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SQL Performance Tuning in the Autonomous Database Era

Andrew Holdsworth
Christine Qu
Cary Dong

Real-World Performance

November 17, 2017

Introductions

Introductions

Andrew Holdsworth

- 28 Years at Oracle
- Vice President Real World Performance
  - Good performance is rarely an accident
  - Most people get the systems they deserve
  - Good enough rarely is, aspire for excellence not good enough.

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ORACLE REAL-WORLD PERFORMANCE

Introductions

曲卓 (Christine Qu)

- 12 Years at Oracle
- Manage Real-World Performance education in China
- Learn to analysis from top down, make sure you are on the right direction
- Be open and positive, aim high

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Introductions

董志平(Cary Dong)

- 15 years of Oracle experience
- 9 years in RWP
- Manage Real-World Performance projects in China

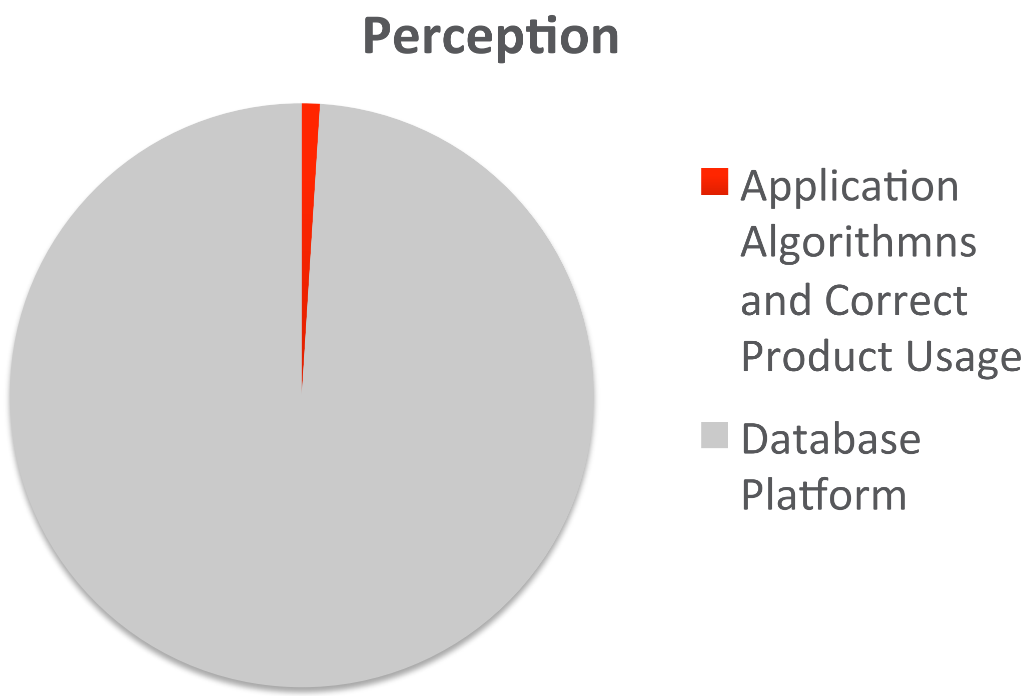
Real-World Performance

Who We Are

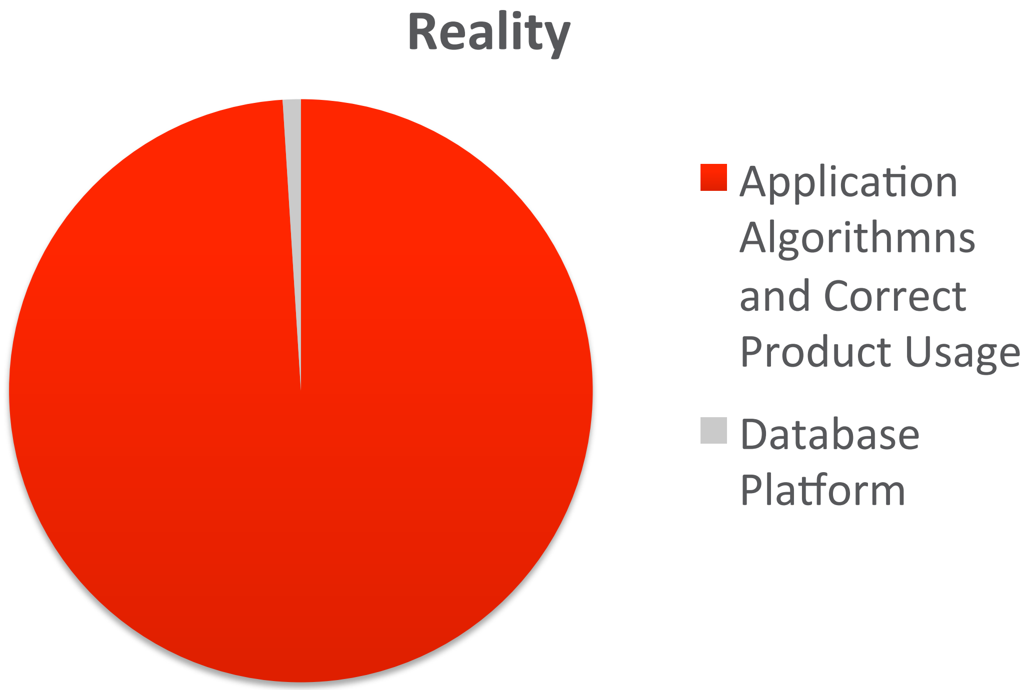
- Part of the Database Development Organization
- Global Team located in USA, Europe, Asia
- 350+ combined years of Oracle database experience
- Innovate to achieve exceptional Database Performance
- Our methods:
  - Use the product as it was designed to be used
  - Numerical and logical debugging techniques
  - Educate others about the best performance methods and techniques
  - Avoid and eliminate “tuning” by hacking/guessing/luck

The Real World Performance Perception Problem

Where database user look for performance improvements



The best place to look for performance Improvements



Program Agenda

1. Why Autonomous Database?
2. SQL Performance Tuning Strategy
3. Makes Tuning Smarter
4. Panel

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Oracle Vision for Autonomous Database

Goal - Eliminate all human labor

No human labor means lower cost

No human error means better reliability and security

Oracle’s Vision for Autonomous Database

How we do it

- Self-Driving
  - User defines workloads and policies, database makes them happen
