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Automatic Indexing in Oracle Database 19c

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Agenda

1. **Original Approach to Index Tuning**
2. Automatic Indexing
   - How it work
   - What to expect
   - Deployments
   - Controls
   - Auditing and Report
3. Validation

Our Original Approach To Performance Features

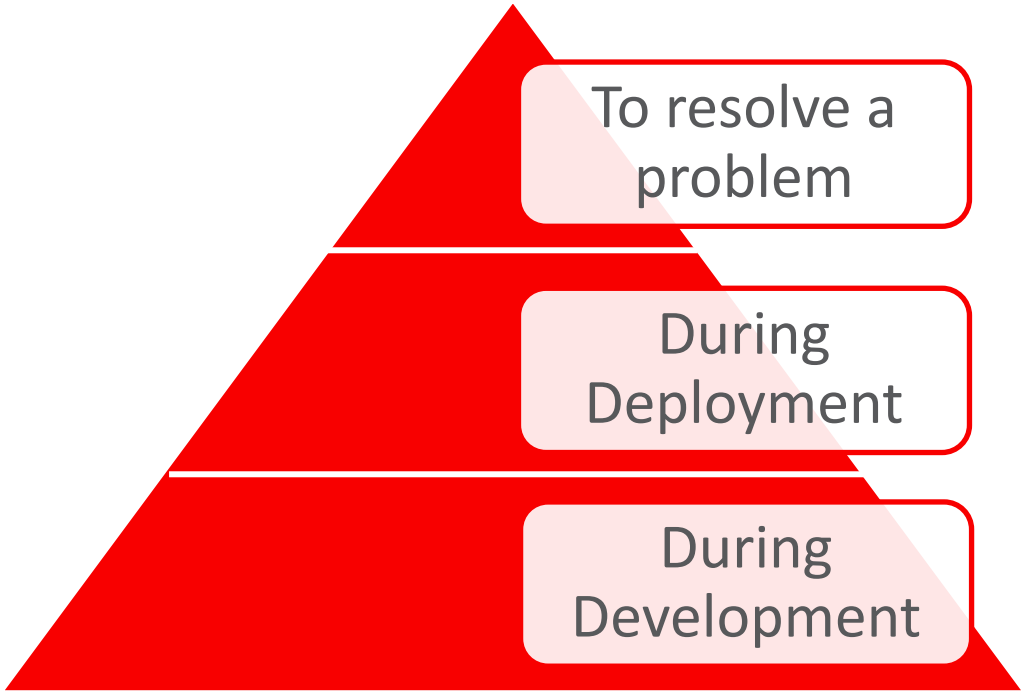
- Up until now we have developed performance features assuming there was an expert driver behind the wheel
- Some features were enabled by default but came with an emergency shut off switch
- We relied on the expert drivers (DBAs & Developers) to know when to use these switches to control a feature

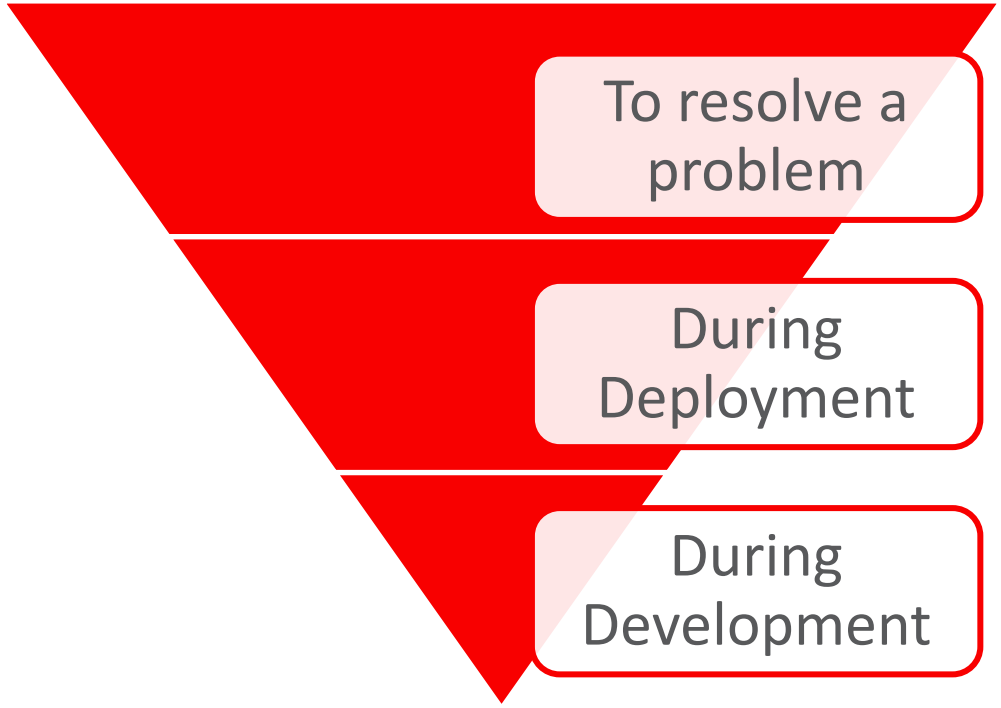
Our Original Approach To Oracle Performance Advisors

