Extract or untar the appropriate client package for your operating system. Do not extract to a new subdirectory; place the files in the client install directory.

   `[Windows]`

   `cvclient-min.zip`
4. Run the setenv script to create a new configuration file containing information required by the Luna Cloud HSM service.

   `[Windows]`

   `Right-click setenv.cmd and select Run as Administrator.`
5. Copy the server and partition certificates from the Cloud HSM service client directory to Luna client certificates directory:

   > **NOTE:** Skip this step, if using Luna Client v10.2 or higher.

   Cloud HSM Certificates:

   `server-certificate.pem`

   `partition-ca-certificate.pem`

   `partition-certificate.pem`

   LunaClient Certificate Directory:

   `[Windows default location for Luna Client]`

   `C:\Program Files\Safenet\Lunaclient\cert\`
6. Open the configuration file from the Cloud HSM service client directory and copy the XTC and REST section.

   `[Windows]`

   `crystoki.ini`
7. Edit the Luna Client configuration file and add the XTC and REST sections copied from Cloud HSM service client configuration file.
8. Change server and partition certificates path from step 5 in XTC and REST sections. Do not change any other entries provided in these sections.

   > **NOTE:** Skip this step, if using Luna Client v10.2 or higher.

   [XTC]

```
. . .
PartitionCAPath=<LunaClient_cert_directory>\partition-ca-certificate.pem
PartitionCertPath00=<LunaClient_cert_directory>\partition-certificate.pem
. . .

[REST]
. . .
SSLClientSideVerifyFile=<LunaClient_cert_directory>\server-certificate.pem
. . .
```

9. Edit the following entry from the Misc section and update the correct path for the plugins directory:

```
Misc]
PluginModuleDir=<LunaClient_plugins_directory>
```

```
[Windows Default]
```

```
C:\Program Files\Safenet\Lunaclient\plugins\
```

Save the configuration file. If you wish, you can now safely delete the extracted Cloud HSM service client directory.

10. Reset the ChrystokiConfigurationPath environment variable and point back to the location of the Luna Client configuration file.

[Windows]

In the Control Panel, search for "environment" and select Edit the system environment variables. Click Environment Variables. In both list boxes for the current user and system variables, edit ChrystokiConfigurationPath and point to the crystoki.ini file in the Luna client install directory.

11. Run the LunaCM utility and verify that the Cloud HSM service is listed.

> **NOTE:** Refer to the Luna Cloud HSM documentation for detailed steps for creating service, client, and initializing various user roles.

Luna HSM and Luna Cloud HSM service in hybrid mode

To configure Luna HSM and Luna Cloud HSM service in hybrid mode, follow the steps mentioned under the Standalone Cloud HSM service using full Luna client package section. In hybrid mode, both Luna and Cloud HSM service will be listed.

> **NOTE:** Luna Client v10.x or higher is required for configuring Luna HSM device and Luna Cloud HSM service in hybrid mode.

Luna Cloud HSM Service in FIPS mode

Luna Cloud HSM service operates in both FIPS and non-FIPS mode. If your organization requires non-FIPS algorithms for your operations, ensure you enable the Allow non-FIPS approved algorithms check box when configuring your Cloud HSM service. The FIPS mode is enabled by default. Refer to the Mechanism List in the SDK Reference Guide for more information about available FIPS and non-FIPS algorithms.

Set up Luna EKM

Install Luna EKM on the host system. A Windows-based installation program setup is provided to assist with the EKM installation interactively.

> **NOTE:** Luna EKM setup available for download from Thales support portal.
>
> DOC ID for EKM 1.5 is KB0023244.
>
> DOC ID for EKM 1.4 is KB0016274.
>
> DOC ID for EKM 1.3 is KB0014957.

> **NOTE:** In Luna EKM 1.5, there is added support for crypto-user of the partition. Crypto-user can perform read-only operations such as encryption or decryption
>
> **NOTE:** Luna EKM 1.5 support the silent installation, execute the command below to install the Luna EKM silently on your host system:
>
> ```
> msiexec.exe /i LunaEKM.msi /qn INSTALLLEVEL=101 /l* EKM.txt
> ```

Luna EKM includes a command line configuration utility `LunaEKMConfig` that is used to register the Luna EKM. This command line utility is available in the Luna EKM installation folder. `LunaEKMconfig` provides command to register slots, view slots, and to configure log settings. Run the following commands, available in `LunaEKMConfig`.

1. Register the slot to Luna EKM.

   ```
   RegisterSlot
   ```

2. View List of the Slots/HSM configured with this client.

   ```
   ViewSlots
   ```

3. Configure log settings for Luna EKM.

   ```
   LogSettings
   LogLevel (NONE=0,INFO=1,DEBUG=2): <LogLevel>
   LogFile name: <Name and location of LogFile>
   ```

Set up SQL Server

Install SQL Server on the target machine to complete the integration process. If you are configuring a high availability (Always ON) SQL server group, the SQL Server must be installed on all nodes and all nodes must have access to WFCS. Refer to the *Microsoft SQL Server Documentation* for detailed installation procedures.

Integrating Luna HSM with SQL Server

This document contains detailed instructions and procedures to integrate Microsoft SQL Server with a Luna HSM or Luna Cloud HSM service. This integration contains the following topics:

- Enable EKM Provider option
- Create and register Luna EKM Provider
- Set up CREDENTIAL for Luna EKM Provider
- Use Luna EKM Provider Option
- Enable Transparent Database Encryption using Asymmetric key on Luna HSM
- Rotate Keys for Transparent Database Encryption
- Migrate TDE from SQL EKM to Luna EKM
- Use Extensible Key Management on a SQL Server Failover Cluster

Enable EKM Provider option

To enable the EKM Provider option:

1. Open the SQL Server Management Studio.
2. Connect to the SQL Server.
3. Open a new query window and execute the following query:

> **NOTE:** The sp_configure command is supported on Enterprise, Developer, and Evaluation editions of SQL server. If you execute the command on an alternative version, you will receive an error.

```
sp_configure 'show advanced', 1
GO
RECONFIGURE
GO
sp_configure 'EKM provider enabled', 1
GO
RECONFIGURE
GO
```

Create and register Luna EKM Provider

To create and register the Luna EKM Provider:

1. Open the SQL Server Management Studio.
2. Connect to the SQL Server.
3. Open a new query window and execute the following command:

```
CREATE CRYPTOGRAPHIC PROVIDER <Name of Cryptographic Provider>
FROM FILE = '<Location of Luna EKM Provider Library>'
```

   Where `<Name of Cryptographic Provider>` can be any user defined unique name.

4. Verify the list of EKM providers:

```
SELECT [provider_id]
[name]
,[guid]
,[version]
,[dll_path]
,[is_enabled]
FROM [model].[sys].[cryptographic_providers]
```

5. Verify the provider properties:

```
SELECT [provider_id],[guid],[provider_version]
,[sqlcrypt_version]
,[friendly_name]
,[authentication_type]
,[symmetric_key_support]
,[symmetric_key_persistance]
,[symmetric_key_export]
```

```
,[symmetric_key_import]
,[asymmetric_key_support]
,[asymmetric_key_persistance]
,[asymmetric_key_export]
,[asymmetric_key_import]
FROM [master].[sys].[dm_cryptographic_provider_properties]
```

Set up CREDENTIAL for Luna EKM Provider

The next step is to create a CREDENTIAL for the Luna EKM Provider. The CREDENTIAL must map to the SQL Service Account or logged in user to use the Luna EKM Provider.

> **NOTE:** In Luna EKM 1.5, there is added support for crypto-user of the partition. The IDENTITY value must use the prefix "CU_" for crypto user. If no prefix is specified then crypto-officer role will be used by default for login to HSM partition.

