SQLShack

SQL Server training Español

An overview of the column level SQL Server encryption

January 14, 2020 by Rajendra Gupta

This article gives an overview of column level SQL Server encryption using examples.

Introduction

Data security is a critical task for any organization, especially if you store customer personal data such as Customer contact number, email address, social security number, bank and credit card numbers. Our main goal is to protect unauthorized access to data within and outside the organization. To achieve this, we start by providing access to relevant persons. We still have a chance that these authorized persons can also misuse the data; therefore, SQL Server provides encryption solutions. We can use these encryptions and protect the data.

It is a crucial aspect in classifying the data based on the information type and sensitivity. For example, we might have customer DOB in a column and depending upon the requirement, and we should classify it as confidential, highly confidential. You can read more about in the article SQL data classification – Add sensitivity classification in SQL Server 2019.

We have many encryptions available in SQL Server such as Transparent Data Encryption (TDE), Always

- Create a new database and create **CustomerInfo** table

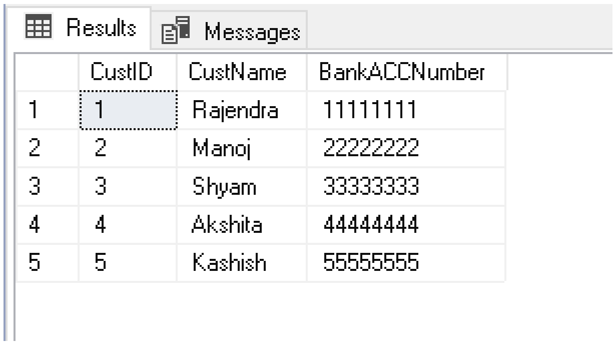
```
CREATE DATABASE CustomerData;
            Go
            USE CustomerData;
            GO

            CREATE TABLE CustomerData.dbo.CustomerInfo
            (CustID         INT PRIMARY KEY,
             CustName      VARCHAR(30) NOT NULL,
             BankACCNumber VARCHAR(10) NOT NULL
            );
            GO
```

- Insert sample data into **CustomerInfo** table

```
Insert into CustomerData.dbo.CustomerInfo (CustID,CustName,BankACCNumber)
            Select 1,'Rajendra',11111111 UNION ALL
            Select 2, 'Manoj',22222222 UNION ALL
            Select 3, 'Shyam',33333333 UNION ALL
            Select 4,'Akshita',44444444 UNION ALL
            Select 5, 'Kashish',55555555
```