- Self-Securing
  - Protection from both external attacks and internal users
- Self-Repairing
  - Automated protection from all downtime

Automated vs. Autonomous

Automated

- The car simplifies operations by automating tasks:
  - Cruise control
  - Emergency stopping
  - Warnings for lane changes
- The database simplifies operations:
  - Automatic storage management, automatic storage management, …
  - Dozens of other features

Autonomous

- The car drives itself
  - No need to use the steering wheel or brake.
  - Simply tell the car where you are going.
- The database manages itself
  - All features automatically implemented
  - Simply tell the database your goals

Automatically Diagnoses Performance

- Autonomous Database includes Oracle's industry leading diagnostics automation
- Automatic Database Diagnostic Monitor (ADDM)
  - Automatically diagnoses root cause of performance issues
  - A.I. (Expert System)
- Active Workload Repository (AWR)
  - Automatically keeps detailed performance and resource utilization history
- Real-Time SQL Monitoring
  - Automatically diagnoses how resources are used in SQL statements

Automatically Optimizes Itself

- Autonomous Database includes Oracle's industry leading database tuning automation
- Many database algorithms self optimize – caching, locking, storage indexes, offload, etc.
- Optimizer is now further automated by gathering statistics as new data is loaded
- Automatic SQL (Re)Tuning
  - Machine learning technology that is constantly re-evaluating SQL plans based on the latest statistics and recommending/implementing better plans
- Tuning is workload dependent – e.g. OLTP vs analytics so we specialize services
- Tuning is an extremely difficult problem
  - Even scheduling a fleet of trucks to optimally make deliveries is incredibly complex
  - Database has many degrees of freedom and tradeoffs that must be considered

Database Administrator Questions and Fears

- Will my job go away?
- Will my job change?
- Will I lose control?

What does Autonomous Database mean for the DBA?