To setup the CREDENTIAL for Luna EKM Provider

1. Open a query window and execute the following command:

   ```
   CREATE CREDENTIAL <Name of credential>
   WITH IDENTITY='<Name of EKM User>', SECRET='<HSM partition password>'
   FOR CRYPTOGRAPHIC PROVIDER LunaEKMProvider
   ```

   Where `CREDENTIAL` and `IDENTITY` can be any user defined unique name

   And `IDENTITY` must use prefix `"CU_"` for Crypto User.

   > **NOTE:** You cannot create/delete/rotate the keys on HSM using Credential associated with Crypto User. Only crypto operations can be performed by login mapped with Crypto User Credential.

   Create credential for crypto-officer (CO).

   ```
   CREATE CREDENTIAL EKMCredential
   WITH IDENTITY='EKMUser', SECRET='userpin1'
   FOR CRYPTOGRAPHIC PROVIDER LunaEKMProvider
   ```

   Create credential for crypto-user (CU).

   ```
   CREATE CREDENTIAL EKMCredential
   WITH IDENTITY='CU_EKMUser', SECRET='userpin2'
   FOR CRYPTOGRAPHIC PROVIDER LunaEKMProvider
   ```

2. Map the Credential with SQL Service Account or Login:

   ```
   ALTER LOGIN [Domain\Login Name]
   ADD CREDENTIAL <Name of Credential created>
   ```

   > **NOTE:** The EKM session must be reopened in case the user changes the credentials or HSM service, or the client machine is deleted from the service, or the machine suffers a network disconnection.

Use Luna EKM Provider Option

The Luna EKM provider is now ready to use, it can be used to create/drop symmetric and asymmetric keys to/from the Luna partition and can perform encryption/decryption using these keys. The following types of symmetric key can be created on Luna HSM from the SQL Server:

- AES_128
- AES_192
- AES_256

Create Symmetric Keys on Luna HSM

The following examples use AES algorithms. To test other algorithms, substitute `AES_256` with an alternate algorithm tag, as mentioned above.

To create the symmetric key using the Luna EKM Provider

Execute the following command from the SQL query window:

```
CREATE SYMMETRIC KEY SQL_EKM_AES_256_Key
FROM Provider LunaEKMProvider
WITH ALGORITHM = AES_256,
PROVIDER_KEY_NAME = 'EKM_AES_256_Key',
CREATION_DISPOSITION=CREATE_NEW
```

> **NOTE:** Once a key is created on the Luna HSM, it can be used or referred to by its name from the SQL Server. In the above test case, `SQL_EKM_ AES_256_Key` is the unique name of the key in the SQL Server. You can use this name for encrypt and decrypt operations.

To view symmetric key using the Luna EKM Provider

Execute the following command from the SQL query window:

```
SELECT * FROM [master].[sys].[symmetric_keys]
```

To encrypt a database table with symmetric keys using the Luna EKM Provider

Follow these steps to encrypt a database table with symmetric keys:

1. Create a test Table in the MASTER database with fields.

   ```
   Create Table test(
   id numeric(10),
   name varchar (50),
   data varchar (max),)
   ```

2. Execute the following command from the SQL query window:

   ```
   INSERT INTO dbo.test
   ```

```
values( 1,'some text',

EncryptByKey(Key_GUID('SQL_EKM_AES_256_Key'), 'text to be encrypted'))
```

To decrypt a database table with symmetric keys using the Luna EKM Provider

Execute the following command from the SQL query window:

```
SELECT id,name,CONVERT(varchar(MAX),

DecryptByKey(data))

FROM dbo.test where id =1
```

To drop symmetric keys using the Luna EKM Provider

Execute the following command from the SQL query window:

```
DROP SYMMETRIC KEY SQL_EKM_AES_256_Key REMOVE PROVIDER KEY
```

Create Asymmetric Keys on Luna HSM

The following types of asymmetric keys can be created on Luna HSM from the SQL Server:

- RSA_2048
- RSA_3072
- RSA_4096

The following examples use RSA_2048 algorithms for asymmetric key operation. To test other algorithms, substitute RSA_2048 with an alternate algorithm tag, as mentioned above.

To create the asymmetric key using the Luna EKM Provider

1. Execute the following command from the SQL query window:

   ```
   CREATE ASYMMETRIC KEY SQL_EKM_RSA_2048_Key
   FROM Provider LunaEKMProvider
   WITH ALGORITHM = RSA_2048,
   PROVIDER_KEY_NAME = 'EKM_RSA_2048_Key',
   CREATION_DISPOSITION=CREATE_NEW
   ```

   > **NOTE:** SQL Server does not implement FIPS 186-4. As a result, RSA key generation by SQL Server is not supported when HSM in FIPS Mode. The procedure to generate RSA Key when HSM in FIPS mode is given below.

   When using HSM in FIPS mode, open the command prompt and generate the key using CMU utility provided with the HSM Client:

   ```
   cmu generatekeypair -label EKM_RSA_2048_Key -modulusBits=2048 -publicExp=65537
   -sign=T -verify=T -encrypt=T -decrypt=T
   ```

   Map the key in SQL Server:

   ```
   CREATE ASYMMETRIC KEY SQL_EKM_RSA_2048_Key
   FROM Provider LunaEKMProvider
   WITH PROVIDER_KEY_NAME = 'EKM_RSA_2048_Key',
   CREATION_DISPOSITION=OPEN_EXISTING
   ```

> **NOTE:** Once a key is created on the Luna HSM, it can be used or referred by its name from the SQL Server. For example, in the above test case, `SQL_EKM_ RSA_2048_Key` is the unique name of the key in the SQL Server. This key name can be used on the HSM for encrypt and decrypt operations.

To view asymmetric keys using the Luna EKM Provider

Execute the following command:

```
SELECT * FROM [master].[sys].[asymmetric_keys]
```

To encrypt a database table with asymmetric keys using the Luna EKM Provider

1. Create a test Table in the MASTER database with fields:

   ```
   Create Table test(
   id numeric(10),
   name varchar (50),
   data varchar (max),)
   ```

2. Execute the following command from the SQL query window:

   ```
   INSERT INTO dbo.test
   values ( 1,'some text',
   EncryptByAsymKey (AsymKey_Id ('SQL_EKM_RSA_2048_Key'), 'text to be encrypted'))
   ```

To decrypt a database table with asymmetric keys using the Luna EKM Provider

Execute the following command from the SQL query window:

```
SELECT id, name, CONVERT (varchar (MAX),

DecryptByAsymKey (AsymKey_Id ('SQL_EKM_RSA_2048_Key'), data))

FROM dbo.test where id =1
```

To drop asymmetric keys using the Luna EKM Provider

Execute the following command from the SQL query window:

```
DROP ASYMMETRIC KEY SQL_EKM_RSA_2048_Key REMOVE PROVIDER KEY
```

Create Symmetric Key Encrypted by Asymmetric Key on Luna HSM

You can encrypt a symmetric keys using an asymmetric key. This increases the security of the symmetric key.

To create a symmetric key encrypted by an asymmetric key

1. Execute the following command from the SQL query window:

   ```
   Create SYMMETRIC KEY key1
   WITH ALGORITHM = AES_256
   ENCRYPTION BY Asymmetric Key SQL_EKM_RSA_2048_Key;
   ```

> **NOTE:** `SQL_EKM_RSA_2048_Key` is an existing asymmetric key on the Luna HSM. For more information about generating an asymmetric key, see Creating Asymmetric Keys on Luna HSM.

2. Before using the key, you need to open the key. Execute the following command to open the symmetric key:

```
OPEN SYMMETRIC KEY key1 DECRYPTION BY Asymmetric Key SQL_EKM_RSA_2048_Key;
```

> **NOTE:** For Microsoft SQL Server 2017, apply the patch as described in the Troubleshooting Tips section.