- View the records in **CustomerInfo** table

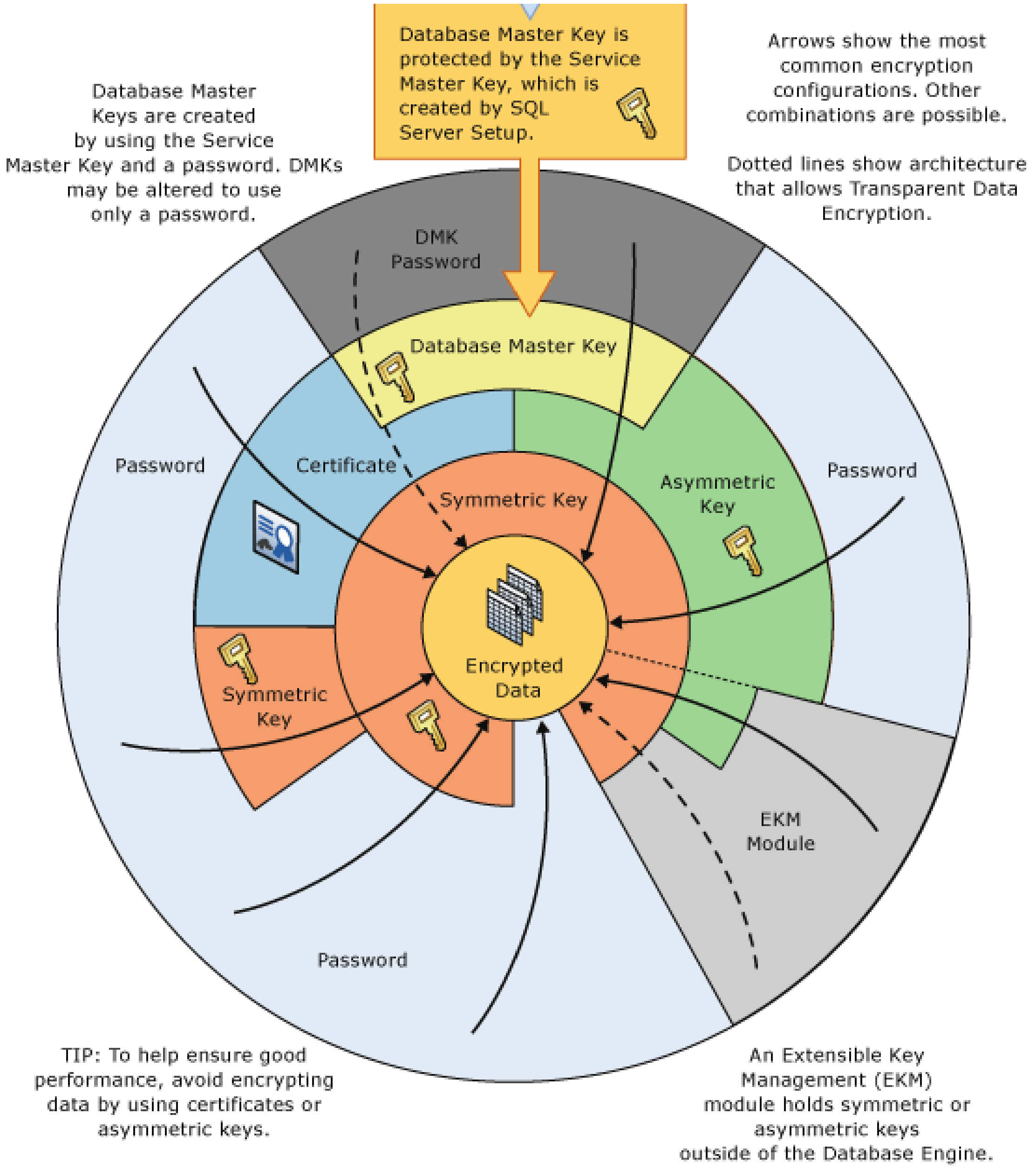


	CustID	CustName	BankACCNumber
1	1	Rajendra	11111111
2	2	Manoj	22222222
3	3	Shyam	33333333
4	4	Akshita	44444444
5	5	Kashish	55555555

We use the following steps for column level encryption:

1. Create a database master key
2. Create a self-signed certificate for SQL Server
3. Configure a symmetric key for encryption
4. Encrypt the column data
5. Query and verify the encryption

We will first use these steps and later explain the overall process using Encryption Hierarchy in SQL


Database Master Key is protected by the Service Master Key, which is created by SQL Server Setup.
Database Master Keys are created by using the Service Master Key and a password. DMKs may be altered to use only a password.
Arrows show the most common encryption configurations. Other combinations are possible.
Dotted lines show architecture that allows Transparent Data Encryption.
DMK Password
Database Master Key
Password
Certificate
Symmetric Key
Asymmetric Key
Password
Symmetric Key
Encrypted Data
EKM Module
Password
TIP: To help ensure good performance, avoid encrypting data by using certificates or asymmetric keys.
An Extensible Key Management (EKM) module holds symmetric or asymmetric keys outside of the Database Engine.

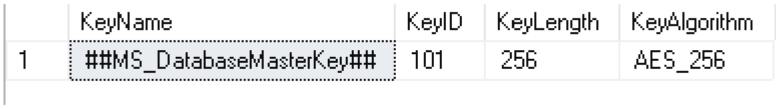
Create a database master key for column level SQL Server encryption

In this first step, we define a database master key and provide a password to protect it. It is a symmetric key for protecting the private keys and asymmetric keys. In the above diagram, we can see that a

We can use **sys.symmetric_keys** catalog view to verify the existence of this database master key in SQL Server encryption:

```
SELECT name KeyName,
    symmetric_key_id KeyID,
    key_length KeyLength,
    algorithm_desc KeyAlgorithm
FROM sys.symmetric_keys;
```