Less time on Administration

- Less time on infrastructure
- Less time on patching, upgrades
- Less time on ensuring availability
- Less time on tuning

More time on Innovation

- More time on database design
- More time on developing new apps
- More time on data analytics
- More time on securing data

Challenge: There are more data management tasks than humans to do the work

Reality vs. Fears

- Your job will not go away - there is a **shortage of skilled database experts**
  - Database automation has been improving for decades
- But your job will change, so you must **change**
- You will spend less time on **generic maintenance**, more time **innovating**
- More time with the **business**
  - Executing more projects, reducing backlog, getting more value from data
  - Cloud's fast provisioning and pay-as-you-go enables rapid experimentation
- More time with **developers**
  - Optimizing data access, improving end-user experience
- More time on new techniques like **Machine Learning**

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Database Administrator Must Ensure End-to-End Service Levels

- Focus on optimizing how applications and databases work together:
  - Define good data model, and good SQL
  - Avoid row at a time processing, and repeated logins/parsing
  - Understand where time is being spent
  - Understand tradeoffs in parallelism, plans, indexes, partitions, etc.
  - Ensure that **sensitive data is kept secure end-to-end**
  - Beware what an application asks for – the database will do exactly that
- Need new skills in Cloud Systems, Cloud Networking, Cloud Storage
  - DBA sizes, monitors, ensures full stack works as expected
- Database Administrator will gain more control
  - Will be in charge of, and in control of, end-to-end service levels

Program Agenda

1. Why Autonomous Database?
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SQL Performance

- Elapsed time: 1 hour → 1 min
  - Will you stop working?
- Could it be possible to make it down to 1 sec?

Aim High

SQL Performance

- Is it a valid SQL?
- Do you know the business logic the SQL represents for?
- Is it a well constructed SQL?
- Any mistakes in the SQL?
  - N-1 join conditions for a N table join?
  - Implicit data type conversion?

Aim High

Work on Good SQL

SQL Performance

- Is your database software correctly patched?
- Are you running with default init.ora parameter settings? If not, why?

Aim High

Work on Good SQL

Environment settings

SQL Performance

- Stats
  - Stats on raw data
  - System stats
- Constraints
  - NOT NULL, PK, FK, UK
- Schema design
  - Index
  - Partitioning
  - Compression
  - Clustering

Aim High

Work on Good SQL

Environment settings

Optimization

SQL Performance

- Access method
- Join method
- Join order
- Distribution method
- Skew?

Aim High

Work on Good SQL

Environment settings

Optimization

Execution

SQL Performance

- Diagnosing
  - SQL Monitor Report
  - Find the leverage

Aim High

Work on Good SQL

Environment settings

Optimization

Execution

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Introduction to SQL Monitor

- Released in Oracle Database 11g
- Enables in depth performance monitoring of a SQL statement
  - Always on, enabled out of the box
  - Single execution of the SQL statement
  - Includes currently executing statements
- Monitored statements
  - Serial statements with 5 seconds of total CPU/IO time
  - All parallel statements
  - /*+ monitor */ hint
  - Queries / DML / DDL

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Introduction to SQL Monitor

- Formats available
  - Text
  - HTML
  - Active (use this one!)
- Available from
  - Monitored SQL screen
  - command line
  - EM, EM Express
  - PerfHub

