Modernizing SQL Server the right way

Slides in http://aka.ms/tigertoolbox

Under “Sessions” folder

PASS DEVOPS VIRTUAL GROUP

Microsoft

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@SQLPedro

Focus Areas

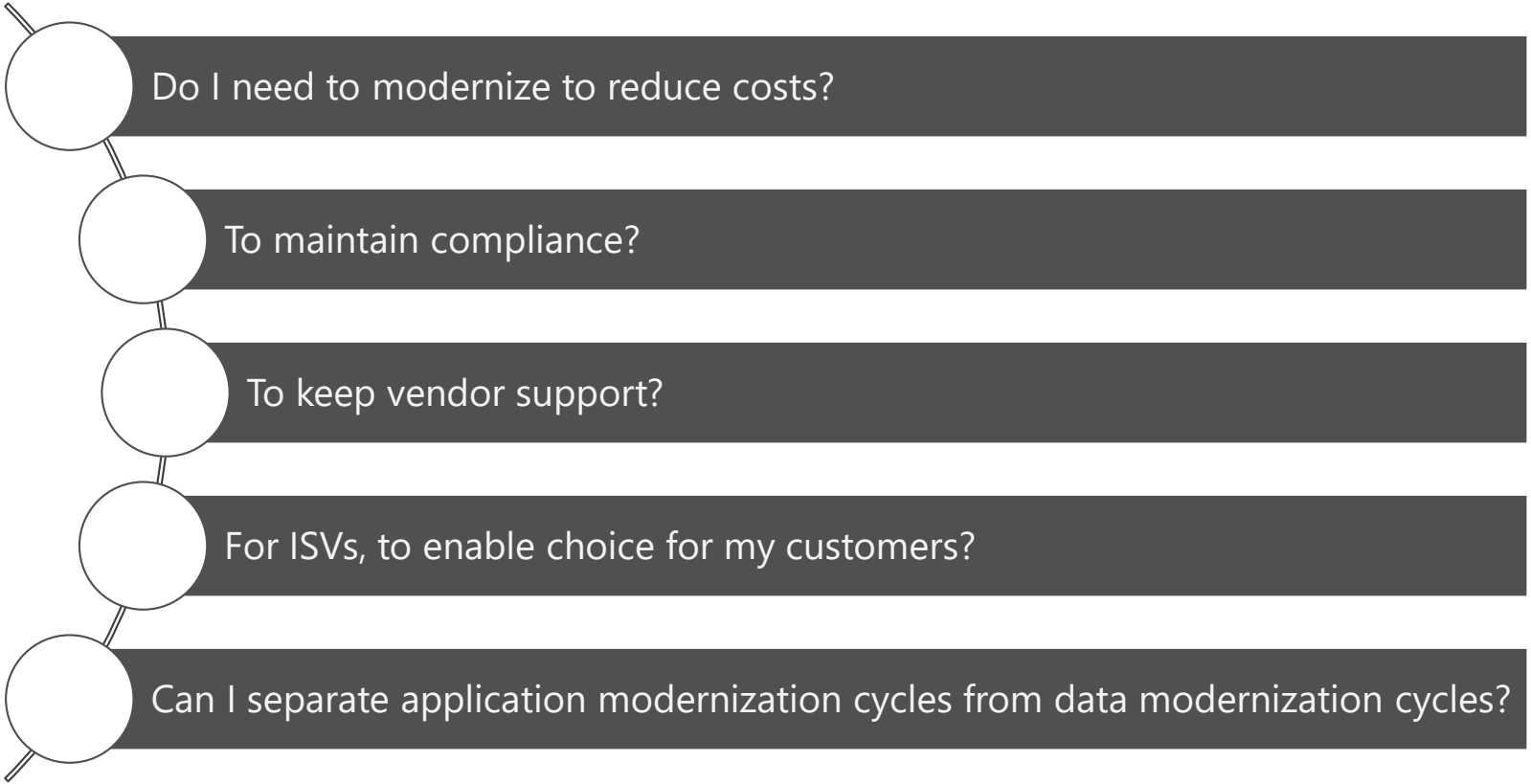
Relational Engine: Query Processor, Programmability, Performance

Agenda

- Why Upgrade?
- Database Compatibility Certification
- Upgrade Process
- Post-migration

Why upgrade?

Is it the right time to modernize?



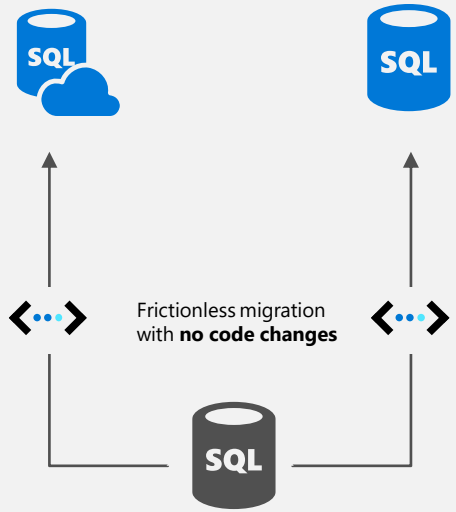
Winter is coming…

Compatibility Certification

Upgrade & modernize SQL Server databases on-premises, in the cloud and on the edge with Compatibility Certification

Reduce risks of application compatibility

Upgrade to the latest SQL Server Database Engine without changing your critical applications



Compatibility Certification benefits

Unified application certification

Applications tested and certified on a given SQL Server version are also implicitly tested and certified on that SQL Server version native database compatibility level

Reduce upgrade risks

Separate application and platform layer upgrade cycles for less disruption

Microsoft fully supports Compatibility Certification

Upgrade to latest SQL Database Engine version

Upgrade your SQL Server Database Engine or move instances to the cloud with no code changes

Database Compatibility Level protection with Microsoft

Microsoft provides an ecosystem of tools and services to test whether Compatibility Certification is right for you and protect you as you upgrade

Maintain backwards compatibility

Applications running on a newer SQL Server Database Engine while using an older Database Compatibility Level can still leverage server-level enhancements without application changes

Database Compatibility Level settings affect behaviors for a specified database, not the entire server

Predictable performance

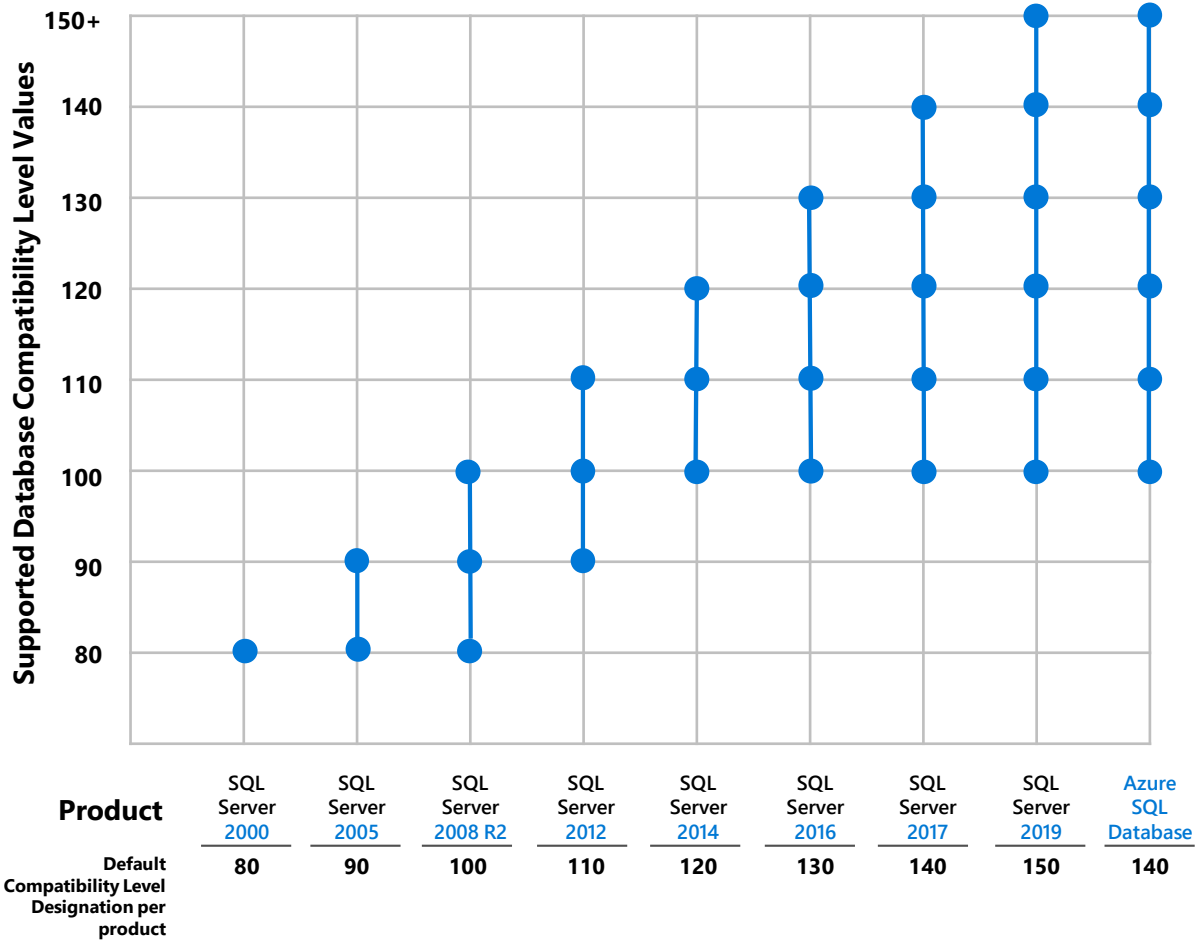
Microsoft gates query optimization changes and improvements behind Database Compatibility Level to upgrade without issues once validation testing is successfully completed

Validation testing tools

Use Data Migration Assistant (DMA) to validate your readiness to upgrade

The DMA tool validation results help protect applications from any functional regressions on target versions

Learn more here: http://aka.ms/dbcompat



Explore your Database Compatibility Level supported values

Upgrade from any earlier version of SQL Server and the database retains its existing compatibility level if it is at least minimum allowed for that instance of SQL Server

For example, SQL Server 2008 databases have supported compatibility up to SQL Server 2019 and Azure SQL Database

Functional change protection – Clarifying the caveats

- Breaking Changes = behavior changes resulting in different outcome
- Protected by Database Compatibility:

```
DECLARE @value datetime = '1900-01-01 00:00:00.003'
SELECT CAST(@value AS datetime2)
```

  - In DB Compat 120 or lower, result is:
    `1900-01-01 00:00:00.0030000`
  - Under DB Compat 130, these show improved accuracy by accounting for the fractional milliseconds, resulting in:
    `1900-01-01 00:00:00.0033333`
- Not Protected by Database Compatibility:
  - The query below works until DB Compat 90, but errors out starting with Database Compatibility 100 (error 241, conversion fail):
    `SELECT DATEPART (year, '2007/05-30')`
  - Instead use:
    `SELECT DATEPART (year, '2007/05/30')` or `SELECT DATEPART (year, '2007-05-30')`