In the output, we can notice that it creates a **##MS_DatabaseMasterKey##** with key algorithm AES_256. SQL Server automatically chooses this key algorithm and key length:



	KeyName	KeyID	KeyLength	KeyAlgorithm
1	##MS_DatabaseMasterKey##	101	256	AES_256

Create a self-signed certificate for Column level SQL Server encryption

In this step, we create a self-signed certificate using the CREATE CERTIFICATE statement. You might have seen that an organization receives a certificate from a certification authority and incorporates into their infrastructures. In SQL Server, we can use a self-signed certificate without using a certification authority certificate.

Execute the following query for creating a certificate:

```
USE CustomerData;
GO
CREATE CERTIFICATE Certificate_test WITH SUBJECT = 'Protect my data';
GO
```

We can verify the certificate using the catalog view **sys.certificates**:

```
SELECT name CertName,
    certificate_id CertID,
    pvt_key_encryption_type_desc EncryptType,
    issuer_name Issuer
FROM sys.certificates;
```

	CertName	CertID	EncryptType	Issuer

- **CertName**: It is the certificate name that we defined in the CREATE CERTIFICATE statement
- **Issuer**: We do not have a certificate authority certificate; therefore, it shows the subject value we defined in the CREATE CERTIFICATE statement

Optionally, we can use **ENCRYPTION BY PASSWORD** and **EXPIRY_DATE** parameters in the CREATE CERTIFICATE; however, we will skip it in this article.

Configure a symmetric key for column level SQL Server encryption

In this step, we will define a symmetric key that you can see in the encryption hierarchy as well. The symmetric key uses a single key for encryption and decryption as well. In the image shared above, we can see the symmetric key on top of the data. It is recommended to use the symmetric key for data encryption since we get excellent performance in it. For column encryption, we use a multi-level approach, and it gives the benefit of the performance of the symmetric key and security of the asymmetric key.

We use **CREATE SYMMETRIC KEY** statement for it using the following parameters:

- **ALGORITHM:** AES_256
- **ENCRYPTION BY CERTIFICATE:** It should be the same certificate name that we specified earlier using CREATE CERTIFICATE statement

```
CREATE SYMMETRIC KEY SymKey_test WITH ALGORITHM = AES_256 ENCRYPTION BY CERTIFICATE Certificate_test;
```

Once we have created this symmetric key, check the existing keys using catalog view for column level SQL Server Encryption as checked earlier:

```
SELECT name KeyName,
    symmetric_key_id KeyID,
    key_length KeyLength,
    algorithm_desc KeyAlgorithm
FROM sys.symmetric_keys;
```

We can see two key entries now as it includes both the database master key and the symmetric key:

- SQL Server installation creates a Service Master Key (SMK), and Windows operating system Data Protection API (DPAPI) protects this key
- This Service Master Key (SMK) protects the database master key (DMK)
- A database master key (DMK) protects the self-signed certificate
- This certificate protects the Symmetric key

Data encryption

SQL Server encrypted column datatype should be **VARBINARY**. In our **CustomerData** table, the **BankACCNumber** column data type is Varchar(10). Let's add a new column of VARBINARY(max) datatype using the ALTER TABLE statement specified below:

```
ALTER TABLE CustomerData.dbo.CustomerInfo
ADD BankACCNumber_encrypt varbinary(MAX)
```

Let's encrypt the data in this newly added column.

- In a query window, open the symmetric key and decrypt using the certificate. We need to use the same symmetric key and certificate name that we created earlier

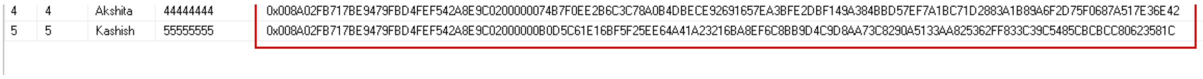
```
OPEN SYMMETRIC KEY SymKey_test
        DECRYPTION BY CERTIFICATE Certificate_test;
```