3. Create a test Table in the MASTER database with the following fields:

```
Create Table test(
id numeric(10),
name varchar (50),
data varchar (max),)
```

4. Encrypt the table data using the symmetric key:

```
INSERT INTO dbo.test
values ( 1,'some text',
Encryptbykey(KEY_GUID('key1'),'text to be encrypted'))
```

5. Decrypt the data using the symmetric key:

```
SELECT id,name,CONVERT(varchar(MAX),
DecryptByKey(data))
FROM dbo.test where id =1
```

6. Close the symmetric key:

```
CLOSE SYMMETRIC KEY key1
```

Enable Transparent Database Encryption using Asymmetric key on Luna HSM

You can enable Transparent Data Encryption (TDE) using an asymmetric key stored on a Luna HSM.

> **NOTE:** We have included support for creating higher length asymmetric keys: RSA_3072 and RSA_4096 from Luna EKM v1.3 onwards. However during our integration testing, we identified an issue in TDE when encrypting the DEK using RSA_4096 key. This issue has been reported to Microsoft technical support and we are awaiting a resolution. At this time, we recommend to use a maximum key length of RSA_3072 for the TDE. We will retest and update the integration guide when Microsoft resolves this issue.

> **NOTE:** Database encryption operations cannot be executed on 'master', 'model', 'tempdb', 'msdb', or 'resource' databases.

To enable TDE using asymmetric key on Luna HSM:

1. Create an asymmetric key using Luna EKM Provider.

```
Use master;
CREATE ASYMMETRIC KEY SQL_EKM_RSA_2048_Key_TDE
```

```
FROM Provider LunaEKMProvider
WITH ALGORITHM = RSA_2048,
PROVIDER_KEY_NAME = 'EKM_RSA_2048_Key_TDE',
CREATION_DISPOSITION=CREATE_NEW
```

> **NOTE:** SQL Server does not implement FIPS 186-4. As a result, RSA key generation by SQL Server is not supported when HSM in FIPS Mode. The procedure to generate RSA Key when HSM in FIPS mode is given below.

When using HSM in FIPS mode, open the command prompt and generate the key using CMU utility provided with HSM Client:

```
cmu generatekeypair -label EKM_RSA_2048_Key_TDE -modulusBits=2048 -
publicExp=65537 -sign=T -verify=T -encrypt=T -decrypt=T
```

Map the key in SQL Server:

```
CREATE ASYMMETRIC KEY SQL_EKM_RSA_2048_Key_TDE
FROM Provider LunaEKMProvider
WITH PROVIDER_KEY_NAME = 'EKM_RSA_2048_Key_TDE',
CREATION_DISPOSITION=OPEN_EXISTING
```

2. Create a CREDENTIAL for Luna EKM Provider.

```
CREATE CREDENTIAL <Name of credential>
WITH IDENTITY='<Name of EKM User>', SECRET='<HSM partition password>'
FOR CRYPTOGRAPHIC PROVIDER LunaEKMProvider
```

3. Create a login based on the recently created asymmetric key.

```
CREATE LOGIN <Name of login>
FROM ASYMMETRIC KEY SQL_EKM_RSA_2048_Key_TDE;
```

4. Map the credential created above to the recently created login.

```
ALTER LOGIN <Name of Login>
ADD CREDENTIAL <Name of credential>;
```

5. Create a Database Encryption Key.

```
CREATE DATABASE TDE;
Use tde;
CREATE DATABASE ENCRYPTION KEY
WITH ALGORITHM = AES_256
ENCRYPTION BY SERVER ASYMMETRIC KEY SQL_EKM_RSA_2048_Key_TDE;
```

6. Enable Transparent Database Encryption.

```
ALTER DATABASE TDE
SET ENCRYPTION ON;
```

7. Query the status of database encryption and the completion percentage.

```
SELECT DB_NAME (e.database_id) AS DatabaseName,
e.database_id,
e.encryption_state,
CASE e.encryption_state
WHEN 0 THEN 'No database encryption key present, no encryption'
WHEN 1 THEN 'Unencrypted'
WHEN 2 THEN 'Encryption in progress'
WHEN 3 THEN 'Encrypted'
WHEN 4 THEN 'Key change in progress'
WHEN 5 THEN 'Decryption in progress'
END AS encryption_state_desc,
c.name,
e.percent_complete
FROM sys.dm_database_encryption_keys AS e
LEFT JOIN master.sys.asymmetric_keys AS c
ON e.encryptor_thumbprint = c.thumbprint
```

Rotate Keys for Transparent Database Encryption

Microsoft recommends updating your TDE security keys regularly by rotating the available symmetric and asymmetric encryption keys. Execute the following command to rotate keys for TDE:

1. Generate an asymmetric key using the Luna EKM Provider.

   ```
   Use master;
   CREATE ASYMMETRIC KEY SQL_EKM_RSA_2048_Key_TDE_Rot
   FROM Provider LunaEKMProvider
   WITH ALGORITHM = RSA_2048,
   PROVIDER_KEY_NAME = 'EKM_RSA_2048_Key_TDE_Rot',
   CREATION_DISPOSITION=CREATE_NEW
   ```

   > **NOTE:** SQL Server does not implement FIPS 186-4. As a result, RSA key generation by SQL Server is not supported when HSM in FIPS Mode. The procedure to generate RSA Key when HSM in FIPS mode is given below.

   When using HSM in FIPS mode, open the command prompt and generate the key using CMU utility provided with HSM Client and then map the key in SQL Server:

   ```
   cmu generatekeypair -label EKM_RSA_2048_Key_TDE_Rot -modulusBits=2048 -
   publicExp=65537 -sign=T -verify=T -encrypt=T -decrypt=T
   ```

   Map the key in SQL Server:

   ```
   CREATE ASYMMETRIC KEY SQL_EKM_RSA_2048_Key_TDE_Rot
   FROM Provider LunaEKMProvider
   WITH PROVIDER_KEY_NAME = 'EKM_RSA_2048_Key_TDE_Rot',
   CREATION_DISPOSITION=OPEN_EXISTING
   ```

2. Create a CREDENTIAL for Luna EKM Provider.

   ```
   CREATE CREDENTIAL <Name of credential>
   WITH IDENTITY='<Name of EKM User>', SECRET='<HSM partition password>'
   FOR CRYPTOGRAPHIC PROVIDER LunaEKMProvider
   ```

3. Create a login based on the recently created asymmetric key.

   ```
   CREATE LOGIN <Name of login>
   FROM ASYMMETRIC KEY SQL_EKM_RSA_2048_Key_TDE_Rot;
   ```

4. Map the credential to the recently created login.

```
ALTER LOGIN <Name of Login>
ADD CREDENTIAL <Name of credential>;
```

5. Enable Transparent Database Encryption Key Rotation.

   To rotate the database encryption key

   ```
   Use tde;
   ALTER DATABASE ENCRYPTION KEY
   REGENERATE
   WITH ALGORITHM = AES_128
   ```

   To rotate the asymmetric key used to encrypt the DEK.

   ```
   ALTER DATABASE ENCRYPTION KEY
   ENCRYPTION BY SERVER ASYMMETRIC KEY SQL_EKM_RSA_2048_Key_TDE_Rot;
   go
   SELECT * FROM sys.dm_database_encryption_keys
   go
   ```

6. Execute the following command to query the status of database encryption, the status of TDE key change, and the tablespace encryptions percentage of completion.

   ```
   SELECT DB_NAME (e.database_id) AS DatabaseName,
   e.database_id,
   e.encryption_state,
   CASE e.encryption_state
   WHEN 0 THEN 'No database encryption key present, no encryption'
   WHEN 1 THEN 'Unencrypted'
   WHEN 2 THEN 'Encryption in progress'
   WHEN 3 THEN 'Encrypted'
   WHEN 4 THEN 'Key change in progress'
   WHEN 5 THEN 'Decryption in progress'
   END AS encryption_state_desc,
   c.name,
   e.percent_complete
   FROM sys.dm_database_encryption_keys AS e
   LEFT JOIN master.sys.asymmetric_keys AS c
   ON e.encryptor_thumbprint = c.thumbprint
   ```

Migrate TDE from SQL EKM to Luna EKM

Previously, the database master key was generated in SQL and encrypted using a certificate or asymmetric key. Now you can perform the following tasks to migrate to Luna EKM.