Functional change protection - Clarifying the caveats

- Deprecated = avoid use in new development
  - Deprecated functionality introduced in a given SQL Server version is still protected by that compatibility level.
- Discontinued = removed from product
  - Discontinued functionality introduced in a given SQL Server version is not protected by compatibility level.
- Removed T-SQL syntax.
  - In SQL Server 2012 the `fastfirstrow` hint was removed.
  - Regardless of the compatibility level, the query below will produce error 321 (not a recognized table hints option):
    ```
    SELECT * FROM HumanResources.Employee WITH (FASTFIRSTROW);
    ```
  - Instead use:
    ```
    SELECT * FROM HumanResources.Employee OPTION (FAST = <n>);
    ```

Feature Roadmaps

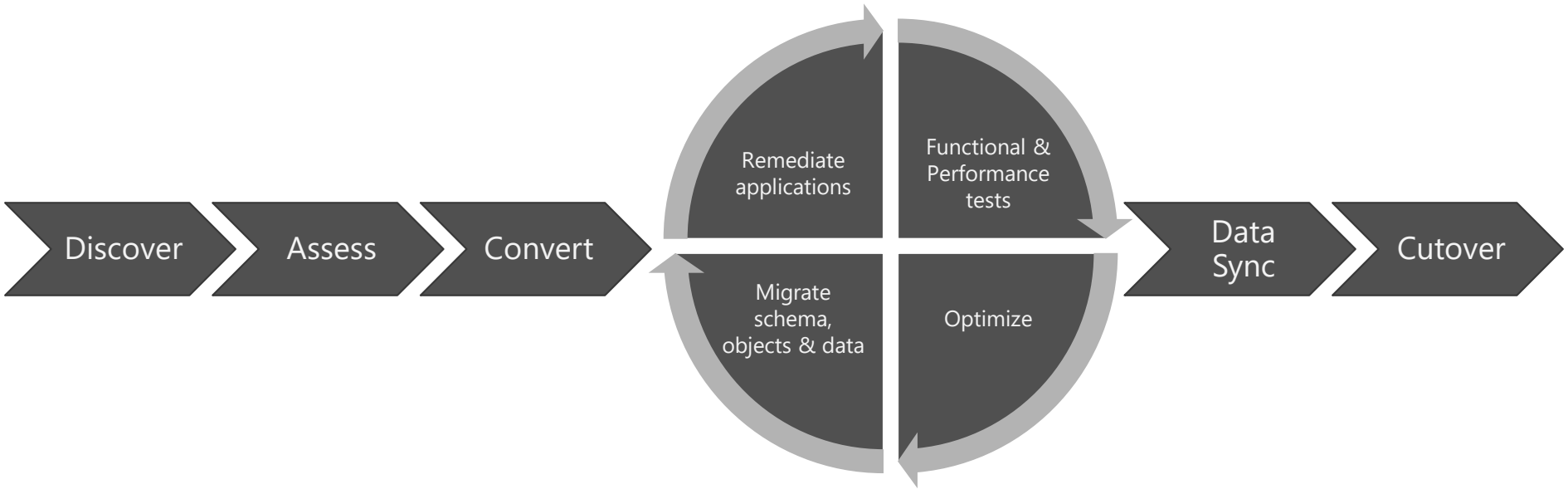
- For new development work, or when an existing application requires use of **new features**, as well as **performance improvements** done in the query optimizer space, plan to certify on the latest database compatibility level…

Upgrade Process

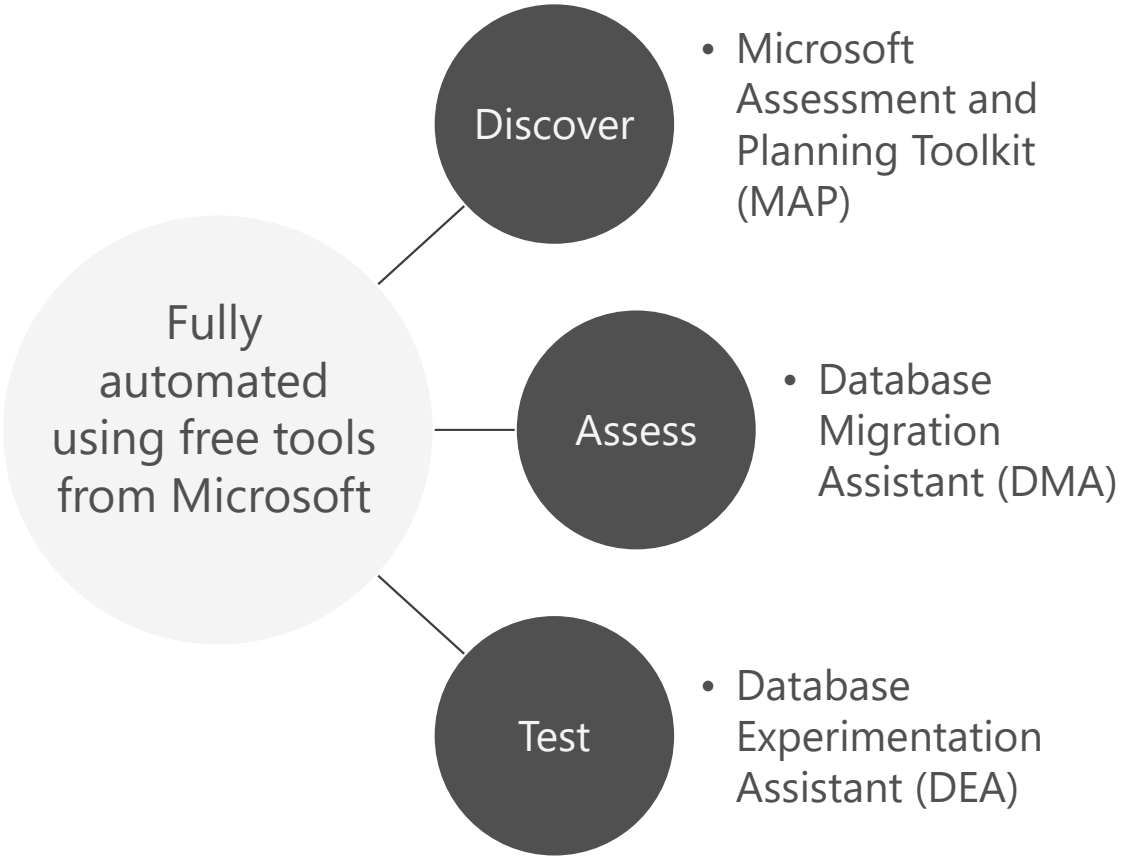
Traditional Upgrade Strategies

Feature	Notes
Log Shipping	Cutover measured in (typically) minutes
Replication	Cutover measured in (potentially) seconds
Backup and Restore	This is going to take a while!
Filesystem/SAN Copy	Ditto - the latter being significantly faster
Availability Groups (NOT available in < 2012)	Cutover measured in (typically) seconds