- In the same session, use the following UPDATE statement. It uses **EncryptByKey** function and uses the symmetric function for encrypting the **BankACCNumber** column and updates the values in the newly created **BankACCNumber_encrypt** column

```
UPDATE CustomerData.dbo.CustomerInfo
        SET BankACCNumber_encrypt = EncryptByKey (Key_GUID('SymKey_test'), Ba
nkACCNumber)
        FROM CustomerData.dbo.CustomerInfo;
        GO
```

- Close the symmetric key using the **CLOSE SYMMETRIC KEY** statement. If we do not close the key, it remains open until the session is terminated

```
CLOSE SYMMETRIC KEY SymKey_test;
            GO
```

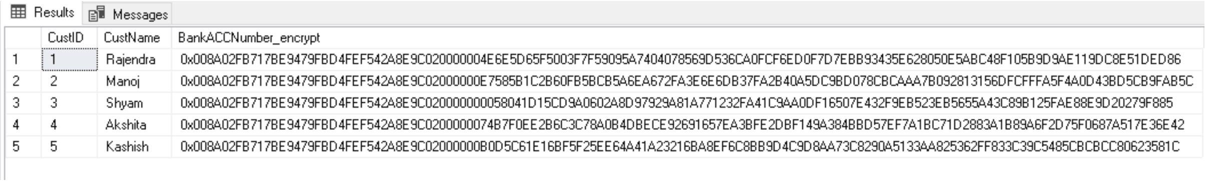


4	4	Akshita	44444444	0x008A02FB717BE9479FBD4FEF542A8E9C0200000074B7F0EE2B6C3C78A0B4DBECE92691657EA3BFE2DBF149A384BBD57EF7A1BC71D2883A1B89A6F2D75F0687A517E36E42
5	5	Kashish	55555555	0x008A02FB717BE9479FBD4FEF542A8E9C02000000B0D5C61E16BF5F25EE64A41A23216BA8EF6C8BB9D4C9D8AA73C8290A5133AA825362FF833C39C5485CBCBCC80623581C

Let's remove the old column as well:

```
ALTER TABLE CustomerData.dbo.CustomerInfo DROP COLUMN BankACCNumber;
GO
```

Now, we have only an encrypted value for the bank account number:



	CustID	CustName	BankACCNumber_encrypt
1	1	Rajendra	0x008A02FB717BE9479FBD4FEF542A8E9C020000004E6E5D65F5003F7F59095A7404078569D536CA0FCF6ED0F7D7EBB93435E628050E5ABC48F105B9D9AE119DC8E51DED86
2	2	Manoj	0x008A02FB717BE9479FBD4FEF542A8E9C02000000E7585B1C2B60FB5BCB5A6EA672FA3E6E6DB37FA2B40A5DC9BD078CBCAAA7B092813156DFCFFFA5F4A0D43BD5CB9FAB5C
3	3	Shyam	0x008A02FB717BE9479FBD4FEF542A8E9C020000000058041D15CD9A0602A8D97929A81A771232FA41C9AA0DF16507E432F9EB523EB5655A43C89B125FAE88E9D20279F885
4	4	Akshita	0x008A02FB717BE9479FBD4FEF542A8E9C0200000074B7F0EE2B6C3C78A0B4DBECE92691657EA3BFE2DBF149A384BBD57EF7A1BC71D2883A1B89A6F2D75F0687A517E36E42
5	5	Kashish	0x008A02FB717BE9479FBD4FEF542A8E9C02000000B0D5C61E16BF5F25EE64A41A23216BA8EF6C8BB9D4C9D8AA73C8290A5133AA825362FF833C39C5485CBCBCC80623581C

Decrypt column level SQL Server encryption data

We need to execute the following commands for decrypting column level encrypted data:

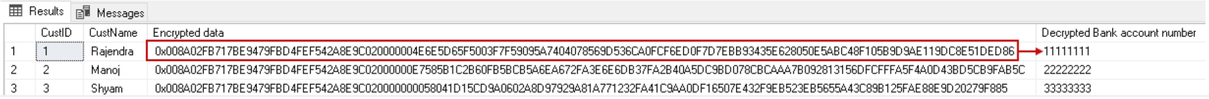
- In a query window, open the symmetric key and decrypt using the certificate. We need to use the same symmetric key and certificate name that we created earlier

```
OPEN SYMMETRIC KEY SymKey_test
        DECRYPTION BY CERTIFICATE Certificate_test;
```