- Rotate the database encryption key (DEK) and migrate to key encryption key (KEK) generated on a Luna HSM.
- Migrate to key encryption key (KEK) generated on a Luna HSM without rotating database encryption key (DEK).

The former will decrypt the database using existing DEK and then re-encrypt the database with new DEK while the latter will only encrypt the DEK with KEK created on Luna HSM without decrypting and re-encrypting the whole database.

This example uses the database name <AdventureWorks>. To migrate TDE from SQL EKM to Luna EKM:

1. Create an asymmetric key.

   ```
   Use master;
   CREATE ASYMMETRIC KEY SQL_EKM_RSA_2048_Key_AW
   FROM Provider LunaEKMProvider
   WITH ALGORITHM = RSA_2048,
   PROVIDER_KEY_NAME = 'EKM_RSA_2048_Key_AW',
   CREATION_DISPOSITION=CREATE_NEW
   ```

   > **NOTE:** SQL Server does not implement FIPS 186-4. As a result, RSA key generation by SQL Server is not supported when HSM in FIPS Mode. The procedure to generate RSA Key when HSM in FIPS mode is given below.

   When using HSM in FIPS mode, open the command prompt and generate the key using CMU utility provided with HSM Client and then map the key in SQL Server:

   ```
   cmu generatekeypair -label EKM_RSA_2048_Key_AW -modulusBits=2048 -
   publicExp=65537 -sign=T -verify=T -encrypt=T -decrypt=T
   ```

   Map the key in SQL Server:

   ```
   CREATE ASYMMETRIC KEY SQL_EKM_RSA_2048_Key_AW
   FROM Provider LunaEKMProvider
   WITH PROVIDER_KEY_NAME = 'EKM_RSA_2048_Key_AW',
   CREATION_DISPOSITION=OPEN_EXISTING
   ```

2. Create a CREDENTIAL for Luna EKM Provider.

   ```
   CREATE CREDENTIAL <Name of credential>
   WITH IDENTITY='<Name of EKM User>', SECRET='<HSM partition password>'
   FOR CRYPTOGRAPHIC PROVIDER LunaEKMProvider
   ```

3. Create a login based on the recently created asymmetric key.

   ```
   CREATE LOGIN <Name of login>
   FROM ASYMMETRIC KEY SQL_EKM_RSA_2048_Key_AW;
   ```

4. Map the CREDENTIAL to the recently created login.

   ```
   ALTER LOGIN <Name of Login>
   ADD CREDENTIAL <Name of credential>;
   ```

5. Migrate Transparent Database Encryption from SQL to Luna EKM.

To rotate the Database Encryption Key (DEK) and migrate to KEK created on Luna HSM

1. Back up the database and transaction logs. When the backup completes, restart the SQL database.
2. Rotate the DEK:

   ```
   USE AdventureWorks;

   ALTER DATABASE ENCRYPTION KEY

   REGENERATE

   WITH ALGORITHM = AES_256
   ```

3. Migrate to KEK:

```
USE AdventureWorks;
ALTER DATABASE ENCRYPTION KEY
ENCRYPTION BY SERVER ASYMMETRIC KEY SQL_EKM_RSA_2048_Key_AW
Go
SELECT * FROM sys.dm_database_encryption_keys
Go
```

To migrate to KEK created on Luna HSM without rotating the Database Encryption Key (DEK)

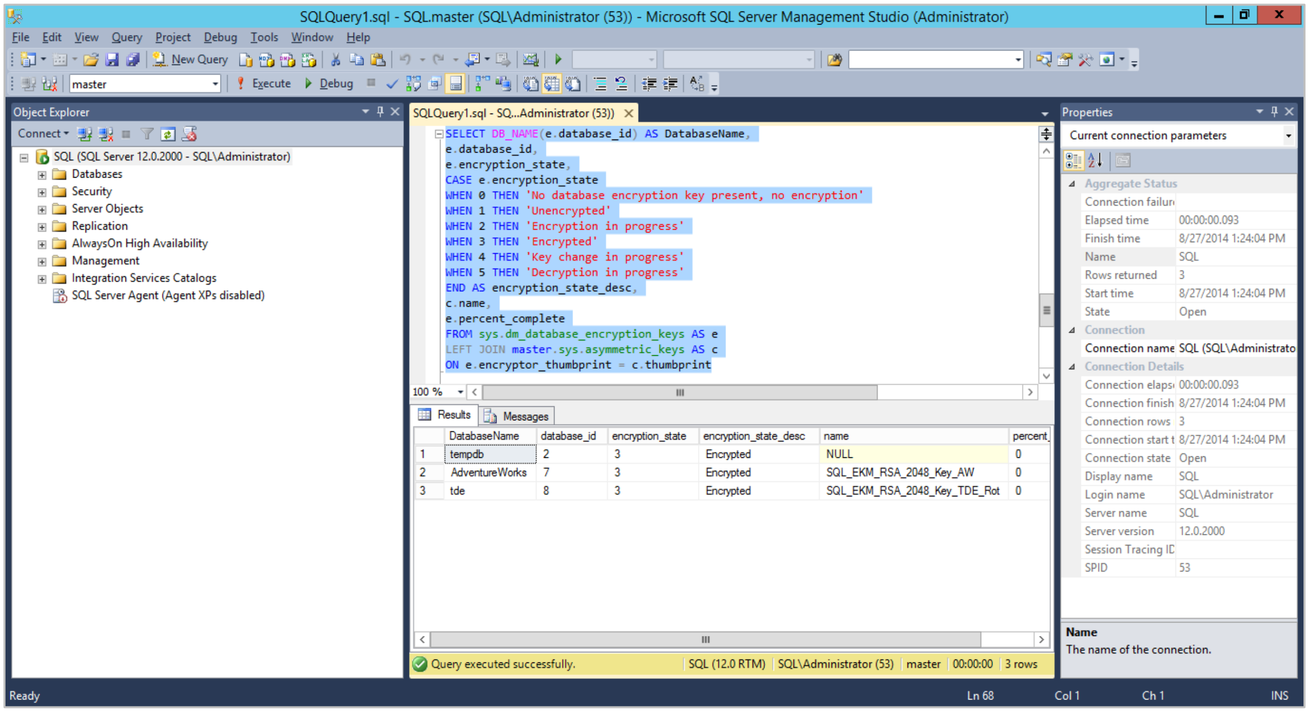
1. Back up the database and transaction logs. When the backup completes, restart the SQL database.
2. Migrate to KEK:

```
        USE AdventureWorks;
        ALTER DATABASE ENCRYPTION KEY
        ENCRYPTION BY SERVER ASYMMETRIC KEY SQL_EKM_RSA_2048_Key_AW
        Go
        SELECT * FROM sys.dm_database_encryption_keys
        Go
```

3. Check the status of Transparent Database Encryption after migration:

```
SELECT DB_NAME(e.database_id) AS DatabaseName,
e.database_id,
e.encryption_state,
CASE e.encryption_state
WHEN 0 THEN 'No database encryption key present, no encryption'
WHEN 1 THEN 'Unencrypted'
WHEN 2 THEN 'Encryption in progress'
WHEN 3 THEN 'Encrypted'
WHEN 4 THEN 'Key change in progress'
WHEN 5 THEN 'Decryption in progress'
END AS encryption_state_desc,
c.name,
e.percent_complete
FROM sys.dm_database_encryption_keys AS e
LEFT JOIN master.sys.asymmetric_keys AS c
ON e.encryptor_thumbprint = c.thumbprint
```

If the query is executed successfully, the status of database encryption and its completion percentage will appear on the screen. The migration from SQL server to Luna HSM or Luna Cloud HSM service is now completed.