Minimize Risk with the Database Migration Guide

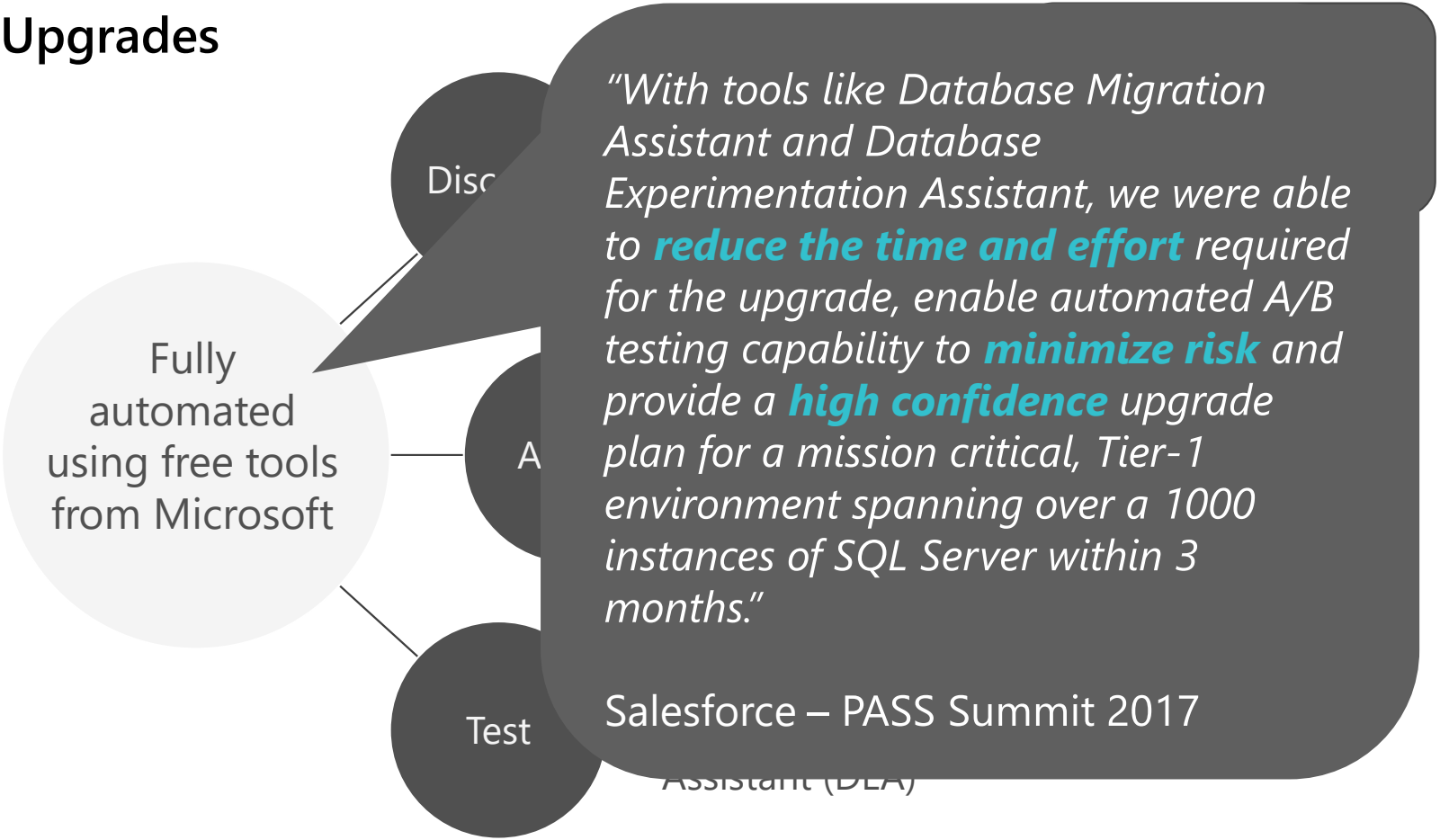


Reliable Upgrades

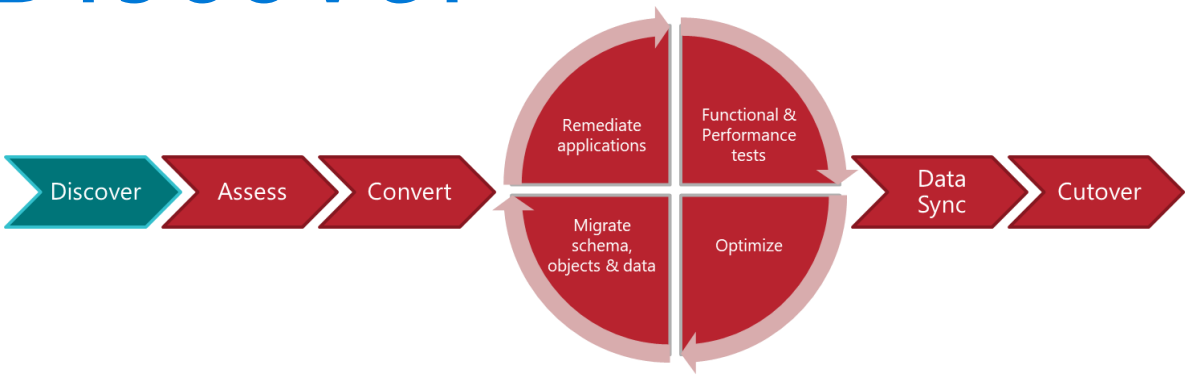


Review the Database Migration Guide for details

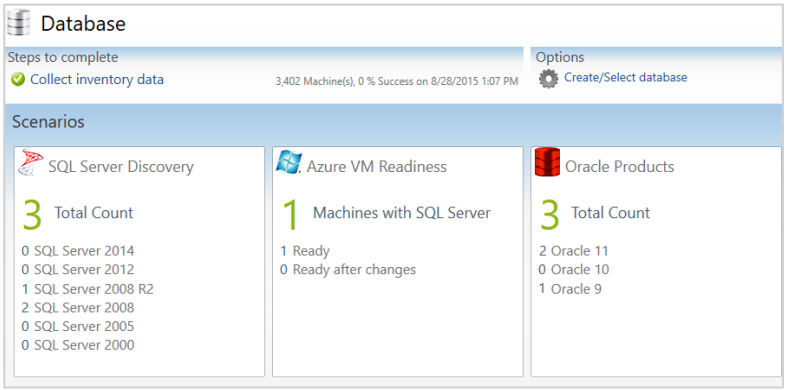
Reliable Upgrades



Discover

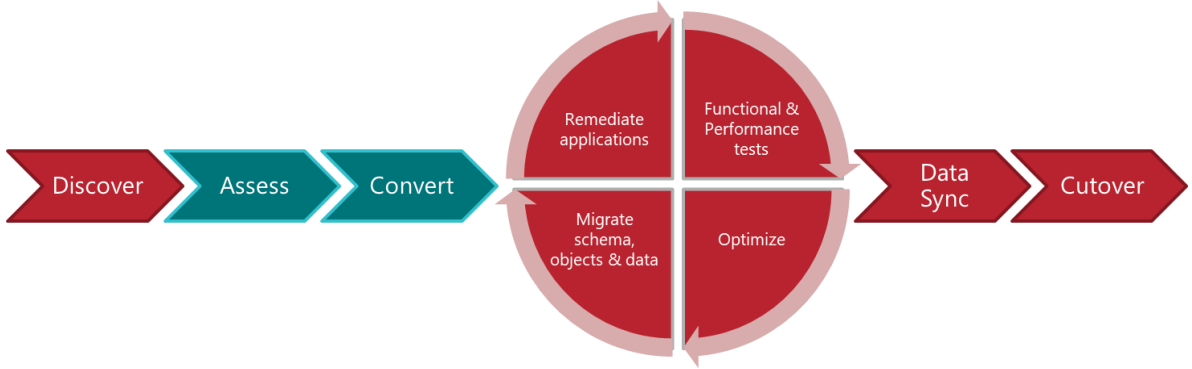

Discover
Assess
Convert
Remediate applications
Functional & Performance tests
Migrate schema, objects & data
Optimize
Data Sync
Cutover

Discover with MAP Toolkit

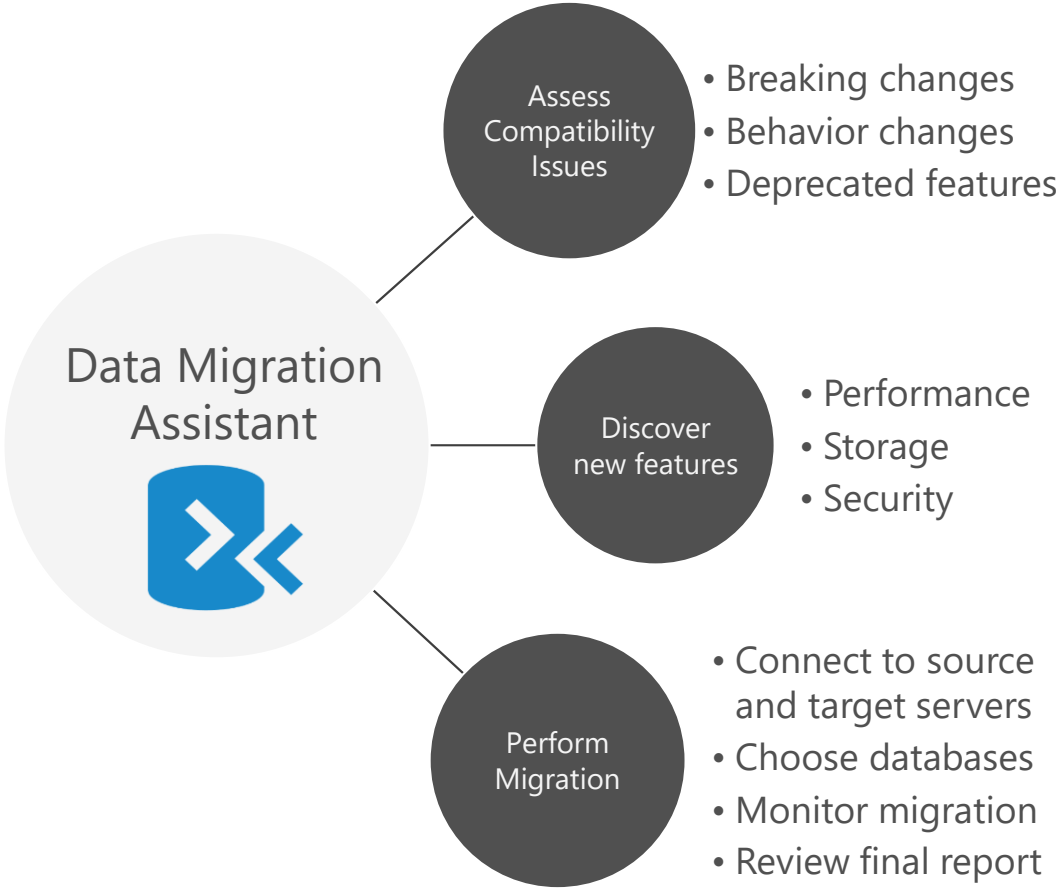


- Which SQL Server versions do I have?
- Which Editions am I running?
- Which SQL Server components are installed?
- How many cores are on each server?
- How many databases are in each instance?
- What are the sizes of all my databases?
- What are the settings for each instance and database?

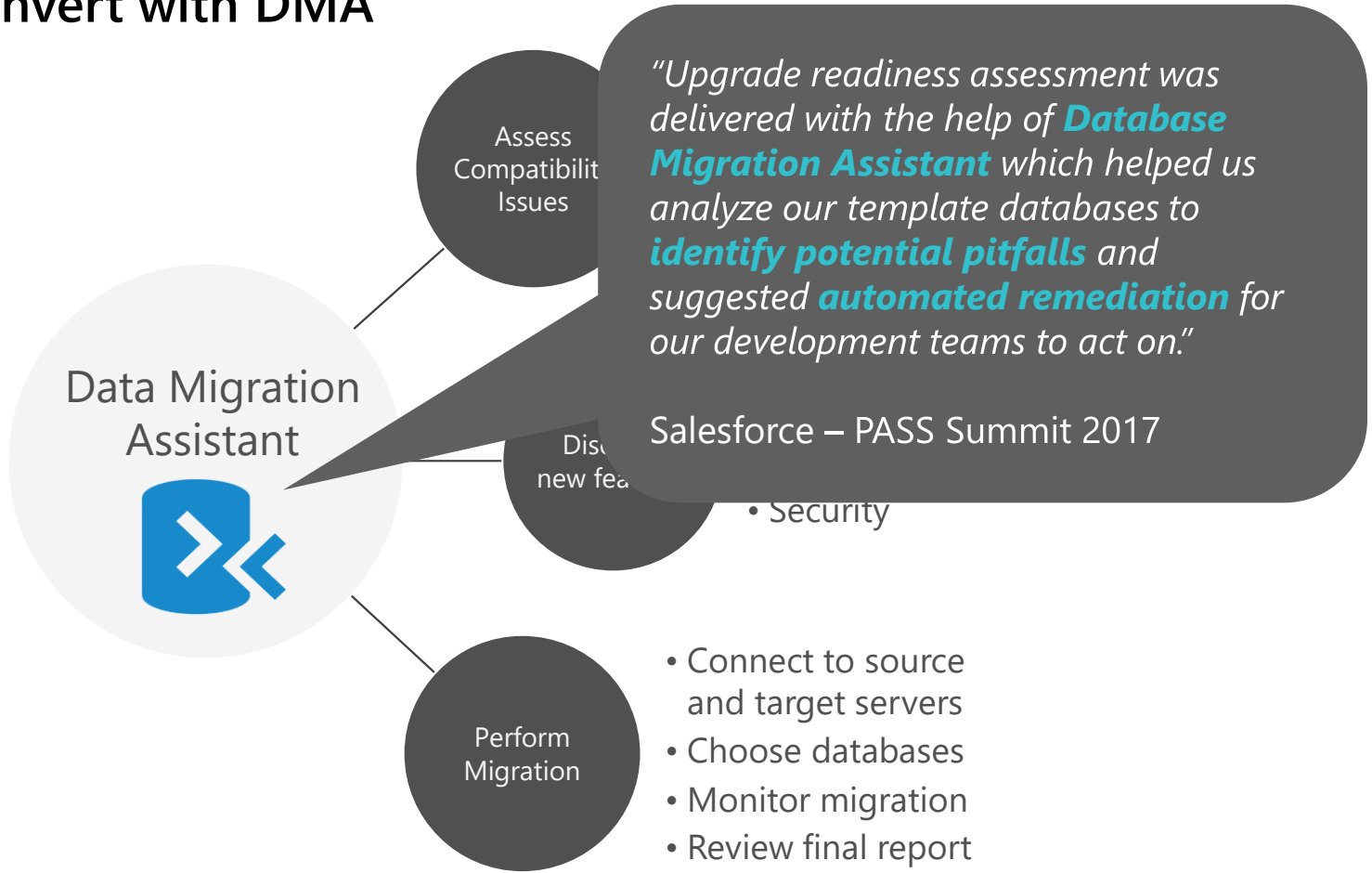
Assess & Convert



Assess & Convert with DMA



Assess & Convert with DMA



WALKTHROUGH

Database Migration Assistant

Note: v4.3 includes adhoc workload assessment

Data Migration Assistant

Get started here

+ New

Use + to create a new project.