- We also provided advisors to assist DBAs in determining what performance structures maybe needed
  - Index Advisor, Partition Advisor, In-Memory Advisor, etc.
- Each advisor generated recommendations on what performance structures **might be** useful for a **given workload**
- The onus was on the DBA to:
  - Validate whether the performance structures actually helps
  - Manage the case of negative side effects, e.g. slower DML
  - Check whether the performance structures are still useful
  - Decide when to repeat the tuning process, e.g. change in the data or app

Traditional Approach To Index Creation

- Indexes are added at different stages of an applications life cycle





- Reality is a more reactive approach that replies on the expertise you have

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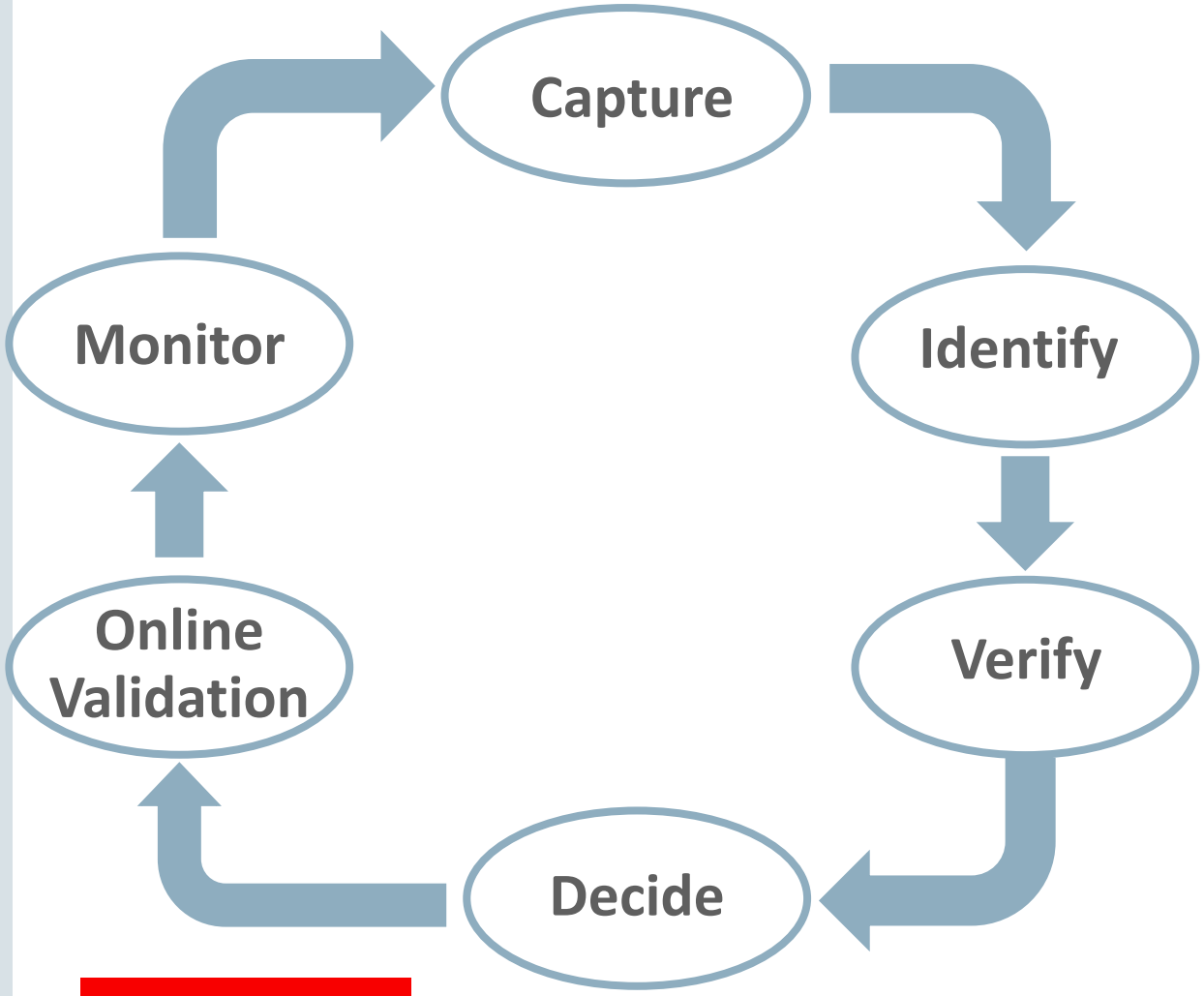
Automatic Indexing – Overview