SQLQuery1.sql - SQL.master (SQL\Administrator (53)) - Microsoft SQL Server Management Studio (Administrator)
File Edit View Query Project Debug Tools Window Help
New Query
master
Execute
Debug
Object Explorer
Connect
SQL (SQL Server 12.0.2000 - SQL\Administrator)
Databases
Security
Server Objects
Replication
AlwaysOn High Availability
Management
Integration Services Catalogs
SQL Server Agent (Agent XPs disabled)
SQLQuery1.sql - SQ...Administrator (53))
100 %
Results
Messages
Properties
Ready
Ln 68
Col 1
Ch 1
INS

```
SELECT DB_NAME(e.database_id) AS DatabaseName,
e.database_id,
e.encryption_state,
CASE e.encryption_state
WHEN 0 THEN 'No database encryption key present, no encryption'
WHEN 1 THEN 'Unencrypted'
WHEN 2 THEN 'Encryption in progress'
WHEN 3 THEN 'Encrypted'
WHEN 4 THEN 'Key change in progress'
WHEN 5 THEN 'Decryption in progress'
END AS encryption_state_desc,
c.name,
e.percent_complete
FROM sys.dm_database_encryption_keys AS e
LEFT JOIN master.sys.asymmetric_keys AS c
ON e.encryptor_thumbprint = c.thumbprint
```

	DatabaseName	database_id	encryption_state	encryption_state_desc	name	percent_
1	tempdb	2	3	Encrypted	NULL	0
2	AdventureWorks	7	3	Encrypted	SQL_EKM_RSA_2048_Key_AW	0
3	tde	8	3	Encrypted	SQL_EKM_RSA_2048_Key_TDE_Rot	0

Query executed successfully. | SQL (12.0 RTM) | SQL\Administrator (53) | master | 00:00:00 | 3 rows

Current connection parameters

Aggregate Status	
Connection failur	
Elapsed time	00:00:00.093
Finish time	8/27/2014 1:24:04 PM
Name	SQL
Rows returned	3
Start time	8/27/2014 1:24:04 PM
State	Open
Connection	
Connection name	SQL (SQL\Administrato
Connection Details	
Connection elaps	00:00:00.093
Connection finish	8/27/2014 1:24:04 PM
Connection rows	3
Connection start t	8/27/2014 1:24:04 PM
Connection state	Open
Display name	SQL
Login name	SQL\Administrator
Server name	SQL
Server version	12.0.2000
Session Tracing ID	
SPID	53

Name
The name of the connection.

Use Extensible Key Management on a SQL Server Failover Cluster

This section focuses on the preparation of environment for a two-node SQL Server Cluster in Windows Server.

1. Refer to the SQL Server documentation to install a failover cluster. To set up a shared storage disk for SQL Server Cluster, refer to the configuration procedures that apply for shared storage solution. Plan the size of the shared storage, depending on the number of certificates that are required to be enrolled.
2. Once the cluster is up and running, install the Luna Network HSM client or Luna Cloud HSM service client on both the nodes.
3. Configure and set up the HSM on both the nodes and register the same partition or Cloud HSM service on both nodes in the SQL Server Cluster.
4. Install the Luna EKM client on both the nodes.
5. Configure the Luna EKM provider on both the nodes.
6. Open the SQL Server management studio to register the Luna EKM provider on the first node.
7. Set up the credential on first node.
8. Create encryption keys using the Luna EKM provider on the first node.
9. Create a table and encrypt a column with the Luna EKM key on the first node.
10. Shut down the first node.
11. Log in to the second node and decrypt the data encrypted on the first node.
12. If the data decrypts successfully, Extensible Key Management (EKM) using Luna EKM is operating correctly on the SQL Server cluster.

Integrating Luna HSM with SQL Server High Availability Group

To integrate Luna HSM with SQL Server, set up and configure the Luna EKM Provider and enable the EKM provider in the SQL server. The EKM feature is available on the Enterprise, Developer, and Evaluation editions of the SQL server. EKM is disabled by default. You can set up SQL server in a High Availability configuration for failover support. Luna Client and Luna EKM must be set up on all SQL Server cluster nodes to be added to the “Always On” availability group. All nodes must be registered with the same partition of Luna HSM or the same service client on Cloud HSM service. This integration involves the following steps:

> Enable EKM Provider Option

> Create and Register Luna EKM Provider

> Set up CREDENTIAL for Luna EKM Provider

> Create Always On Availability Group

> Enable Transparent Database Encryption using Asymmetric key on Luna HSM

> Add Encrypted Database to Availability Group

> Rotate Keys for Transparent Database Encryption

Enable EKM Provider Option

Use the `sp_configure` command to enable the EKM Provider option on all nodes in the high availability configuration. To enable the Extensible Key Management option:

1. Open the SQL Server Management Studio.
2. Connect to the SQL Server.
3. Open a query window, and execute the following:

```
sp_configure 'show advanced', 1
GO
RECONFIGURE
GO
sp_configure 'EKM provider enabled', 1
GO
RECONFIGURE
GO
```

> **NOTE:** The `sp_configure` command is supported on Enterprise, Developer, and Evaluation editions of SQL server. If you execute the command on an alternative version, you will receive an error.

Create and Register Luna EKM Provider

Set up the Luna EKM provider. Install the Luna EKM Software and register it for use with SQL Server on all nodes in the high availability configuration. To create and register the Luna EKM Provider:

1. Open the SQL Server Management Studio.
2. Connect to the SQL Server.
3. Open a query window, and execute the following:

   ```
   CREATE CRYPTOGRAPHIC PROVIDER <Name of Cryptographic Provider>
   FROM FILE = '<Location of Luna EKM Provider Library>'
   ```

   where `CRYPTOGRAPHIC PROVIDER` can be any user defined unique name.
4. To view the list of EKM providers:

   ```
   SELECT [provider_id]
   ,[name]
   ,[guid]
   ,[version]
   ,[dll_path]
   ,[is_enabled]
   FROM [model].[sys].[cryptographic_providers]
   ```
5. View the provider properties:

   ```
   SELECT [provider_id],[guid],[provider_version]
   ,[sqlcrypt_version]
   ,[friendly_name]
   ,[authentication_type]
   ,[symmetric_key_support]
   ,[symmetric_key_persistance]
   ,[symmetric_key_export]
   ,[symmetric_key_import]
   ,[asymmetric_key_support]
   ,[asymmetric_key_persistance]
   ,[asymmetric_key_export]
   ,[asymmetric_key_import]
   FROM [master].[sys].[dm_cryptographic_provider_properties]
   ```

Set up CREDENTIAL for Luna EKM Provider

Create a CREDENTIAL for the Luna EKM Provider and map the CREDENTIAL to the SQL Service Account or log in to use the Luna EKM Provider on all nodes in the High Availability configuration. To set up the CREDENTIAL for Luna EKM Provider:

1. Open a query window, and execute the following command:

   ```
   CREATE CREDENTIAL <Name of credential>
   WITH IDENTITY='<Name of EKM User>', SECRET='<HSM partition password>'
   FOR CRYPTOGRAPHIC PROVIDER LunaEKMProvider
   ```

   Where `CREDENTIAL` and `IDENTITY` can be any user defined unique name.
2. Map the Credential to the SQL Service Account or Login:

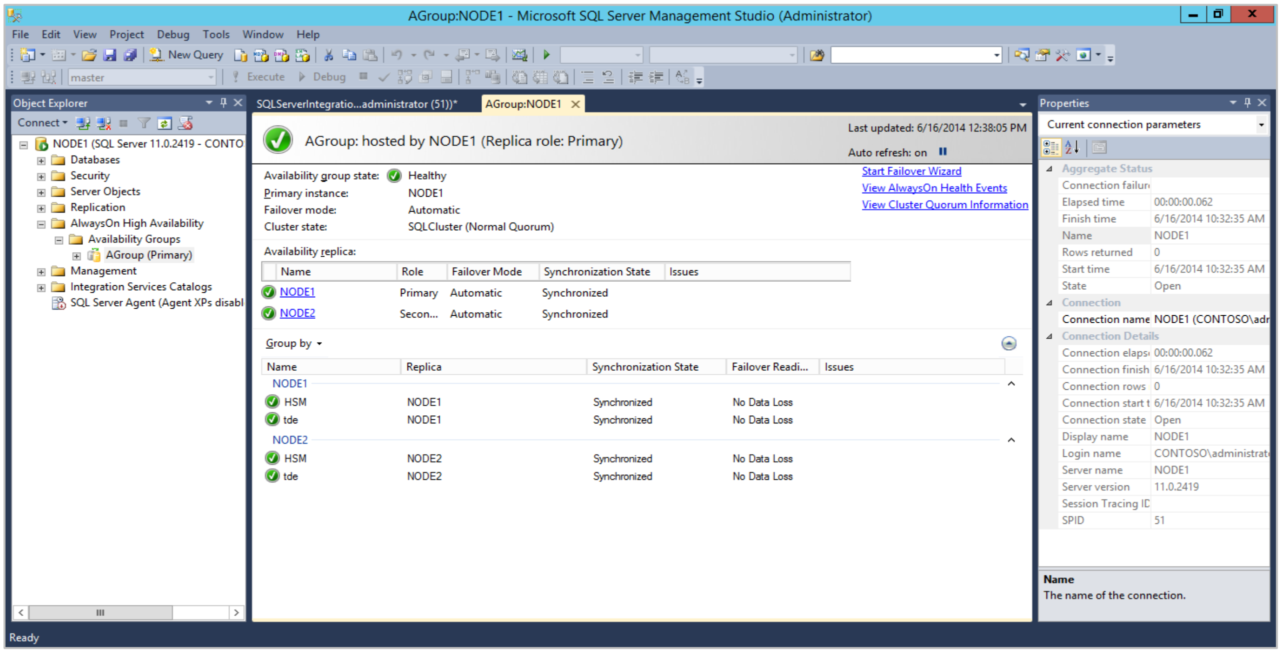
```
ALTER LOGIN [Domain\Login Name]
ADD CREDENTIAL <Name of Credential created>
```

> **NOTE:** We recommend using a domain user on all SQL Server nodes. The EKM session must be reopened if the user changes the HSM service, the client machine is deleted from the service, or the machine suffers a network disconnection.

Create Always On Availability Group

Create the Always On Availability group and configure the nodes in the cluster to communicate with each other. For detailed installation procedures, refer to the Microsoft Documentation for creating the Always on Availability group. To create the Always On Availability Group:

1. Open the Microsoft SQL Server management Studio on the primary node.
2. Create a database.
3. Back up the database to a shared network location that is accessible by all of the SQL Server nodes.
4. Open the Always On Availability Group Creation wizard and create an Always On Availability group for the cluster configuration. After the successful creation of the group, the dashboard displays all the participating nodes. An example of a dashboard is shown below. For demonstration purposes, two nodes were added: primary and secondary.


AGroup:NODE1 - Microsoft SQL Server Management Studio (Administrator)
File Edit View Project Debug Tools Window Help
New Query
master
Execute Debug
Object Explorer
Connect
NODE1 (SQL Server 11.0.2419 - CONTO
Databases
Security
Server Objects
Replication
AlwaysOn High Availability
Availability Groups
AGroup (Primary)
Management
Integration Services Catalogs
SQL Server Agent (Agent XPs disabl
SQLServerIntegratio...administrator (51))*
AGroup:NODE1
Start Failover Wizard
View AlwaysOn Health Events
View Cluster Quorum Information
Group by
Properties
Ready

AGroup: hosted by NODE1 (Replica role: Primary)

Last updated: 6/16/2014 12:38:05 PM
Auto refresh: on

Availability group state: ✓ Healthy
Primary instance: NODE1
Failover mode: Automatic
Cluster state: SQLCluster (Normal Quorum)

Availability replica:

Name	Role	Failover Mode	Synchronization State	Issues
✓ NODE1	Primary	Automatic	Synchronized	
✓ NODE2	Secon...	Automatic	Synchronized	

Name	Replica	Synchronization State	Failover Readi...	Issues
NODE1				
✓ HSM	NODE1	Synchronized	No Data Loss	
✓ tde	NODE1	Synchronized	No Data Loss	
NODE2				
✓ HSM	NODE2	Synchronized	No Data Loss	
✓ tde	NODE2	Synchronized	No Data Loss	

Current connection parameters

Aggregate Status	
Connection failur	
Elapsed time	00:00:00.062
Finish time	6/16/2014 10:32:35 AM
Name	NODE1
Rows returned	0
Start time	6/16/2014 10:32:35 AM
State	Open
Connection	
Connection name	NODE1 (CONTOSO\adr
Connection Details	
Connection elaps	00:00:00.062
Connection finish	6/16/2014 10:32:35 AM
Connection rows	0
Connection start t	6/16/2014 10:32:35 AM
Connection state	Open
Display name	NODE1
Login name	CONTOSO\administrat
Server name	NODE1
Server version	11.0.2419
Session Tracing ID	
SPID	51

Name
The name of the connection.

Create Encryption Keys for Availability Group Database

You can use the Luna EKM provider to create/drop symmetric and asymmetric keys to/from the HSM and can perform encryption/decryption using these keys.

To create the symmetric key using the Luna EKM Provider

1. Open the SSMS on the primary node.
2. Execute the following command from the SQL query window:

   ```
   USE HSMDB;
   ```

3. Execute the following command from the SQL query window:

   ```
   CREATE SYMMETRIC KEY SQL_EKM_AES_256_Key
   FROM Provider LunaEKMProvider
   WITH ALGORITHM = AES_256,
   PROVIDER_KEY_NAME = 'EKM_AES_256_Key',
   CREATION_DISPOSITION=CREATE_NEW
   ```

   > **NOTE:** Once a key is created on the Luna HSM, it can be used or referred by its name from the SQL Server. For example, in the above said test case, `SQL_EKM_ AES_256_Key` is the unique name of the key in the SQL Server. Using this key name will use the key on the HSM for encrypt and decrypt operations.

To view symmetric keys using the Luna EKM Provider

Execute the following command from the SQL query window:

```
SELECT * FROM [hsmdb].[sys].[symmetric_keys]
```

To encrypt a database table with symmetric keys using the Luna EKM Provider

1. Create a test Table in the HSMDB database with fields.

   ```
   Create Table test(
   id numeric(10),
   name varchar (50),
   data varchar (max),)
   ```

2. Execute the following command from the SQL query window:

   ```
   INSERT INTO dbo.test
   values( 1,'some text',
   EncryptByKey(Key_GUID('SQL_EKM_AES_256_Key'), 'text to be encrypted'))
   ```

To decrypt a database table with symmetric keys using the Lune EKM Provider

1. Execute the following command from the SQL query window:

   ```
   SELECT id,name,CONVERT(varchar(MAX),
   DecryptByKey(data))
    FROM dbo.test where id =1
   ```

2. Execute the above command on secondary replica and verify that the output is same as primary replica.

Create Asymmetric Keys on Luna HSM

To create the asymmetric key using the Lune EKM Provider:

1. Execute the following command from the SQL query window:

   ```
   CREATE ASYMMETRIC KEY SQL_EKM_RSA_2048_Key
   FROM Provider LunaEKMProvider
   WITH ALGORITHM = RSA_2048,
   PROVIDER_KEY_NAME = 'EKM_RSA_2048_Key',
   CREATION_DISPOSITION=CREATE_NEW
   ```

   > **NOTE:** SQL Server does not implement FIPS 186-4. As a result, RSA key generation by SQL Server is not supported when HSM in FIPS Mode. The procedure to generate RSA Key when HSM in FIPS mode is given below.