Welcome to Data Migration Assistant

Data Migration Assistant

New

Project type

Assessment

Migration

Project name

Inventory-Assessment1

Source server type

SQL Server

SQL Server

AWS RDS for SQL Server

Azure SQL Database

Create

Welcome to Data Migration Assistant

Data Migration Assistant

New

Project type

Assessment

Migration

Project name

Inventory-Assessment1

Source server type

SQL Server

Target server type

Azure SQL Database

Azure SQL Database

Azure SQL Database Managed Instance

SQL Server on Azure Virtual Machines

SQL Server

Welcome to Data Migration Assistant

Data Migration Assistant

Inventory-Assessment1

Delete Assessment

1 Options | 2 Select sources | 3 Review results

Select target version

SQL Server 2017 on Windows

Select report type

- [x] **Compatibility Issues**
  Discover breaking changes, behavior changes, and deprecated features by analyzing the databases you chose in your source server to be migrated to a new SQL Server platform.
- [ ] **New features' recommendation**
  Discover new SQL Server features that are applicable to the databases and tables in your source server once migrated to the new target SQL Server platform.
- [ ] **Check feature parity**
  Discover unsupported or partially-supported features and functions that your applications may rely on. Get guidance around these areas that may need some re-engineering.

Next

Data Migration Assistant

Inventory-Assessment1

Delete Assessment

1 Options | 2 Select sources | 3 Review results

Select target version

SQL Server 2017 on Windows

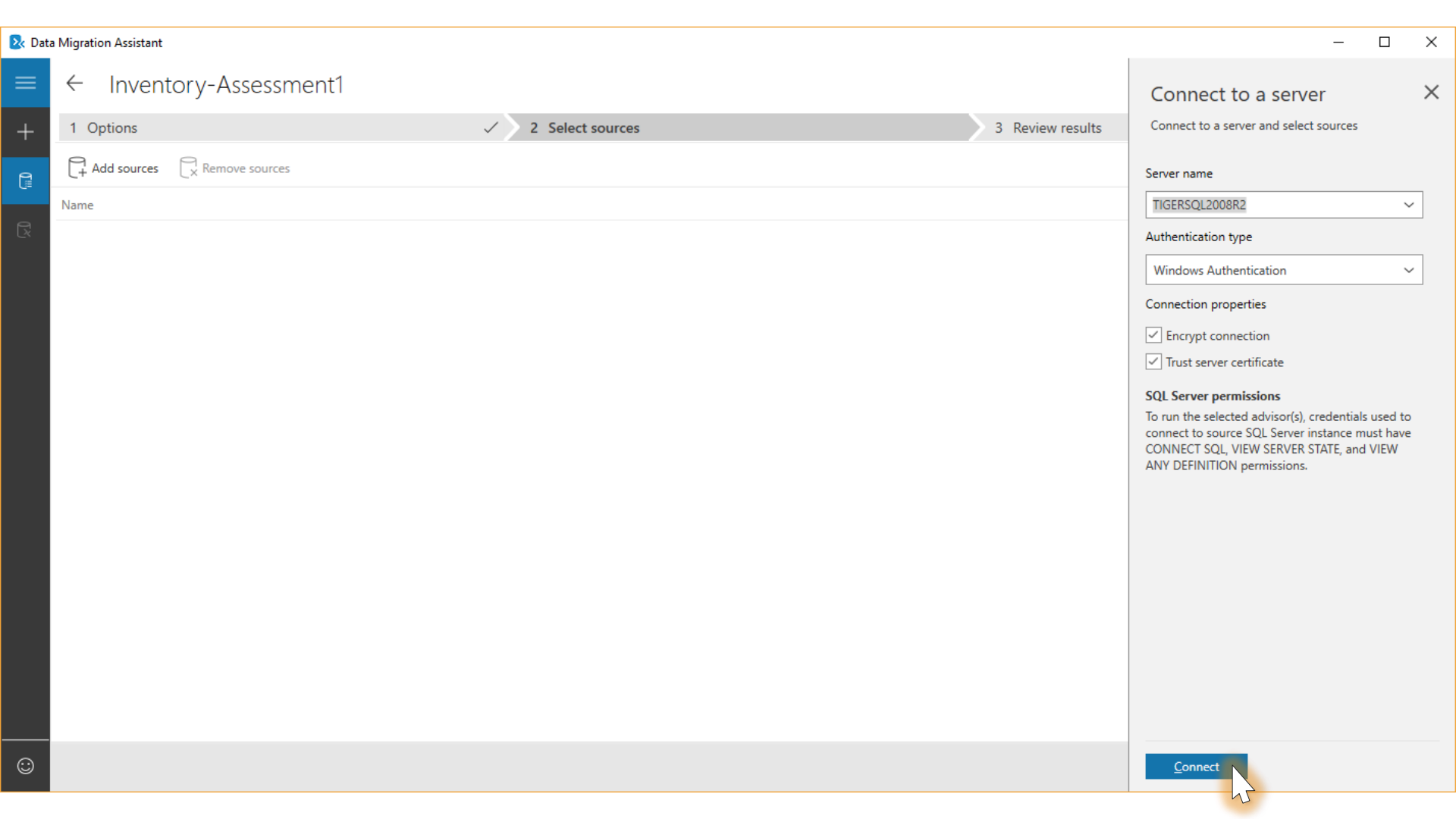
- SQL Server 2012
- SQL Server 2014
- SQL Server 2016
- SQL Server 2017 on Linux
- SQL Server 2017 on Windows

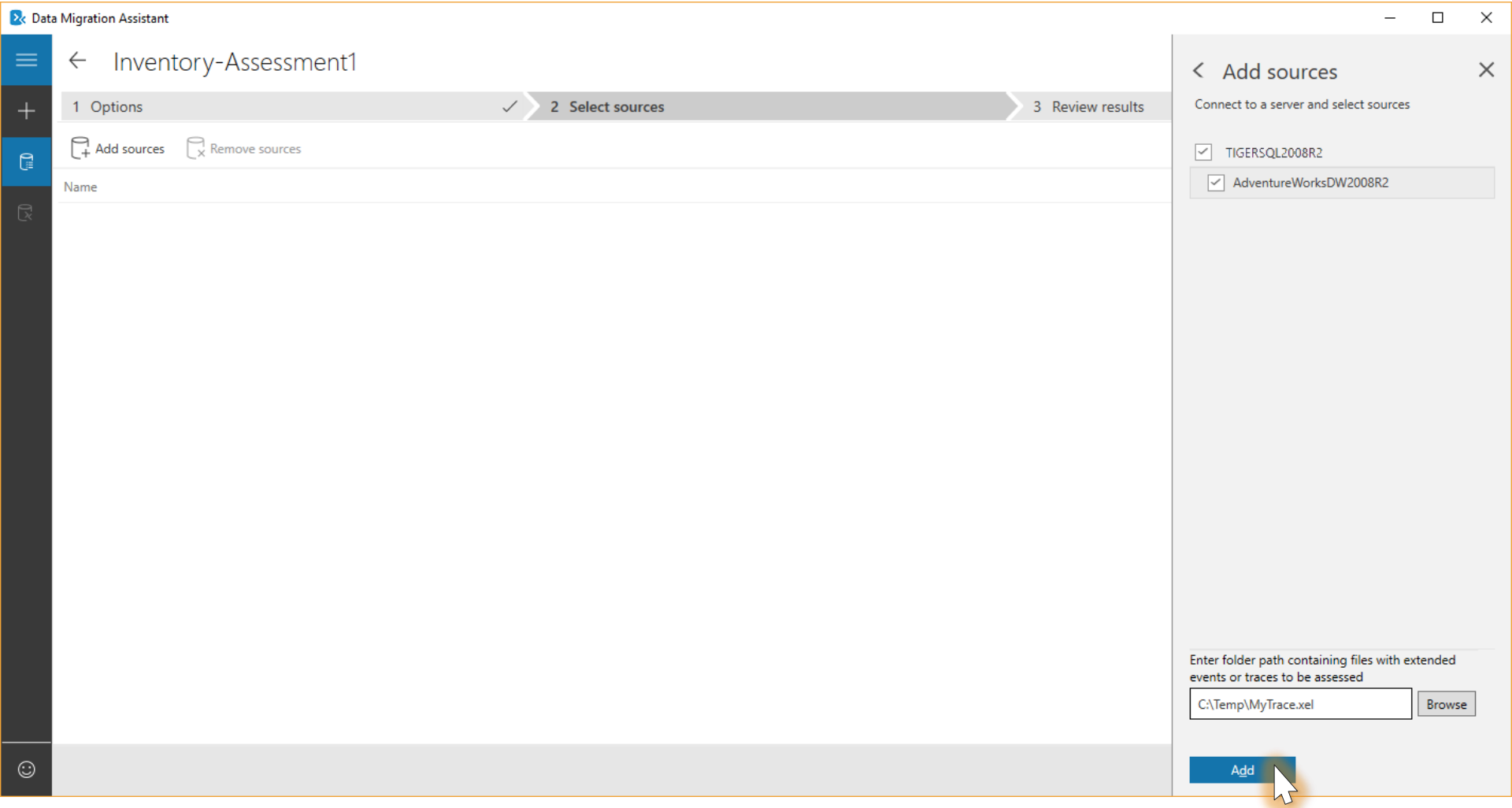
ior changes, and deprecated features by analyzing the databases you chose in your source server to be migrated to a new SQL Server platform.

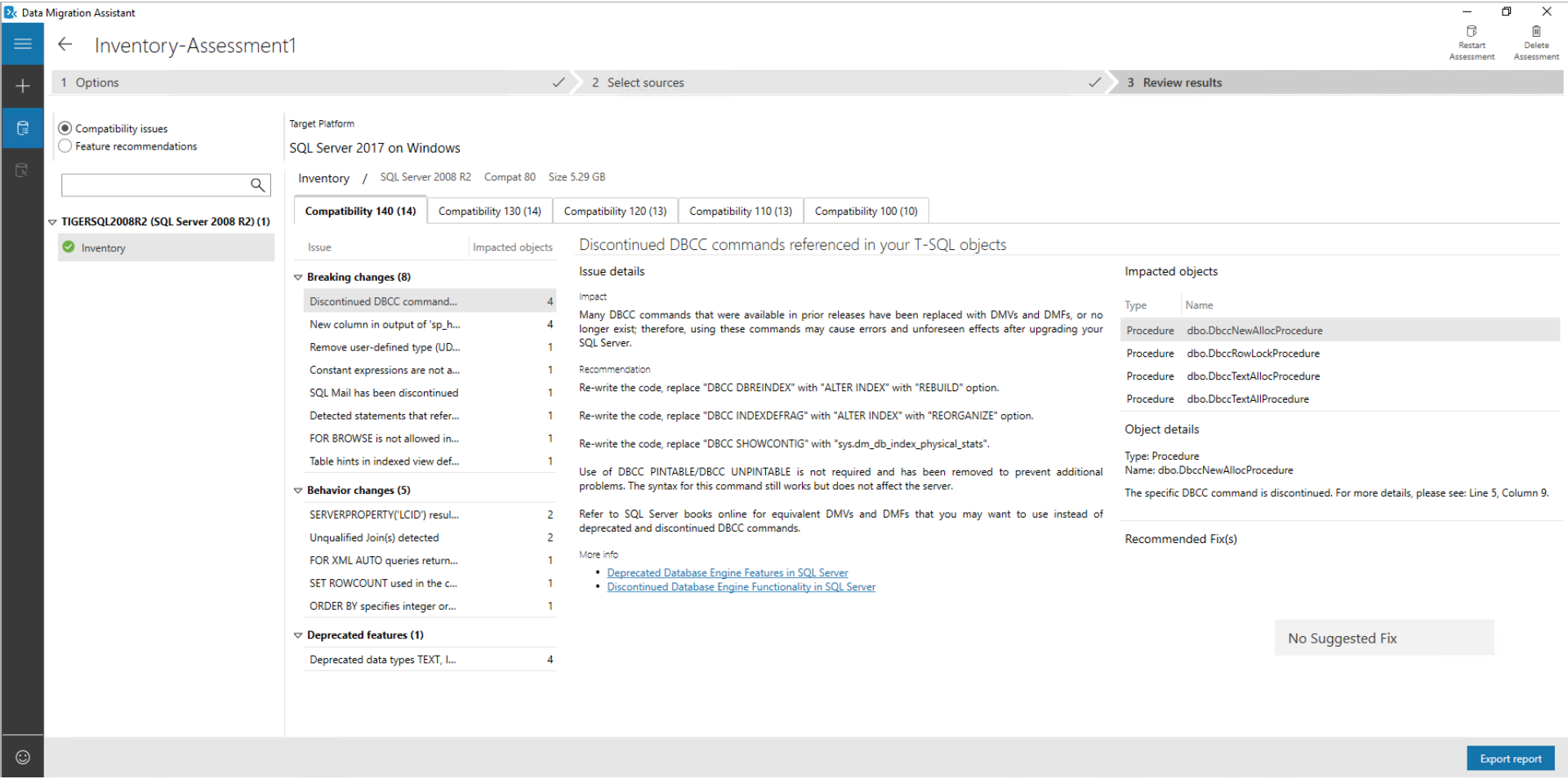
New features' recommendation
Discover new SQL Server features that are applicable to the databases and tables in your source server once migrated to the new target SQL Server platform.