- Use the SELECT statement and decrypt encrypted data using the **DecryptByKey()** function

```
SELECT CustID, CustName,BankACCNumber_encrypt AS 'Encrypted data',
            CONVERT(varchar, DecryptByKey(BankACCNumber_encrypt)) AS 'De-
crypted Bank account number'
            FROM CustomerData.dbo.CustomerInfo;
```

We can see both encrypted and decrypted data in the following screenshot:



	CustID	CustName	Encrypted data	Decrypted Bank account number
1	1	Rajendra	0x008A02FB717BE9479FBD4FEF542A8E9C020000004E6E5D65F5003F7F59095A7404078569D536CA0FCF6ED0F7D7EBB93435E628050E5ABC48F105B9D9AE119DC8E51DED86	11111111
2	2	Manoj	0x008A02FB717BE9479FBD4FEF542A8E9C02000000E7585B1C2B60FB5BCB5A6EA672FA3E6E6DB37FA2B40A5DC9BD078CBCAAA7B092813156DFCFFFA5F4A0D43BD5CB9FAB5C	22222222
3	3	Shyam	0x008A02FB717BE9479FBD4FEF542A8E9C020000000058041D15CD9A0602A8D97929A81A771232FA41C9AA0DF16507E432F9EB523EB5655A43C89B125FAE88E9D20279F885	33333333

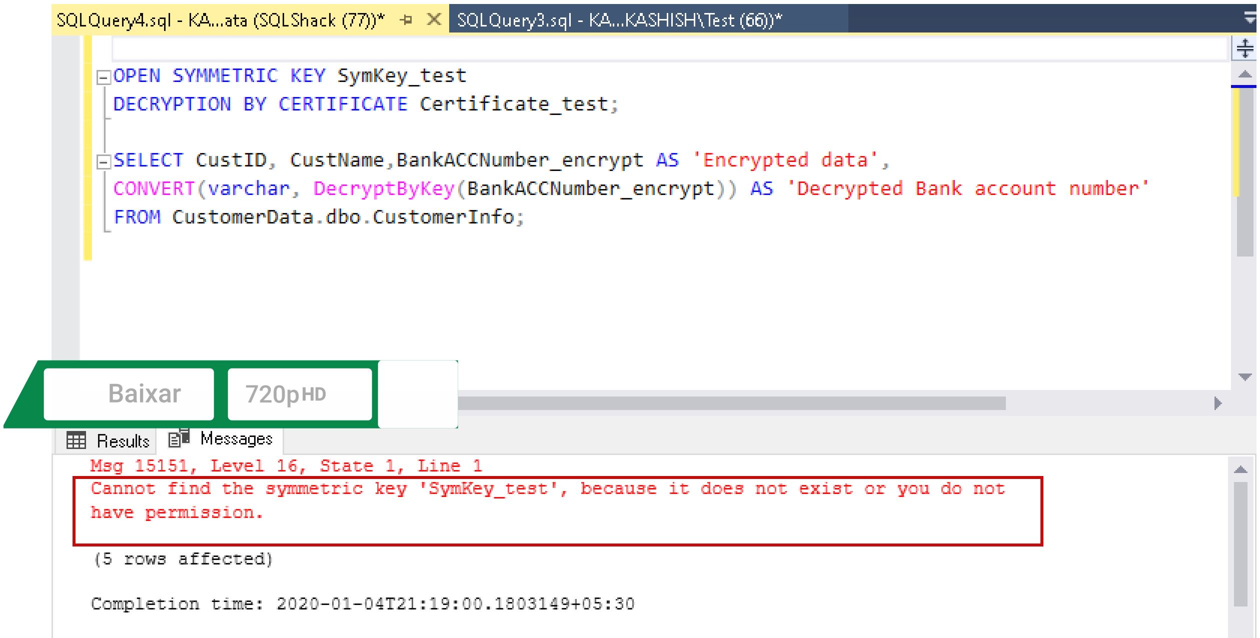
```
USE [master]
GO
CREATE LOGIN [SQLShack] WITH PASSWORD=N'sqlshack', DEFAULT_DATABASE=[CustomerData]
, CHECK_EXPIRATION=OFF, CHECK_POLICY=OFF
GO
USE [CustomerData]
GO
CREATE USER [SQLShack] FOR LOGIN [SQLShack]
GO
USE [CustomerData]
GO
ALTER ROLE [db_datareader] ADD MEMBER [SQLShack]
GO
```