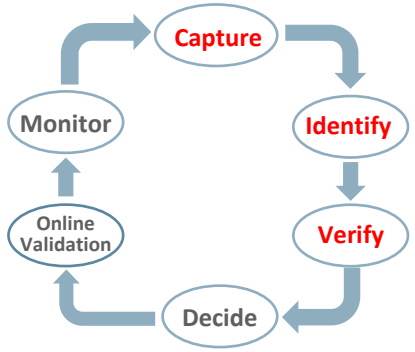
- An **expert system** that implements indexes based on what a performance engineer skilled in index tuning would do
  - But it is able to work 24 hours a day, 7 days a week, 52 weeks a year
- It is not an advisor
  - The DBA is not expected to provide any specific inputs (workload, etc.)
  - The DBA is not expected to take any action
- The interaction is limited to
  - Optional setting of **preferences**, e.g. where the indexes are stored etc.
  - Viewing a **report** on actions performed and their impact on the application
- It works in an **incremental** fashion and therefore it has to be **iterative** and **continuous**
- It takes **responsibility** for its decisions and hence its decisions must be **validated**
- It **adapts** to changes in the schema, data and application

Automatic Indexing Methodology



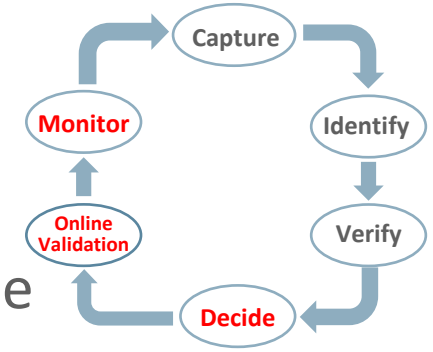
- The Automatic Indexing methodology is based on a common approach to manual SQL tuning
- It identifies candidate indexes and validates them before implementing
- The entire process is fully automatic
- Transparency is equally important as sophisticated automation
  - All tuning activities are auditable via reporting

Automatic Indexing – How It Works



1. Capture
   - Periodically capture the application SQL history into a SQL repository
   - Includes SQL, plans, bind values, execution statistics, etc.
2. Identify Candidates
   - Identify candidate indexes that may benefit the newly captured SQL statements
   - Creates index candidates as unusable, invisible indexes (***metadata*** only)
   - Drop indexes obsoleted by newly created indexes (logical merge)
3. Verify
   - Ask the optimizer if index candidates will be used for captured SQL statements
   - Materialize indexes and run SQL to validate that the indexes improve their performance
   - All verification is done outside application workflow