Check feature parity
Discover unsupported or partially-supported features and functions that your applications may rely on. Get guidance around these areas that may need some re-engineering.

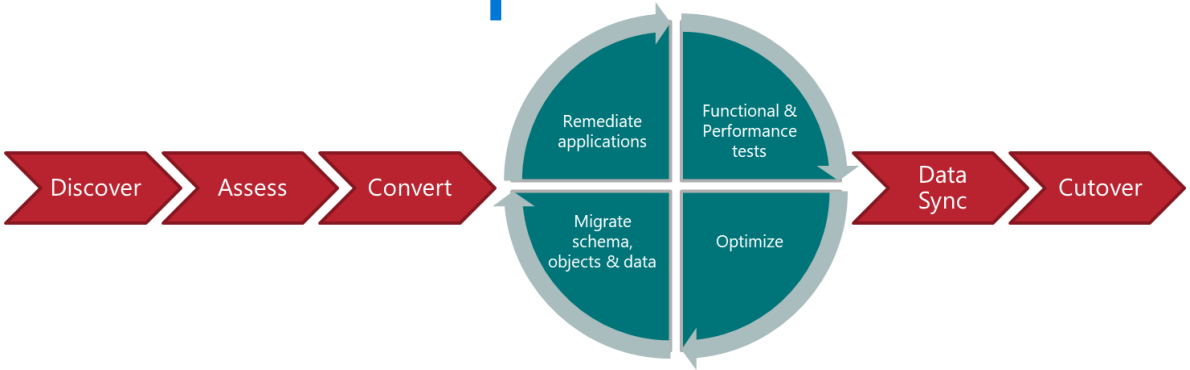
Next


Data Migration Assistant
Inventory-Assessment1
1 Options
2 Select sources
3 Review results
Add sources
Remove sources
Name
Connect to a server
Connect to a server and select sources
Server name
TIGERSQL2008R2
Authentication type
Windows Authentication
Connection properties
Encrypt connection
Trust server certificate
SQL Server permissions
To run the selected advisor(s), credentials used to connect to source SQL Server instance must have CONNECT SQL, VIEW SERVER STATE, and VIEW ANY DEFINITION permissions.
Connect

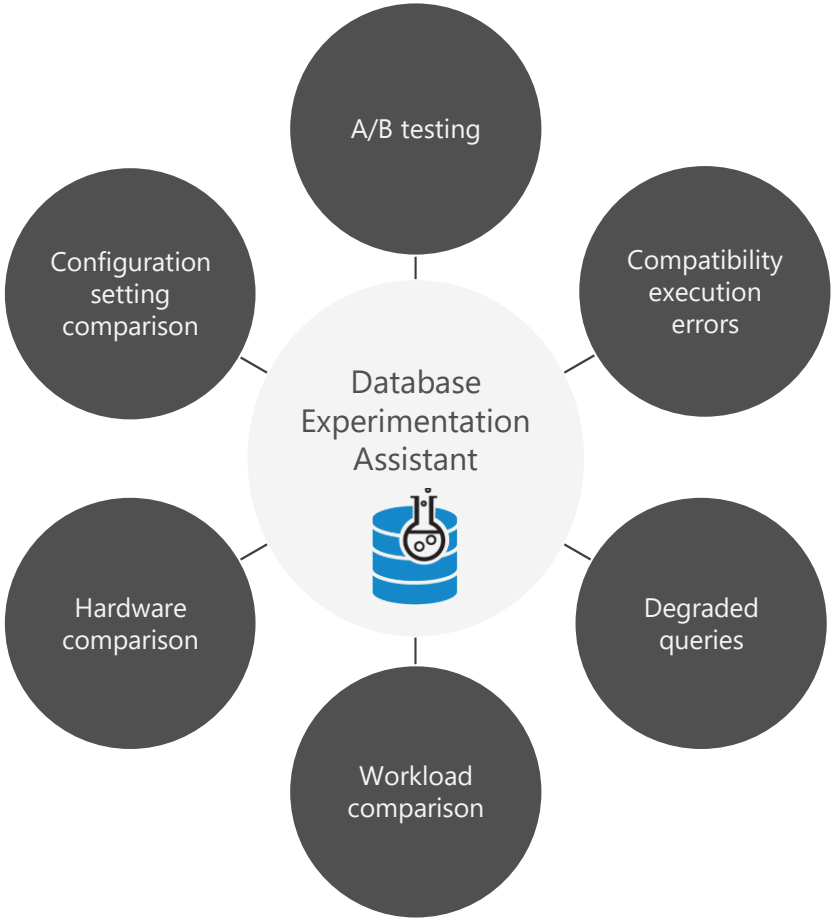

Data Migration Assistant
Inventory-Assessment1
1 Options
2 Select sources
3 Review results
Add sources
Remove sources
Name
Add sources
Connect to a server and select sources
TIGERSQL2008R2
AdventureWorksDW2008R2
Enter folder path containing files with extended events or traces to be assessed
C:\Temp\MyTrace.xel
Browse
Add


Data Migration Assistant
Inventory-Assessment1
Restart Assessment
Delete Assessment
1 Options
2 Select sources
3 Review results
Compatibility issues
Feature recommendations
TIGERSQL2008R2 (SQL Server 2008 R2) (1)
Inventory
Target Platform
SQL Server 2017 on Windows
Inventory / SQL Server 2008 R2 Compat 80 Size 5.29 GB
Compatibility 140 (14)
Compatibility 130 (14)
Compatibility 120 (13)
Compatibility 110 (13)
Compatibility 100 (10)
Issue
Impacted objects
Breaking changes (8)
Discontinued DBCC command... 4
New column in output of 'sp_h... 4
Remove user-defined type (UD... 1
Constant expressions are not a... 1
SQL Mail has been discontinued 1
Detected statements that refer... 1
FOR BROWSE is not allowed in... 1
Table hints in indexed view def... 1
Behavior changes (5)
SERVERPROPERTY('LCID') resul... 2
Unqualified Join(s) detected 2
FOR XML AUTO queries return... 1
SET ROWCOUNT used in the c... 1
ORDER BY specifies integer or... 1
Deprecated features (1)
Deprecated data types TEXT, I... 4
Discontinued DBCC commands referenced in your T-SQL objects
Issue details
Impact
Many DBCC commands that were available in prior releases have been replaced with DMVs and DMFs, or no longer exist; therefore, using these commands may cause errors and unforeseen effects after upgrading your SQL Server.
Recommendation
Re-write the code, replace "DBCC DBREINDEX" with "ALTER INDEX" with "REBUILD" option.
Re-write the code, replace "DBCC INDEXDEFRAG" with "ALTER INDEX" with "REORGANIZE" option.
Re-write the code, replace "DBCC SHOWCONTIG" with "sys.dm_db_index_physical_stats".
Use of DBCC PINTABLE/DBCC UNPINTABLE is not required and has been removed to prevent additional problems. The syntax for this command still works but does not affect the server.
Refer to SQL Server books online for equivalent DMVs and DMFs that you may want to use instead of deprecated and discontinued DBCC commands.
More info
Deprecated Database Engine Features in SQL Server
Discontinued Database Engine Functionality in SQL Server
Impacted objects
Type
Name
Procedure dbo.DbccNewAllocProcedure
Procedure dbo.DbccRowLockProcedure
Procedure dbo.DbccTextAllocProcedure
Procedure dbo.DbccTextAllProcedure
Object details
Type: Procedure
Name: dbo.DbccNewAllocProcedure
The specific DBCC command is discontinued. For more details, please see: Line 5, Column 9.
Recommended Fix(s)
No Suggested Fix
Export report

Test & Optimize



Test & Optimize with DEA

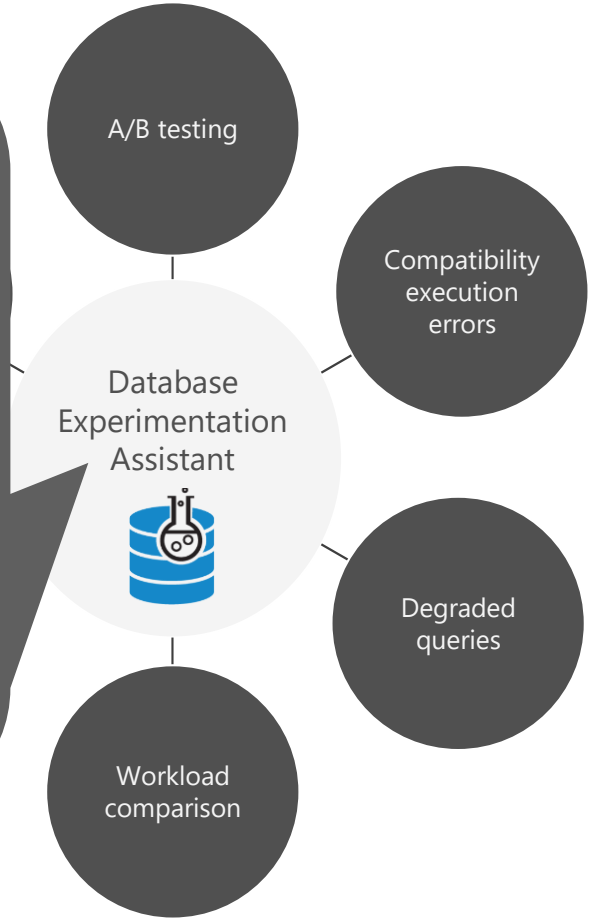


Test & Optimize with DEA

*"**Database Experimentation Assistant** helped us perform comparison tests between our current environment and a test SQL Server 2016 environment to identify **regressions**, **breaking changes** and **performance characteristics**.*