Now connect to SSMS using SQLShack user and execute the query to select the record with decrypting **BankACCNumber_encrypt** column:

```
OPEN SYMMETRIC KEY SymKey_test
DECRYPTION BY CERTIFICATE Certificate_test;

SELECT CustID, CustName,BankACCNumber_encrypt AS 'Encrypted data',
CONVERT(varchar, DecryptByKey(BankACCNumber_encrypt)) AS 'Decrypted Bank account n
umber'
FROM CustomerData.dbo.CustomerInfo;
```

In the output message, we get the message that the symmetric key does not exist, or the user does not have permission to use it:


SQLQuery4.sql - KA...ata (SQLShack (77))*
SQLQuery3.sql - KA...KASHISH\Test (66))*
Results
Messages

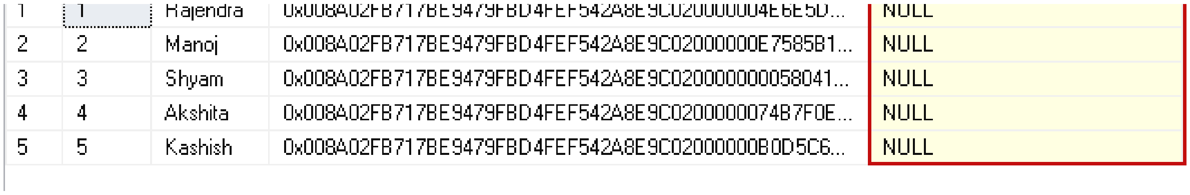
```
OPEN SYMMETRIC KEY SymKey_test
DECRYPTION BY CERTIFICATE Certificate_test;

SELECT CustID, CustName,BankACCNumber_encrypt AS 'Encrypted data',
CONVERT(varchar, DecryptByKey(BankACCNumber_encrypt)) AS 'Decrypted Bank account number'
FROM CustomerData.dbo.CustomerInfo;
```

```
Msg 15151, Level 16, State 1, Line 1
Cannot find the symmetric key 'SymKey_test', because it does not exist or you do not
have permission.

(5 rows affected)

Completion time: 2020-01-04T21:19:00.1803149+05:30
```



1	1	Rajendra	0x008A02FB717BE9479FBD4FEF542A8E9C020000004E6E5D...	NULL
2	2	Manoj	0x008A02FB717BE9479FBD4FEF542A8E9C02000000E7585B1...	NULL
3	3	Shyam	0x008A02FB717BE9479FBD4FEF542A8E9C020000000058041...	NULL
4	4	Akshita	0x008A02FB717BE9479FBD4FEF542A8E9C0200000074B7F0E...	NULL
5	5	Kashish	0x008A02FB717BE9479FBD4FEF542A8E9C02000000B0D5C6...	NULL