   When using HSM in FIPS mode, open the command prompt and generate the key using CMU utility provided with HSM Client:

   ```
   cmu generatekeypair -label EKM_RSA_2048_Key -modulusBits=2048 -publicExp=65537
   -sign=T -verify=T -encrypt=T -decrypt=T
   ```

   Map the key in SQL Server:

   ```
   CREATE ASYMMETRIC KEY SQL_EKM_RSA_2048_Key
   FROM Provider LunaEKMProvider
   WITH PROVIDER_KEY_NAME = 'EKM_RSA_2048_Key',
   CREATION_DISPOSITION=OPEN_EXISTING
   ```

   > **NOTE:** Once a key is created, it can be used or referred by its name from the SQL Server, For example, in the above test case, `SQL_EKM_ RSA_2048_Key` is the unique name of the key in the SQL Server. This key name can be used for encrypt and decrypt operations.

To view asymmetric keys using the Luna EKM Provider

Execute the following command from the SQL query window:

```
SELECT * FROM [hsmdb].[sys].[asymmetric_keys]
```

To encrypt a database table with asymmetric keys using the Luna EKM Provider

Execute the following command from the SQL query window:

```
INSERT INTO dbo.test

values ( 2,'some text',

EncryptByAsymKey (AsymKey_Id ('SQL_EKM_RSA_2048_Key'), 'text to be encrypted'))
```

To decrypt a database table with asymmetric keys using the Luna EKM Provider

1. Execute the following command from the SQL query window:

   ```
   SELECT id, name, CONVERT (varchar (MAX),

   DecryptByAsymKey (AsymKey_Id ('SQL_EKM_RSA_2048_Key'), data))

   FROM dbo.test where id =2
   ```

2. Now execute the above command on secondary replica and verify that the output is same as primary replica.

Create Symmetric Key Encrypted by Asymmetric Key on Luna HSM

You can encrypt the symmetric keys using an asymmetric key. This increases the security of the symmetric key. To create a symmetric key encrypted by an asymmetric key:

1. Open the SSMS on the primary node.
2. Execute the following command from SQL query window:

   ```
   Create SYMMETRIC KEY key1
   WITH ALGORITHM = AES_256
   ENCRYPTION BY Asymmetric Key SQL_EKM_RSA_2048_Key;
   ```

   Where `“SQL_EKM_RSA_2048_Key”` is an existing asymmetric key.
3. Before using the key you need to open the key. Execute the following command to open the symmetric key:

   ```
   OPEN SYMMETRIC KEY key1 DECRYPTION BY Asymmetric Key SQL_EKM_RSA_2048_Key;
   ```

   > **NOTE:** For Microsoft SQL Server 2017, apply the patch as described in the Troubleshooting Tips section.

4. Encrypt the data using the key1.

   ```
   INSERT INTO dbo.test
   values ( 3,'some text',
   Encryptbykey(KEY_GUID('Key1'), 'text to be encrypted'))
   ```
5. Decrypt the data using the key1.

   ```
   SELECT id,name,CONVERT(varchar(MAX),
   DecryptByKey(data))
   FROM dbo.test where id =3
   ```
6. Close the symmetric key.

   ```
   CLOSE SYMMETRIC KEY key1
   ```
7. Execute the steps 3-6 on secondary replica and verify that the output is the same as primary replica.

Enable Transparent Database Encryption using Asymmetric key on Luna HSM

> **NOTE:** We have included support for creating higher length asymmetric keys: RSA_3072 and RSA_4096 from Luna EKM v1.3 onwards. However during our integration testing, we identified an issue in TDE when encrypting the DEK using RSA_4096 key. This issue has been reported to Microsoft technical support and we are awaiting a resolution. At this time, we recommend to use a maximum key length of RSA_3072 for the TDE. We will retest and update the integration guide when Microsoft resolves this issue.

> **NOTE:** Database encryption operations cannot be executed on 'master', 'model', 'tempdb', 'msdb', or 'resource' databases.

You can enable Transparent Data Encryption (TDE) using an asymmetric key stored on a Luna HSM. To enable TDE using asymmetric key on Luna HSM:

1. Create an asymmetric key using Luna EKM Provider on primary replica.

   ```
   Use master;
   CREATE ASYMMETRIC KEY SQL_EKM_RSA_2048_Key_TDE
   FROM Provider LunaEKMProvider
   WITH ALGORITHM = RSA_2048,
   PROVIDER_KEY_NAME = 'EKM_RSA_2048_Key_TDE',
   CREATION_DISPOSITION=CREATE_NEW
   ```

   > **NOTE:** SQL Server does not implement FIPS 186-4. As a result, RSA key generation by SQL Server is not supported when HSM is in FIPS Mode. The procedure to generate RSA Key when HSM in FIPS mode is given below.

   When using HSM in FIPS mode, open the command prompt and generate the key using CMU utility provided with HSM Client and then map the key in SQL Server:

   ```
   cmu generatekeypair -label EKM_RSA_2048_Key_TDE -modulusBits=2048 -
   publicExp=65537 -sign=T -verify=T -encrypt=T -decrypt=T
   ```

   Map the key in SQL Server

   ```
   CREATE ASYMMETRIC KEY SQL_EKM_RSA_2048_Key_TDE
   FROM Provider LunaEKMProvider
   WITH PROVIDER_KEY_NAME = 'EKM_RSA_2048_Key_TDE',
   CREATION_DISPOSITION=OPEN_EXISTING
   ```

2. Create the same asymmetric key using Luna EKM Provider on secondary replica.

   ```
   Use master;
   CREATE ASYMMETRIC KEY SQL_EKM_RSA_2048_Key_TDE
   FROM Provider LunaEKMProvider
   WITH PROVIDER_KEY_NAME = 'EKM_RSA_2048_Key_TDE',
   CREATION_DISPOSITION=OPEN_EXISTING
   ```

3. Create a CREDENTIAL for Luna EKM Provider.

   ```
   CREATE CREDENTIAL <Name of credential>
   WITH IDENTITY='<Name of EKM User>', SECRET='<HSM partition password>'
   FOR CRYPTOGRAPHIC PROVIDER LunaEKMProvider
   ```

4. Create a login based on the recently created asymmetric key.

   ```
   CREATE LOGIN <Name of login>
   FROM ASYMMETRIC KEY SQL_EKM_RSA_2048_Key_TDE;
   ```

5. Map the CREDENTIAL to the recently created Login.

   ```
   ALTER LOGIN <Name of Login>
   ADD CREDENTIAL <Name of credential>;
   ```

6. Execute the above steps (2-5) for all secondary nodes.

> **NOTE:** Repeating the procedure is required for all nodes in the database because the TDE encryption key, CREDENTIAL, and Login, are objects in the master database and are not replicated by including the node in the **Availability Groups**.

7. Create a Database Encryption Key on the primary node.

```
CREATE DATABASE TDE;
Use tde;
CREATE DATABASE ENCRYPTION KEY
WITH ALGORITHM = AES_256
ENCRYPTION BY SERVER ASYMMETRIC KEY SQL_EKM_RSA_2048_Key_TDE;
```

8. Enable Transparent Database Encryption:

```
ALTER DATABASE TDE
SET ENCRYPTION ON;
```

9. Query the status of database encryption and its completion percentage.

```
SELECT DB_NAME (e.database_id) AS DatabaseName,
e.database_id,
e.encryption_state,
CASE e.encryption_state
WHEN 0 THEN 'No database encryption key present, no encryption'
WHEN 1 THEN 'Unencrypted'
WHEN 2 THEN 'Encryption in progress'
WHEN 3 THEN 'Encrypted'
WHEN 4 THEN 'Key change in progress'
WHEN 5 THEN 'Decryption in progress'
END AS encryption_state_desc,
c.name,
e.percent_complete
FROM sys.dm_database_encryption_keys AS e
LEFT JOIN master.sys.asymmetric_keys AS c
ON e.encryptor_thumbprint = c.thumbprint
```

Add Encrypted Database to Availability Group

Before adding the already encrypted database into the availability group, back up the encrypted database to a network location that is accessible by all secondary nodes. To add the encrypted database to the availability group:

1. Open the SMS on the primary node.
2. Add the database (e.g. TDE) into the availability group (e.g. AGroup).

```
use master;
ALTER AVAILABILITY GROUP AGroup ADD DATABASE tde;
GO
```

   This command adds the database to the Availability Group, but it is not yet available on the secondary node. To access the encrypted database from the secondary node, you need to synchronize the databases by restoring the database on the second node.