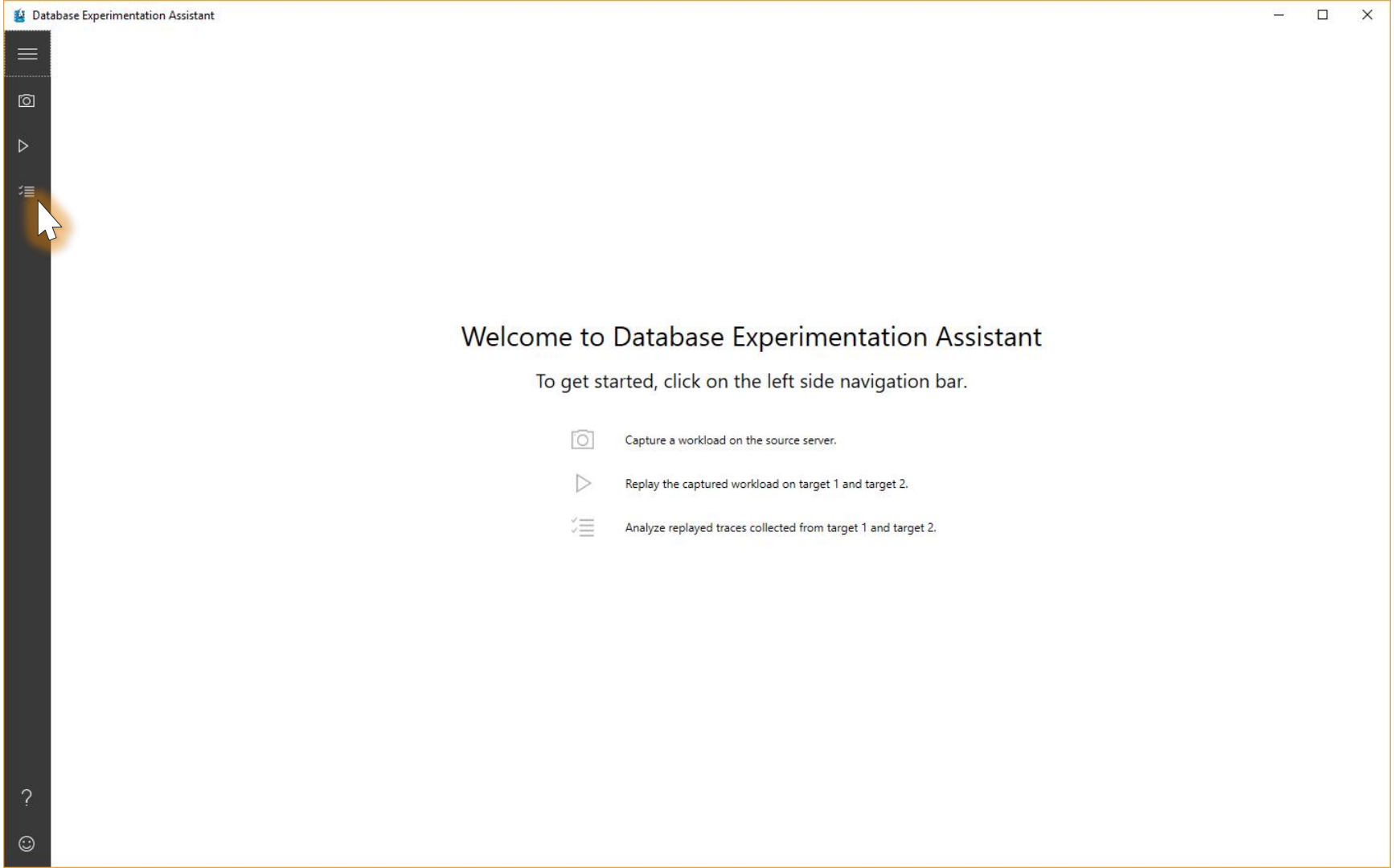
*Because of the **automation**, we were able to repeat such an exercise with multiple iterations using **different configuration settings**."*

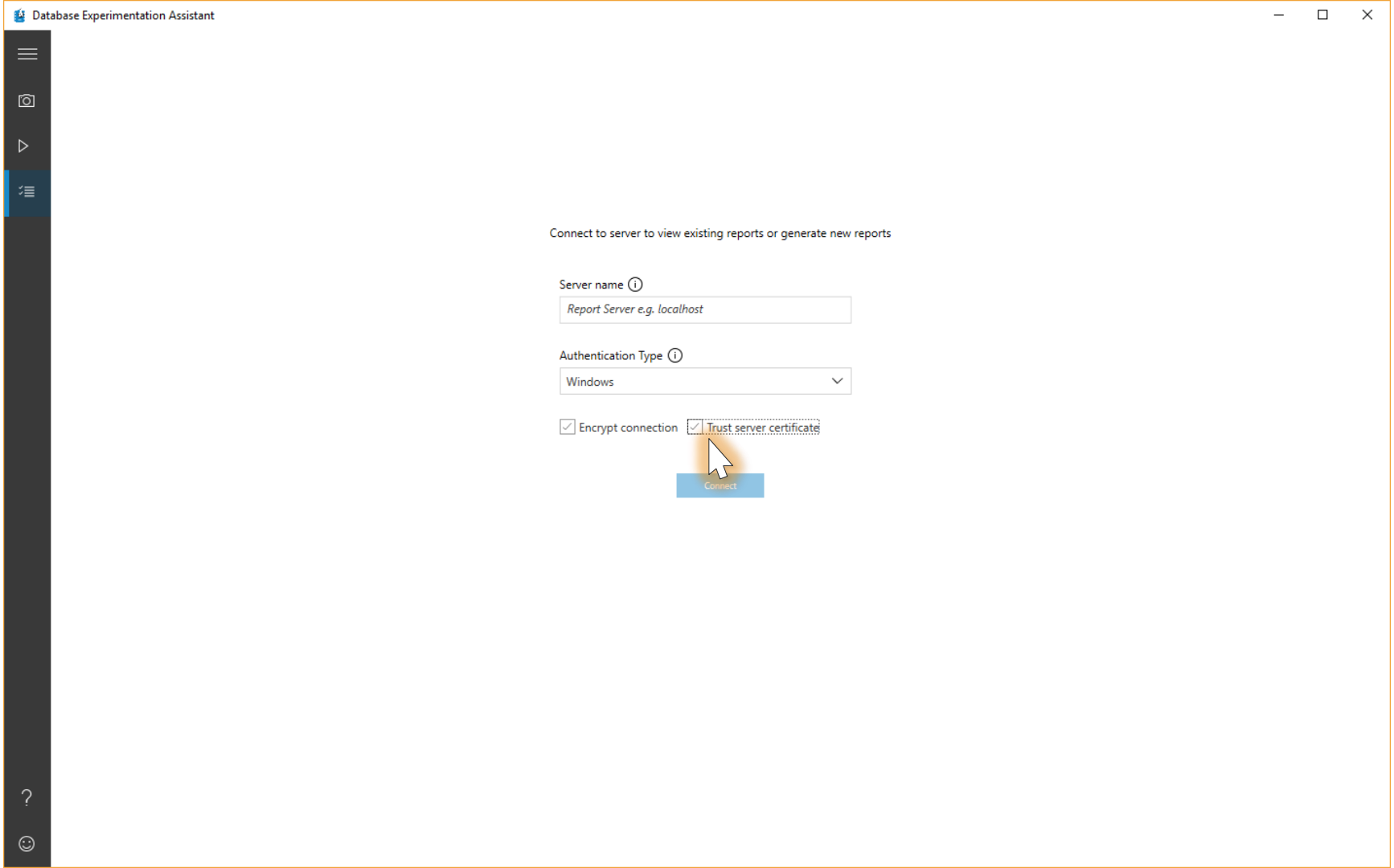
Salesforce – PASS Summit 2017

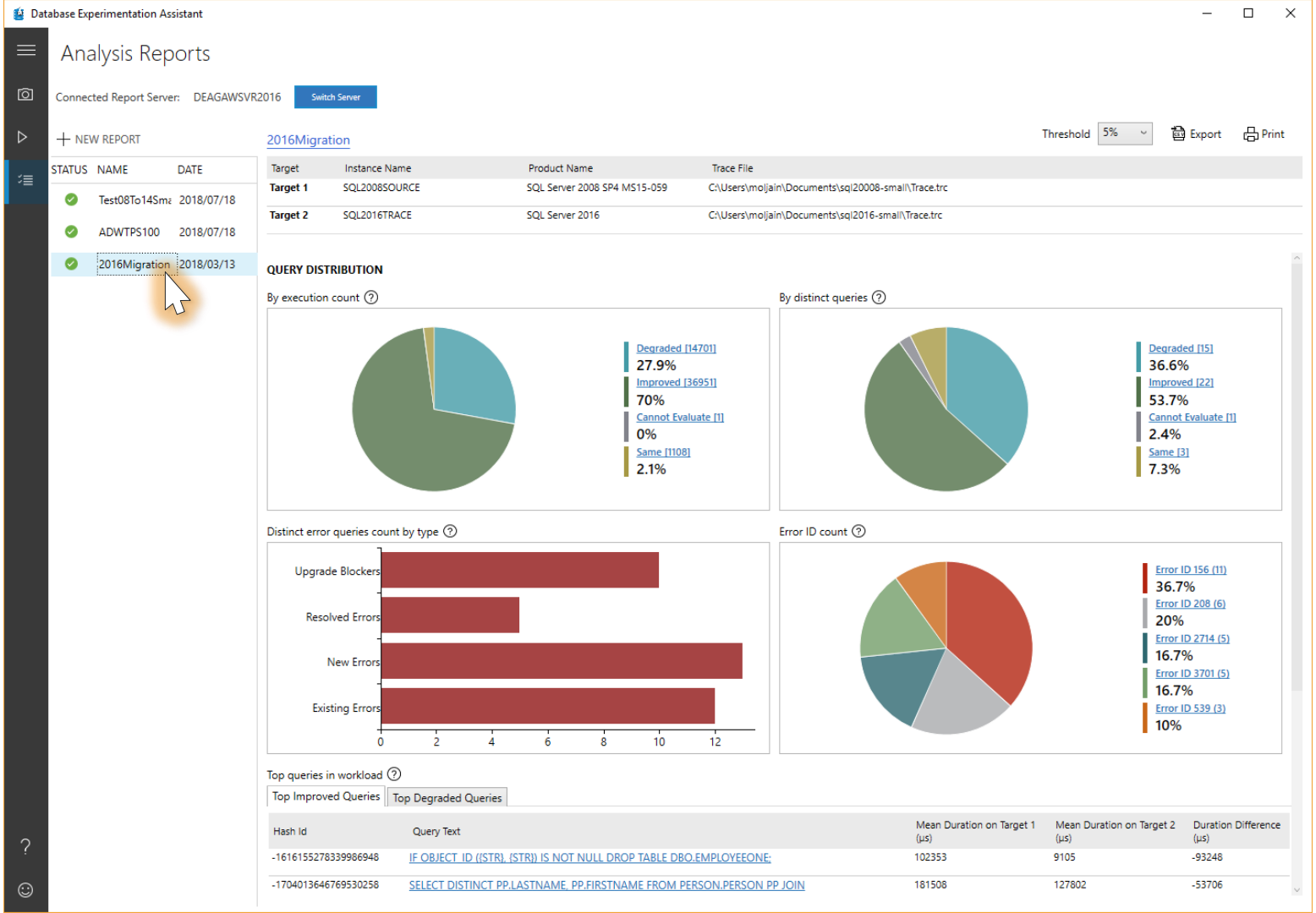


WALKTHROUGH

Database Experimentation Assistant


Database Experimentation Assistant
Welcome to Database Experimentation Assistant
To get started, click on the left side navigation bar.
Capture a workload on the source server.
Replay the captured workload on target 1 and target 2.
Analyze replayed traces collected from target 1 and target 2.