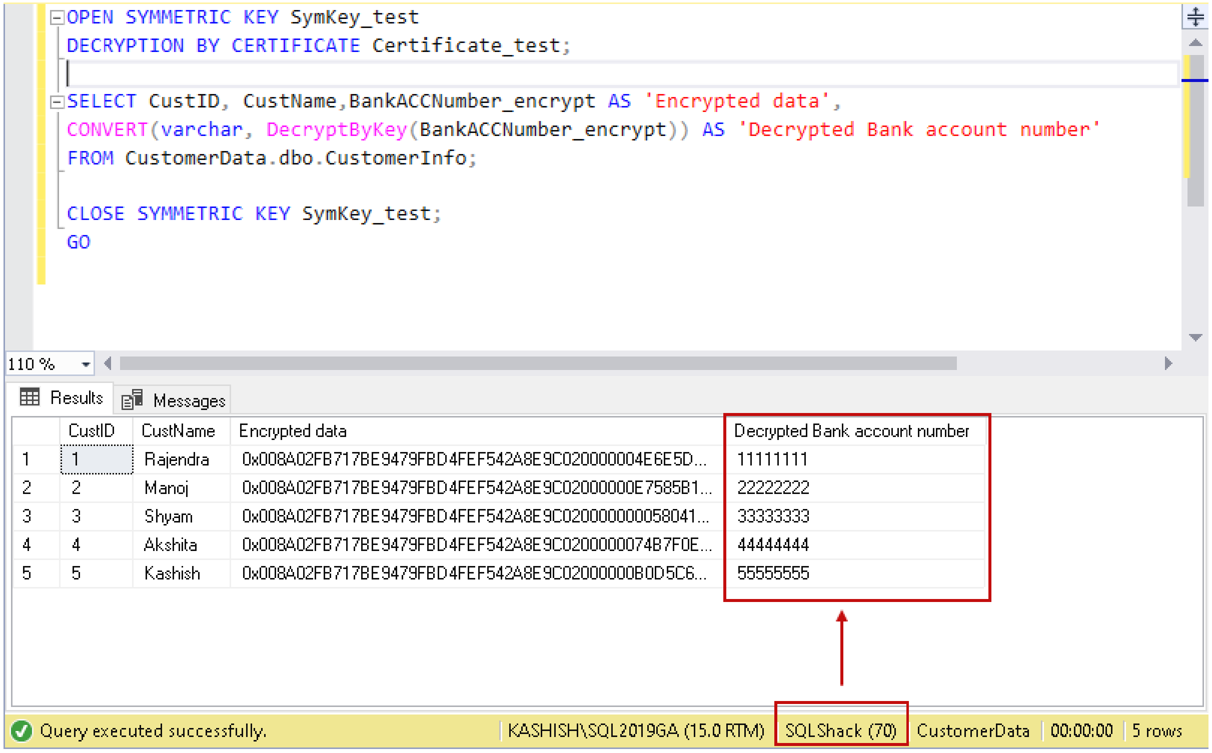
We can provide permissions to the Symmetric key and Certificate:

- **Symmetric key permission**: GRANT VIEW DEFINITION
- **Certificate permission:** GRANT VIEW DEFINITION and GRANT CONTROL permissions

Execute these scripts with from a user account with admin privileges:

```
GRANT VIEW DEFINITION ON SYMMETRIC KEY::SymKey_test TO SQLShack;
GO
GRANT VIEW DEFINITION ON Certificate::[Certificate_test] TO SQLShack;
GO
GRANT CONTROL ON Certificate::[Certificate_test] TO SQLShack;
```

Now, go back and re-execute the SELECT statement:



```
OPEN SYMMETRIC KEY SymKey_test
DECRYPTION BY CERTIFICATE Certificate_test;

SELECT CustID, CustName,BankACCNumber_encrypt AS 'Encrypted data',
CONVERT(varchar, DecryptByKey(BankACCNumber_encrypt)) AS 'Decrypted Bank account number'
FROM CustomerData.dbo.CustomerInfo;

CLOSE SYMMETRIC KEY SymKey_test;
GO
```

	CustID	CustName	Encrypted data	Decrypted Bank account number
1	1	Rajendra	0x008A02FB717BE9479FBD4FEF542A8E9C020000004E6E5D...	11111111
2	2	Manoj	0x008A02FB717BE9479FBD4FEF542A8E9C02000000E7585B1...	22222222
3	3	Shyam	0x008A02FB717BE9479FBD4FEF542A8E9C020000000058041...	33333333
4	4	Akshita	0x008A02FB717BE9479FBD4FEF542A8E9C0200000074B7F0E...	44444444
5	5	Kashish	0x008A02FB717BE9479FBD4FEF542A8E9C02000000B0D5C6...	55555555

Query executed successfully. | KASHISH\SQL2019GA (15.0 RTM) | SQLShack (70) | CustomerData | 00:00:00 | 5 rows