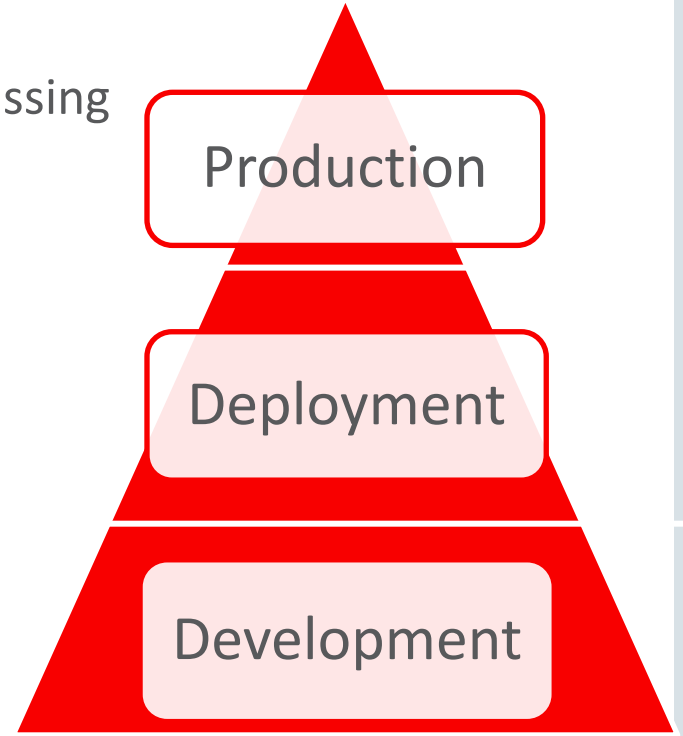
Automatic Indexing – How It Works



4. Decide
   - If performance is better for all statements, the indexes are marked visible
   - If performance is worse for all statements, the indexes remain invisible
   - If performance is worse for some, the indexes are marked visible except for the SQL statements that regressed
5. Online Validation
   - The validation of the new indexes continues for *other* statements, *online*
   - Only one of the sessions executing a SQL statement is allowed to use the new indexes
6. Monitor
   - Index usage is continuously monitored
   - Automatically created indexes that have not been used in a long time will be dropped