Database Experimentation Assistant
Connect to server to view existing reports or generate new reports
Server name
Report Server e.g. localhost
Authentication Type
Windows
Encrypt connection
Trust server certificate
Connect


Database Experimentation Assistant
Analysis Reports
Connected Report Server: DEAGAWSVR2016
Switch Server
NEW REPORT
STATUS NAME DATE
Test08To14Sma 2018/07/18
ADWTPS100 2018/07/18
2016Migration 2018/03/13
2016Migration
Threshold 5%
Export
Print
Target Instance Name Product Name Trace File
Target 1 SQL2008SOURCE SQL Server 2008 SP4 MS15-059 C:\Users\moljain\Documents\sql2008-small\Trace.trc
Target 2 SQL2016TRACE SQL Server 2016 C:\Users\moljain\Documents\sql2016-small\Trace.trc
QUERY DISTRIBUTION
By execution count
Degraded [14701] 27.9%
Improved [36951] 70%
Cannot Evaluate [1] 0%
Same [1108] 2.1%
By distinct queries
Degraded [15] 36.6%
Improved [22] 53.7%
Cannot Evaluate [1] 2.4%
Same [3] 7.3%
Distinct error queries count by type
Upgrade Blockers
Resolved Errors
New Errors
Existing Errors
0 2 4 6 8 10 12
Error ID count
Error ID 156 (11) 36.7%
Error ID 208 (6) 20%
Error ID 2714 (5) 16.7%
Error ID 3701 (5) 16.7%
Error ID 539 (3) 10%
Top queries in workload
Top Improved Queries
Top Degraded Queries
Hash Id Query Text Mean Duration on Target 1 (µs) Mean Duration on Target 2 (µs) Duration Difference (µs)
-1616155278339986948 IF OBJECT_ID ([STR], [STR]) IS NOT NULL DROP TABLE DBO.EMPLOYEEONE; 102353 9105 -93248
-1704013646769530258 SELECT DISTINCT PP.LASTNAME, PP.FIRSTNAME FROM PERSON.PERSON PP JOIN 181508 127802 -53706

Database Experimentation Assistant

Analysis Reports

Connected Report Server: DEAGAWSVR2016 Switch Server

+ NEW REPORT

STATUS	NAME	DATE
✓	Test08To14Sma	2018/07/18
✓	ADWTPS100	2018/07/18
✓	2016Migration	2018/03/13

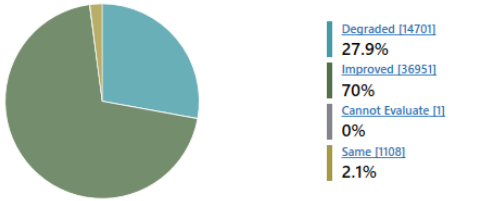
2016Migration

Threshold 5% Export Print

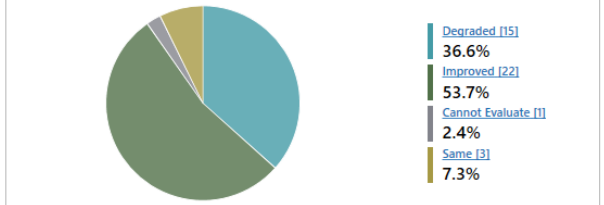
Target	Instance Name	Product Name	Trace File
Target 1	SQL2008SOURCE	SQL Server 2008 SP4 MS15-059	C:\Users\moljain\Documents\sql2008-small\Trace.trc
Target 2	SQL2016TRACE	SQL Server 2016	C:\Users\moljain\Documents\sql2016-small\Trace.trc

QUERY DISTRIBUTION

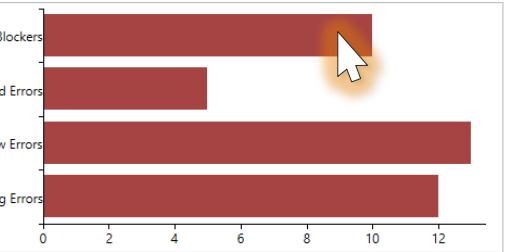
By execution count



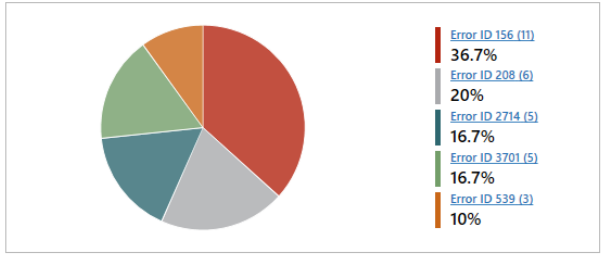
By distinct queries



Distinct error queries count by type



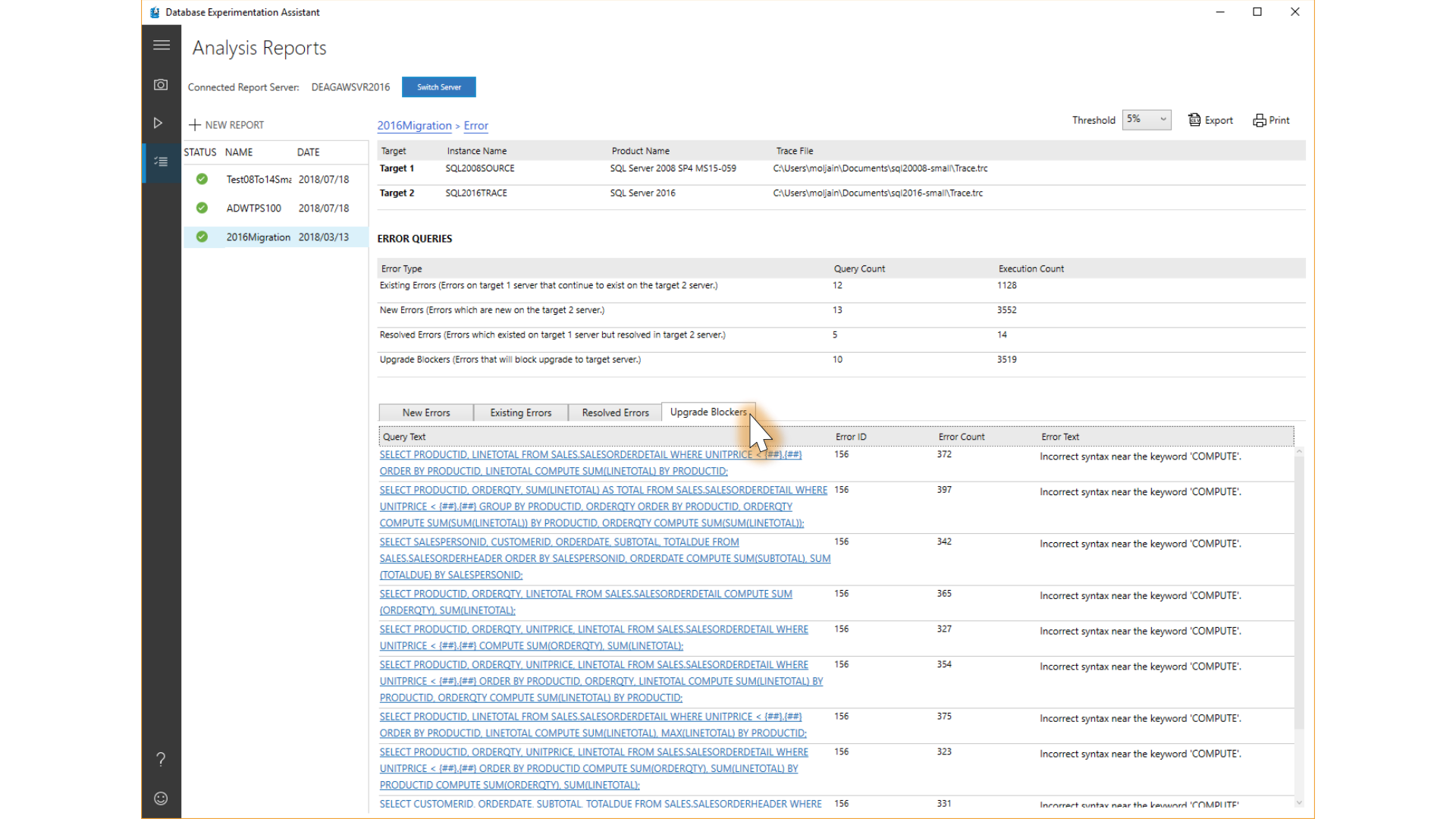
Error ID count



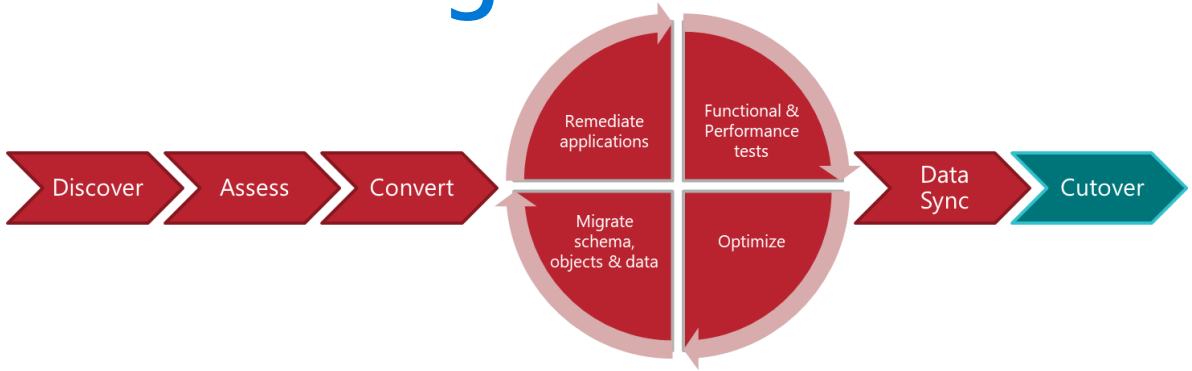
Top queries in workload

Top Improved Queries | Top Degraded Queries

Hash Id	Query Text	Mean Duration on Target 1 (µs)	Mean Duration on Target 2 (µs)	Duration Difference (µs)
-1616155278339986948	IF OBJECT_ID ((STR), (STR)) IS NOT NULL DROP TABLE DBO.EMPLOYEEONE;	102353	9105	-93248
-1704013646769530258	SELECT DISTINCT PP.LASTNAME, PP.FIRSTNAME FROM PERSON.PERSON PP JOIN	181508	127802	-53706