3. Restore the database on the secondary node. Restore the database from the location where you have stored the encrypted database with the “RESTORE WITH NORECOVERY” parameter.

4. Add the database on the secondary node using the following SQL command:

```
use master;
ALTER DATABASE tde SET HADR AVAILABILITY GROUP = AGroup;
```

5. Query the status of database encryption and its completion percentage on the secondary node.

```
SELECT DB_NAME (e.database_id) AS DatabaseName,
e.database_id,
e.encryption_state,
CASE e.encryption_state
WHEN 0 THEN 'No database encryption key present, no encryption'
WHEN 1 THEN 'Unencrypted'
WHEN 2 THEN 'Encryption in progress'
WHEN 3 THEN 'Encrypted'
WHEN 4 THEN 'Key change in progress'
WHEN 5 THEN 'Decryption in progress'
END AS encryption_state_desc,
c.name,
e.percent_complete
FROM sys.dm_database_encryption_keys AS e
LEFT JOIN master.sys.asymmetric_keys AS c
ON e.encryptor_thumbprint = c.thumbprint
```

Rotate Keys for Transparent Database Encryption

We recommend updating your TDE security keys regularly by rotating the available symmetric and asymmetric encryption keys. To rotate keys for TDE:

1. Create an asymmetric key using the Luna EKM Provider on the primary node.

```
Use master;
CREATE ASYMMETRIC KEY SQL_EKM_RSA_2048_Key_TDE_Rot
FROM Provider LunaEKMProvider
WITH ALGORITHM = RSA_2048,
PROVIDER_KEY_NAME = ‘EKM_RSA_2048_Key_TDE_Rot’,
CREATION_DISPOSITION=CREATE_NEW
```

> **NOTE:** SQL Server does not implement FIPS 186-4. As a result, RSA key generation by SQL Server is not supported when HSM in FIPS Mode. The procedure to generate RSA Key when HSM in FIPS mode is given below.

When using HSM in FIPS mode, open the command prompt and generate the key using CMU utility provided with HSM Client and then map the key in SQL Server:

```
cmu generatekeypair -label EKM_RSA_2048_Key_TDE_Rot -modulusBits=2048 -
publicExp=65537 -sign=T -verify=T -encrypt=T -decrypt=T
```

Map the key in SQL Server:

```
CREATE ASYMMETRIC KEY SQL_EKM_RSA_2048_Key_TDE_Rot
FROM Provider LunaEKMProvider
```

```
WITH PROVIDER_KEY_NAME = 'EKM_RSA_2048_Key_TDE_Rot',
CREATION_DISPOSITION=OPEN_EXISTING
```

2. Create the same asymmetric key using the Luna EKM Provider on a secondary node.

```
Use master;
CREATE ASYMMETRIC KEY SQL_EKM_RSA_2048_Key_TDE_Rot
FROM Provider LunaEKMProvider
WITH PROVIDER_KEY_NAME = 'EKM_RSA_2048_Key_TDE_Rot',
CREATION_DISPOSITION=OPEN_EXISTING
```

3. Create a CREDENTIAL for Luna EKM Provider.

```
CREATE CREDENTIAL <Name of credential>
WITH IDENTITY='<Name of EKM User>', SECRET='<HSM partition password>'
FOR CRYPTOGRAPHIC PROVIDER LunaEKMProvider
```

4. Create a login based on the recently created asymmetric key.

```
CREATE LOGIN <Name of login>
FROM ASYMMETRIC KEY SQL_EKM_RSA_2048_Key_TDE_Rot;
```

5. Map the CREDENTIAL to the recently created Login.

```
ALTER LOGIN <Name of Login>
ADD CREDENTIAL <Name of credential>;
```

6. Execute steps 2-5 for all secondary nodes.

> **NOTE:** Repeating the procedure is required for all nodes in the database because the TDE encryption key, CREDENTIAL, and Login, are objects in the master database and are not replicated by including the node in the Availability Groups.

7. Enable TDE Key Rotation on the primary replica.

```
Use tde;
ALTER DATABASE ENCRYPTION KEY
REGENERATE
WITH ALGORITHM = AES_128

ALTER DATABASE ENCRYPTION KEY
ENCRYPTION BY SERVER ASYMMETRIC KEY SQL_EKM_RSA_2048_Key_TDE_Rot;
go
SELECT * FROM sys.dm_database_encryption_keys
go
```

8. Query the status of database encryption, TDE key change and its completion percentage.

```
SELECT DB_NAME (e.database_id) AS DatabaseName,
e.database_id,
e.encryption_state,
CASE e.encryption_state
WHEN 0 THEN 'No database encryption key present, no encryption'
WHEN 1 THEN 'Unencrypted'
WHEN 2 THEN 'Encryption in progress'
WHEN 3 THEN 'Encrypted'
WHEN 4 THEN 'Key change in progress'
WHEN 5 THEN 'Decryption in progress'
END AS encryption_state_desc,
c.name,
e.percent_complete
FROM sys.dm_database_encryption_keys AS e
LEFT JOIN master.sys.asymmetric_keys AS c
ON e.encryptor_thumbprint = c.thumbprint
```

This completes the integration of Microsoft SQL Server High Availability with a Luna Network HSM or Luna Cloud HSM service.

Troubleshooting Tips

Problem

Failed to verify Authenticode signature on DLL `"C:\Program Files\LunaPCI\EKM\LunaEKM.dll".`

Solution

This error could appear in SQL logs if the certificate in the signature of dll cannot be verified because there are no corresponding certificates for the issuer and therefore the issuer is not trusted. Go to http://www.verisign.com/support/roots.html and download the all root certificates. Install the certificate and install/import it to Trusted Root Certification Authorities store.

Problem

`CREATE CRYPTOGRAPHIC PROVIDER EKMProvider FROM FILE = <Path to EKM DLL>'` fails with following error on Windows 2012:

```
Error:
Msg 33029, Level 16, State 1, Line 3
Cannot initialize cryptographic provider.  Provider error code: 1. (Failure -
Consult EKM Provider for details)
```

Solution

Reboot the OS server and try to create cryptographic provider.

Problem 3

Unable to open Symmetric key which is encrypted by Asymmetric Key in Microsoft SQL Server 2017.

```
Error:
Msg 15466, Level 16, State 28, Line 1
An error occurred during decryption.
```

Solution

Download the cumulative update package for SQL Server provided by Microsoft and apply it to resolve the issue:

https://support.microsoft.com/en-us/help/4342123/cumulative-update-10-for-sql-server-2017

Contacting Customer Support

If you encounter a problem during this integration, contact your supplier or Thales Customer Support. Thales Customer Support operates 24 hours a day, 7 days a week. Your level of access to this service is governed by the support plan arrangements made between Thales and your organization. Please consult this support plan for further information about your entitlements, including the hours when telephone support is available to you.

Customer Support Portal

The Customer Support Portal, at https://supportportal.thalesgroup.com, is a database where you can find solutions for most common problems. The Customer Support Portal is a comprehensive, fully searchable repository of support resources, including software and firmware downloads, release notes listing known problems and workarounds, a knowledge base, FAQs, product documentation, technical notes, and more. You can also use the portal to create and manage support cases.

> **NOTE:** You require an account to access the Customer Support Portal. To create a new account, go to the portal and click on the **REGISTER** link.

Telephone Support

If you have an urgent problem, or cannot access the Customer Support Portal, you can contact Thales Customer Support by telephone at +1 410-931-7520. Additional local telephone support numbers are listed on the support portal.

Email Support

You can also contact technical support by email at technical.support.DIS@thalesgroup.com.