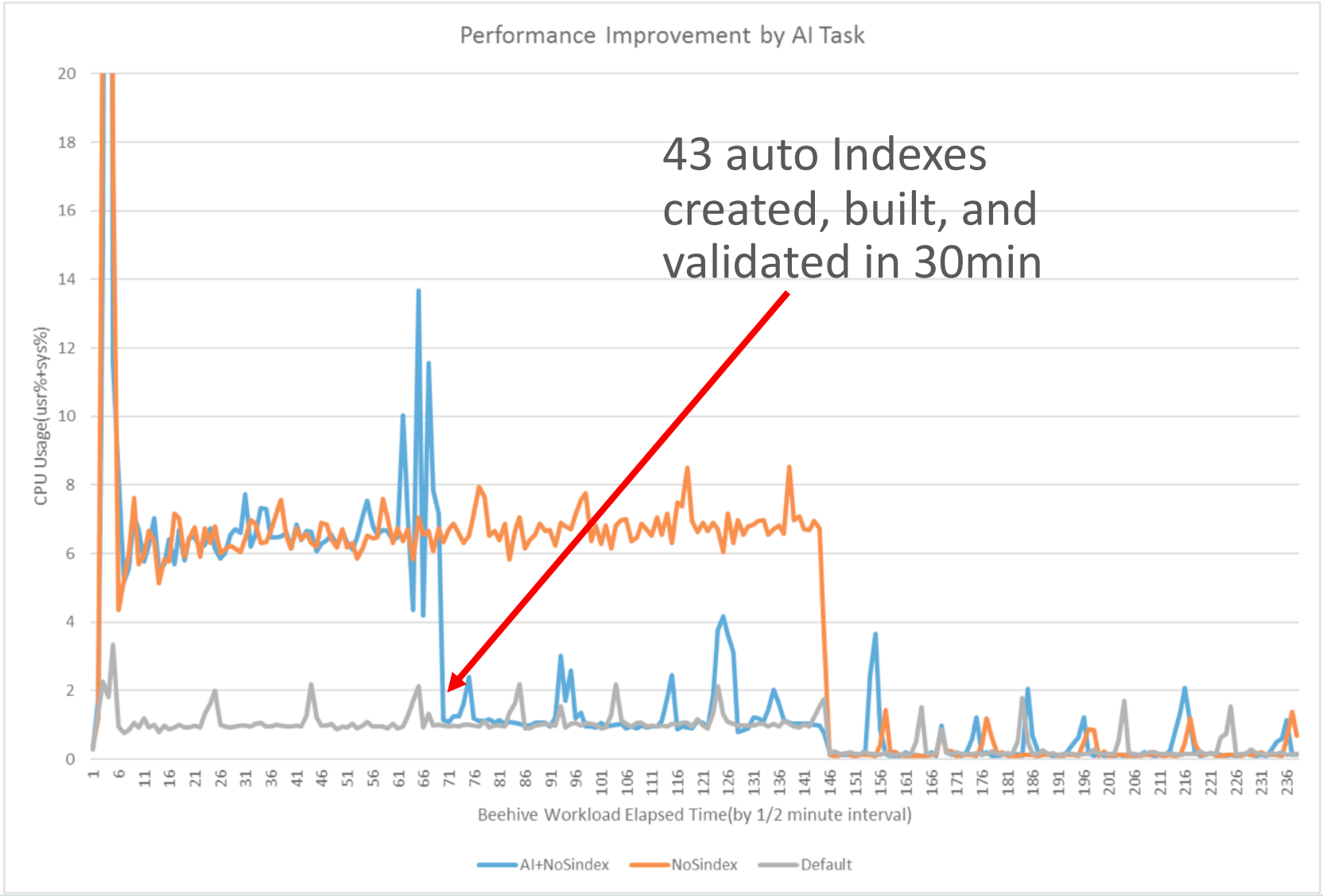
Automatic Indexing – Scope

- Useful for OLTP, DW, Mixed workloads but very ***critical*** for OLTP
- Applies to tuned and un-tuned applications
  - Tuned
    - Existing secondary indexes may be outdated or important ones can be missing
    - Some secondary indexes can be dropped and auto indexes can be added
  - Un-tuned
    - Existing indexes support primary or unique key constraints
- Applicable to all stages of an application lifecycle
- Supports
  - Single and concatenated indexes
  - Function-based indexes
  - Compression Advanced Low



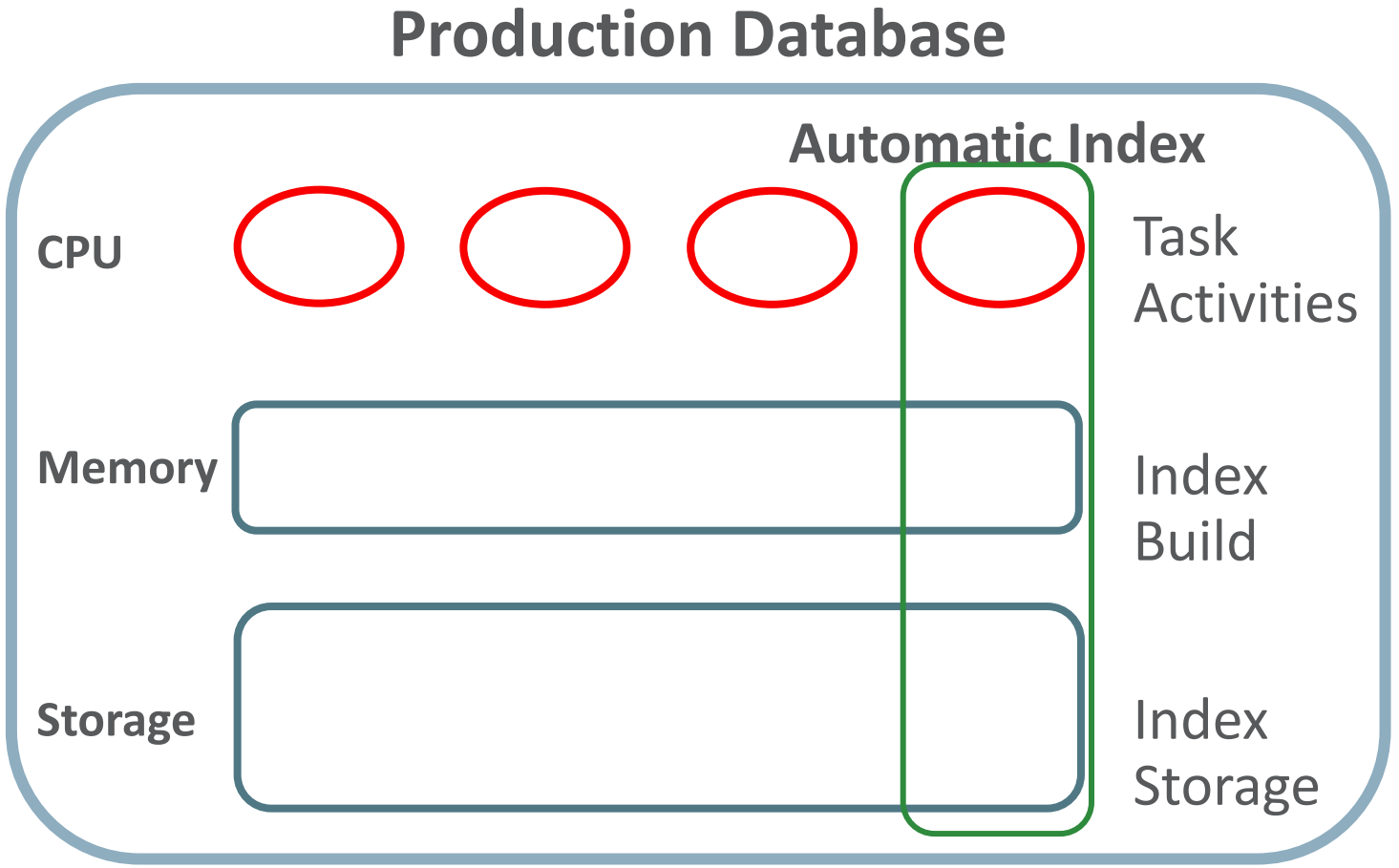
Automatic Indexing in Action (live)