Database Experimentation Assistant
Analysis Reports
Connected Report Server: DEAGAWSVR2016
Switch Server
NEW REPORT
STATUS NAME DATE
Test08To14Sma 2018/07/18
ADWTPS100 2018/07/18
2016Migration 2018/03/13
2016Migration > Error
Threshold 5%
Export
Print
Target Instance Name Product Name Trace File
Target 1 SQL2008SOURCE SQL Server 2008 SP4 MS15-059 C:\Users\moljain\Documents\sql20008-small\Trace.trc
Target 2 SQL2016TRACE SQL Server 2016 C:\Users\moljain\Documents\sql2016-small\Trace.trc
ERROR QUERIES
Error Type Query Count Execution Count
Existing Errors (Errors on target 1 server that continue to exist on the target 2 server.) 12 1128
New Errors (Errors which are new on the target 2 server.) 13 3552
Resolved Errors (Errors which existed on target 1 server but resolved in target 2 server.) 5 14
Upgrade Blockers (Errors that will block upgrade to target server.) 10 3519
New Errors
Existing Errors
Resolved Errors
Upgrade Blockers
Query Text Error ID Error Count Error Text
SELECT PRODUCTID, LINETOTAL FROM SALES.SALESORDERDETAIL WHERE UNITPRICE < {##}.{##} ORDER BY PRODUCTID, LINETOTAL COMPUTE SUM(LINETOTAL) BY PRODUCTID; 156 372 Incorrect syntax near the keyword 'COMPUTE'.
SELECT PRODUCTID, ORDERQTY, SUM(LINETOTAL) AS TOTAL FROM SALES.SALESORDERDETAIL WHERE UNITPRICE < {##}.{##} GROUP BY PRODUCTID, ORDERQTY ORDER BY PRODUCTID, ORDERQTY COMPUTE SUM(SUM(LINETOTAL)) BY PRODUCTID, ORDERQTY COMPUTE SUM(SUM(LINETOTAL)); 156 397 Incorrect syntax near the keyword 'COMPUTE'.
SELECT SALESPERSONID, CUSTOMERID, ORDERDATE, SUBTOTAL, TOTALDUE FROM SALES.SALESORDERHEADER ORDER BY SALESPERSONID, ORDERDATE COMPUTE SUM(SUBTOTAL), SUM (TOTALDUE) BY SALESPERSONID; 156 342 Incorrect syntax near the keyword 'COMPUTE'.
SELECT PRODUCTID, ORDERQTY, LINETOTAL FROM SALES.SALESORDERDETAIL COMPUTE SUM (ORDERQTY), SUM(LINETOTAL); 156 365 Incorrect syntax near the keyword 'COMPUTE'.
SELECT PRODUCTID, ORDERQTY, UNITPRICE, LINETOTAL FROM SALES.SALESORDERDETAIL WHERE UNITPRICE < {##}.{##} COMPUTE SUM(ORDERQTY), SUM(LINETOTAL); 156 327 Incorrect syntax near the keyword 'COMPUTE'.
SELECT PRODUCTID, ORDERQTY, UNITPRICE, LINETOTAL FROM SALES.SALESORDERDETAIL WHERE UNITPRICE < {##}.{##} ORDER BY PRODUCTID, ORDERQTY, LINETOTAL COMPUTE SUM(LINETOTAL) BY PRODUCTID, ORDERQTY COMPUTE SUM(LINETOTAL) BY PRODUCTID; 156 354 Incorrect syntax near the keyword 'COMPUTE'.
SELECT PRODUCTID, LINETOTAL FROM SALES.SALESORDERDETAIL WHERE UNITPRICE < {##}.{##} ORDER BY PRODUCTID, LINETOTAL COMPUTE SUM(LINETOTAL), MAX(LINETOTAL) BY PRODUCTID; 156 375 Incorrect syntax near the keyword 'COMPUTE'.
SELECT PRODUCTID, ORDERQTY, UNITPRICE, LINETOTAL FROM SALES.SALESORDERDETAIL WHERE UNITPRICE < {##}.{##} ORDER BY PRODUCTID COMPUTE SUM(ORDERQTY), SUM(LINETOTAL) BY PRODUCTID COMPUTE SUM(ORDERQTY), SUM(LINETOTAL); 156 323 Incorrect syntax near the keyword 'COMPUTE'.
SELECT CUSTOMERID, ORDERDATE, SUBTOTAL, TOTALDUE FROM SALES.SALESORDERHEADER WHERE 156 331 Incorrect syntax near the keyword 'COMPUTE'

Post-Migration



I moved the data, am I done?

SQL Server post migration step is crucial for reconciling any **data accuracy and completeness**.

But also to **uncover performance issues** with the workload.

Recommended DB Compatibility Level upgrade process:

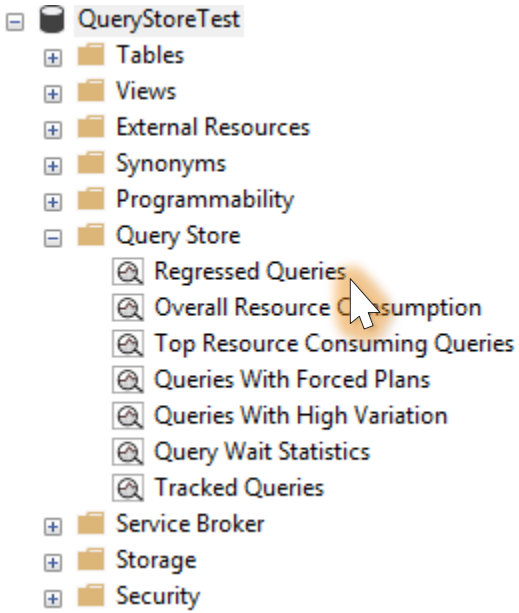
Why? Because of plan affecting changes – CE

CE estimates how many rows your query will likely return and is used by the Query Optimizer to generate the optimal query plan.

Most systems **benefit** from the latest CE because it is the most accurate.

So I need Query Store?

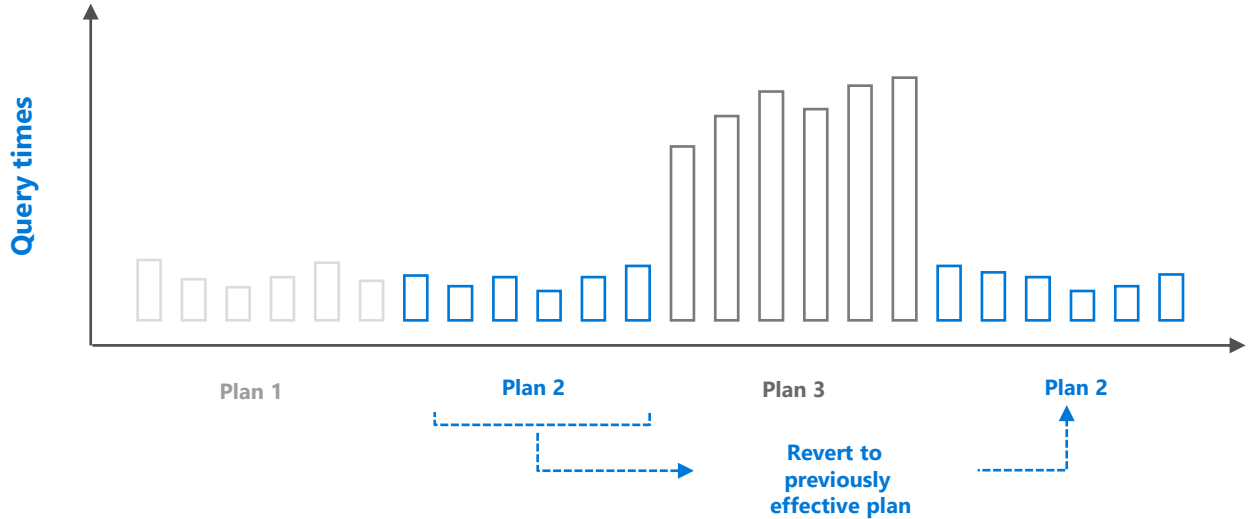
Comprehensive query-performance information when you need it most!



Query Store and Automatic Plan Correction

Identifies the problematic query plan and reverts to a more optimal point in time.

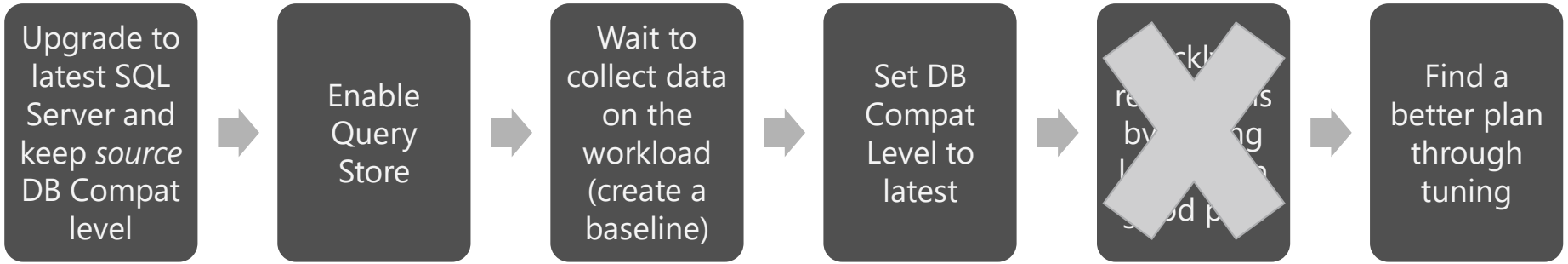
In the scope of a DB Compatibility upgrade, only works if the recommended process was followed!



DB Upgrade with Query Tuning Assistant

Priority 1: guides you through the documented DB Compatibility upgrade procedure.

What if instead of choosing between current and last know good plan, we find a 3rd, better plan?



Query Tuning Assistant (QTA) Workflow

Available in SSMS v18 and Powershell (preview)

Analysis and Recommendations

- Correlation vs Independence
  'ASSUME_MIN_SELECTIVITY_FOR_FILTER_ESTIMATES'
- Simple vs Base Join Containment
  'ASSUME_JOIN_PREDICATE_DEPENDS_ON_FILTERS'
- MSTVF fixed estimation of 100 rows vs 1 row
  'QUERYTRACEON 9488'
- As a last resort, full-fledge use of CE 70 is also considered, when all else doesn't yield desired results.

Deployment via Plan Guide

DEMO

Upgrading a database with QTA

Modernization Tools Breakdown

DEA

- A/B Testing
- Capture and Replay workload for performance testing and reporting
- Also reports on migration blockers because of failed T-SQL syntax

DMA

- Readiness assessment: blocking issues breaking changes, behavior changes
- Moves schema, data and uncontained objects (like logins) To Azure SQL Database
- Backup / Restore to another SQL Server
  - Keeps source DB Compatibility Level
- New feature recommendation

QTA

- Upgrade Database Compatibility Model to desired state
- Detects workload regressions, and tests CE model variations (subsets)
  - Does not move to last known good state
- Provides tangible recommendations for tuning queries
  - Tweak most common CE model assumptions
  - Overall keeps use of CE version mapped to the DB Compatibility Level

Learn more

Migration Resources	Database Migration Guide Microsoft Assessment and Planning Toolkit Overview of Data Migration Assistant DEA 2.6 – Database Experimentation Assistant
Compatibility Certification	http://aka.ms/dbcompat
Continue learning with our new book	https://aka.ms/LearnTSQLQuerying
One shortcut to rule them all!	https://aka.ms/SQLShortcuts