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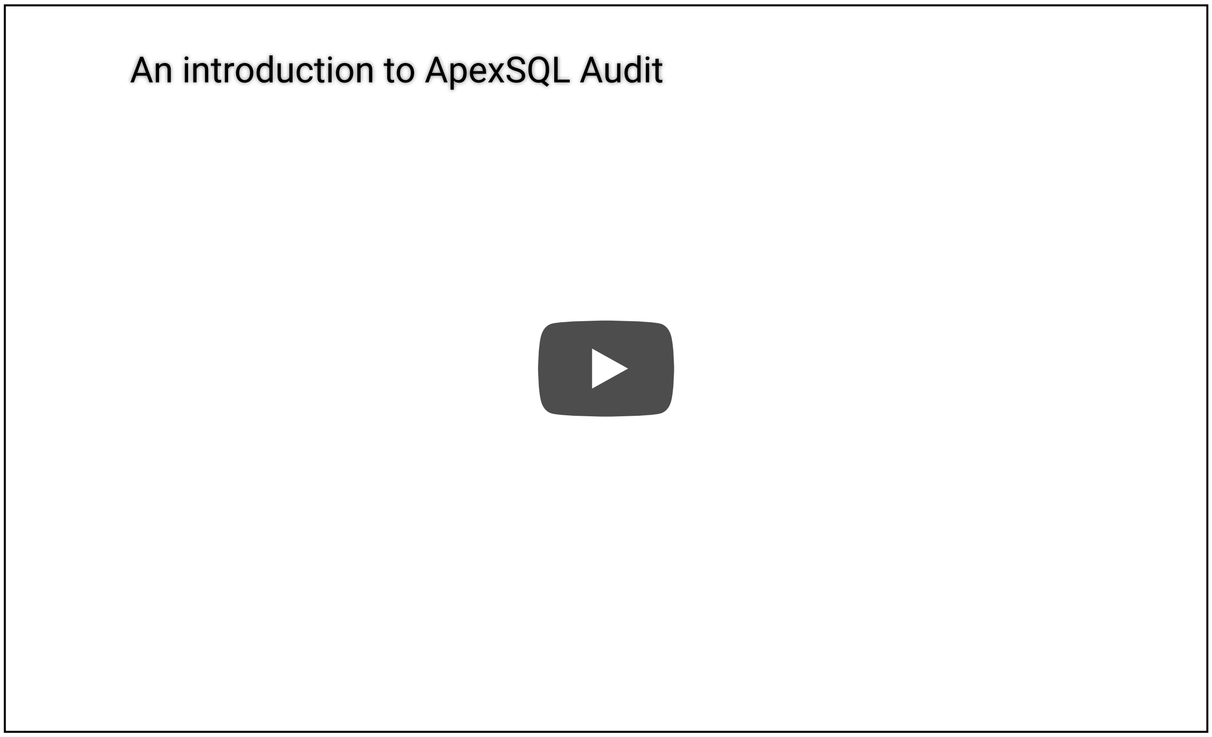

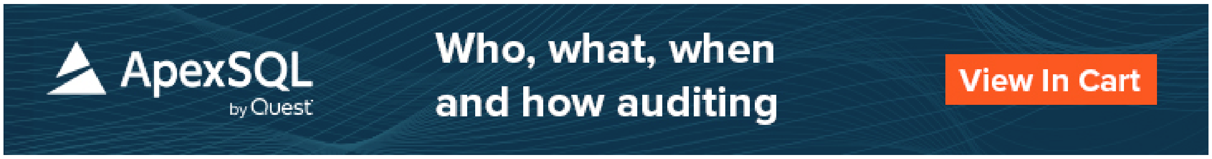

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with various awards including the prestigious "Best author of the year" continuously in 2020 and 2021 at SQLShack.

Raj is always interested in new challenges so if you need consulting help on any subject covered in his writings, he can be reached at rajendra.gupta16@gmail.com

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Do you have any examples using a CA certificate? Does this method have any special caveats?

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Hi,
thx for your post.
I've got an error i don't understand

I try to use this function : decrypt_binarydata and i get this error
Padding is invalid and cannot be removed.

Have experienced it ?