Total run time 2 h
-10 min ramp-up
-60 min steady
-50 min ramp-down



Deployment – Inline Automatic Indexing

- By default Automatic Indexing runs in the same database as application



- The task does consume CPU Memory and storage
  - Resource manager plan limits the task to 1 CPU
  - Customers can control which temp tablespace is used to build indexes
  - Customers can control which tablespace and how much space can be used by Auto Indexing

New DBMS_AUTO_INDEX Package to Controls Behavior

- The following parameters control the behavior of Automatic Indexing:
  - AUTO_INDEX_EXCLUDE_SCHEMA
    specify schema name(s) to be excluded from creating indexes automatically
    By default, auto indexing consider tables in all user created schemas
  - AUTO_INDEX_RETENTION_FOR_AUTO
    Number of days the auto indexes are retained after last used date before purge (373 days)
  - AUTO_INDEX_RETENTION_FOR_MANUAL
    Number of days the manual indexes are retained after their last used date before purge (NULL)
  - AUTO_INDEX_DEFAULT_TABLESPACE
    The tablespace name where all auto indexes will be stored (user default tablespace)
  - AUTO_INDEX_MODE
    Put automatic Indexing into reporting mode (IMPLEMENT)
    Indexes are created, tested, and a report shows the impact without affecting the app

Auditing Automatic Indexing

- All activities are logged and can be viewed via new DBA views:
  - `DBA_AUTO_INDEX_EXECUTIONS` – Shows history automatic indexing tasks executions
  - `DBA_AUTO_INDEX_STATISTICS` - Shows statistics related to automatic indexes
  - `DBA_AUTO_INDEX_IND_ACTIONS` -Shows actions performed on automatic indexes
  - `DBA_AUTO_INDEX_SQL_ACTIONS` – Shows actions performed on SQL to verify automatic indexes
  - `DBA_AUTO_INDEX_CONFIG` - Shows history of configuration settings related to automatic indexes

Reporting on Automatic Indexing Activity

- Each Auto Index Task generates a report showing the task activities
- Reports can be generated via `DBMS_AUTO_INDEX.REPORT_ACTIVITY` function
  - Date/Time range
  - Format (XML, HTML, Text)
  - Level (basic, typical, all)
  - Section (Summary, Index Details, Verification Details, Errors, All)

Sample Report

```
------------------------------------------------------------------------------
GENERAL INFORMATION
------------------------------------------------------------------------------
Activity start                : 29-AUG-2018 12.20.40
Activity end                  : 30-AUG-2018 12.20.40
Executions completed          : 13
Executions interrupted        : 3
Executions with fatal error   : 1
------------------------------------------------------------------------------
SUMMARY (AUTO INDEXES)
------------------------------------------------------------------------------
Index candidates                                 : 53
Indexes created (visible / invisible)            : 12 (12 / 0)
Space used (visible / invisible)                 : 3.48 MB (3.48 MB / 0 B)
Indexes dropped                                  : 0
SQL statements verified                          : 16
SQL statements improved (improvement factor)     : 16 (3x)
SQL statements disallowed from auto indexes      : 0
Overall improvement factor                       : 3x
------------------------------------------------------------------------------
SUMMARY (MANUAL INDEXES)
------------------------------------------------------------------------------
Unused indexes (visible / invisible)  : 10 (8 / 2)
Space used (visible / invisible)      : 100 MB (76 MB / 24 MB)
Unusable indexes                      : 0
------------------------------------------------------------------------------
```

INDEX DETAILS

1. The following indexes were created:*: invisible

Owner	Table	Index	Key	Type	Properties
OPT	T_10K_CP1	SYS_AI_3cpm0ahgt469g	ROWID_UNIQUE	B-TREE	NONE
OPT	T_10K_CP1	SYS_AI_3rk4h2m9d49b5	CHAR_UNIQUE	B-TREE	NONE
OPT	T_10K_CP1	SYS_AI_5cq2h6jhmznc9	DATE_UNIQUE	B-TREE	NONE
OPT	T_10K_CP1	SYS_AI_6vg5wr5nwcqxs	THOUSAND	B-TREE	NONE
OPT	T_10K_CP1	SYS_AI_agnvzczmz4z0a	TEN,UNIQUE1,UNIQUE2	B-TREE	NONE
OPT	T_10K_CP1	SYS_AI_bcms9qy98nq1c	VCHAR_UNIQUE	B-TREE	NONE
OPT	T_5K_CP	SYS_AI_0urcv8chmxu20	VCHAR_UNIQUE	B-TREE	NONE
OPT	T_5K_CP	SYS_AI_2pvk34mqdh7pa	TEN,UNIQUE1,UNIQUE2	B-TREE	NONE
OPT	T_5K_CP	SYS_AI_428hqd6qu531y	THOUSAND	B-TREE	NONE
OPT	T_5K_CP	SYS_AI_5d2cukrm2gju2	DATE_UNIQUE	B-TREE	NONE
OPT	T_5K_CP	SYS_AI_97zrtmcmn5tz6	CHAR_UNIQUE	B-TREE	NONE
OPT	T_5K_CP	SYS_AI_cn9fsv12paxcb	ROWID_UNIQUE	B-TREE	NONE

```
-------------------------------------------------------------------------------
VERIFICATION DETAILS
-------------------------------------------------------------------------------
1. The performance of the following statements improved:-------------------------------------------------------------------
-------------------------------------------------------------------------------------
Schema Name         : OPT
SQL ID              : 2vy3tr5kyg88z
SQL Text            : select count(*) from t_5k_cp where vchar_unique ='MAN'
Improvement Factor  : 2x

PLANS SECTION
-------------------------------------------------------------------------------
Original
------------------------------
Plan Hash Value  : 3944640934
-----------------------------------------------------------------
| Id | Operation            | Name    | Rows | Bytes | Cost | Time |
-----------------------------------------------------------------
|  0 | SELECT STATEMENT     |         |      |       |      |      |
|  1 |   SORT AGGREGATE     |         |      |       |      |      |
|  2 |    TABLE ACCESS FULL | T_5K_CP |      |       |      |      |
-----------------------------------------------------------------
With Auto Indexes
------------------------------
Plan Hash Value  : 2541075899
-------------------------------------------------------------------------------
| Id  | Operation           | Name                 | Rows | Bytes | Cost | Time|
-------------------------------------------------------------------------------
|   0 | SELECT STATEMENT    |                      |      |       |      |     |
|   1 |   SORT AGGREGATE    |                      |      |       |      |     |
| * 2 |    INDEX RANGE SCAN | SYS_AI_0urcv8chmxu20 |      |       |      |     |
-------------------------------------------------------------------------------
Predicate Information (identified by operation id):
---------------------------------------
* 2 - access("VCHAR_UNIQUE"='MAN')
```

Using Automatic Indexing Hints

- You can use hints to control if auto indexes will be used for a SQL statements
- The `USE_AUTO_INDEXES` hint instructs the optimizer to use auto indexes

```
SELECT /*+ USE_AUTO_INDEXES */ emp_id, emp_name, dept_id
FROM employees
WHERE dept_id > 50;
```

- The `NO_USE_AUTO_INDEXES` hint instructs the optimizer not to use auto indexes

```
SELECT /*+ NO_USE_AUTO_INDEXES */ emp_id, emp_name, dept_id
FROM employees
WHERE dept_id > 50;
```

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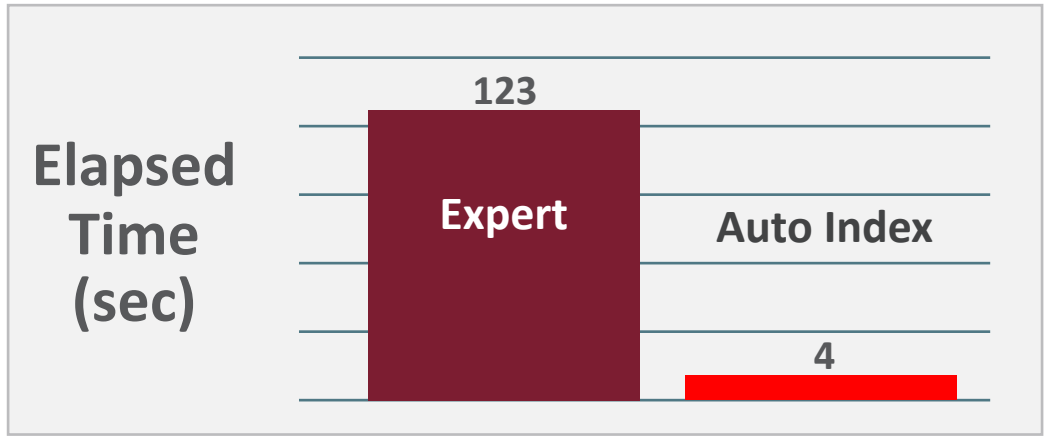
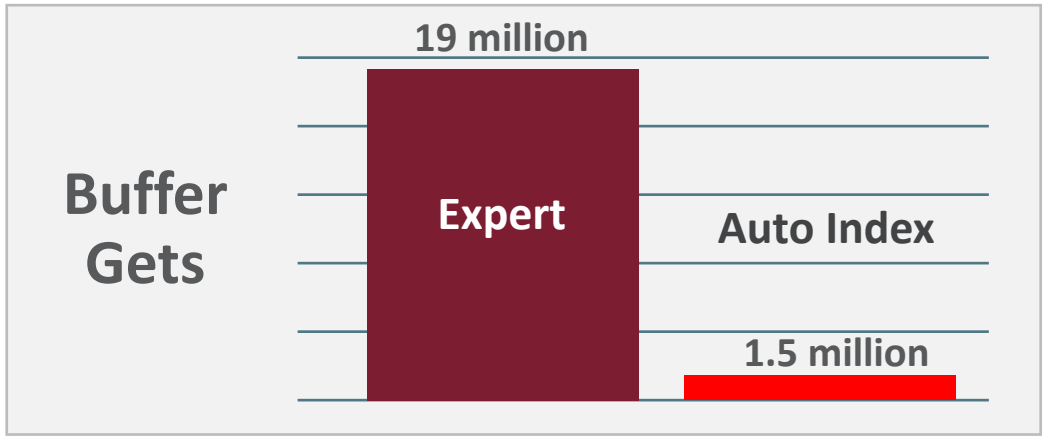
Validation – **Accounts Receivable**

- Workload: 4,889 SQL statements
- Indexes:
  - Experts created 49 indexes of which 17 were used
  - Automatic indexing created 5 indexes, ***all*** of which were used





Summary

- Automatic Indexing will provide
  - Continuous optimization of the workload
  - Stable performance
  - Minimal human interaction required
  - Fully manageable if desired
- Additional automations in Oracle Database 19c
  - Statistics Management
  - Run-away SQL statements