How we use the SQL Monitor report

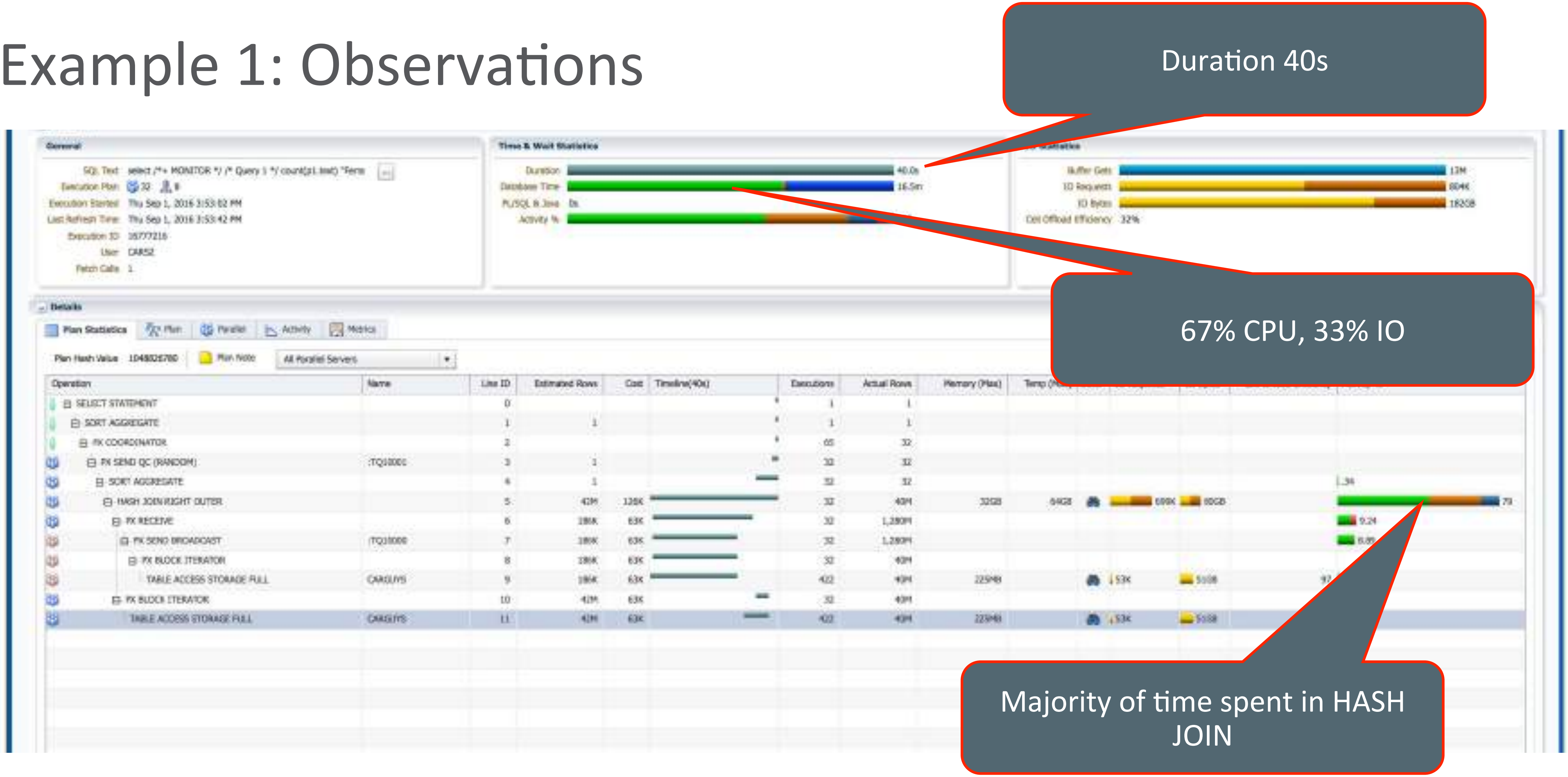
- Top down
  - Where is time spent?
  - Which row sources?
  - Estimated vs actual row cardinalities?
  - Executions
    - Parallel server executions
    - Nested loop iterations
    - Partition wise operations
  - Skew

Example 1

Observations

- Query currently runs for 40 seconds
- Needs to run under 5 seconds
- Examination of the SQL Monitor report shows
  - 67% CPU
  - 33% IO
- The most expensive row source is HASH JOIN RIGHT OUTER (line 5)
  - 45% of the CPU
  - Large amount of read/write from TEMP

Example 1: Observations



Example 1

Diagnosis

- However…
  - Is the HASH JOIN itself the problem?
- Examination of the Cardinality estimates
  - The scan of the CARGUYS table at line 11
    - estimate of 42M rows vs actual 40M rows
    - estimate is very accurate
  - The scan of the CARGUYS table at line 9
    - estimate of 186K rows vs actual 40M
    - more that 200x underestimated

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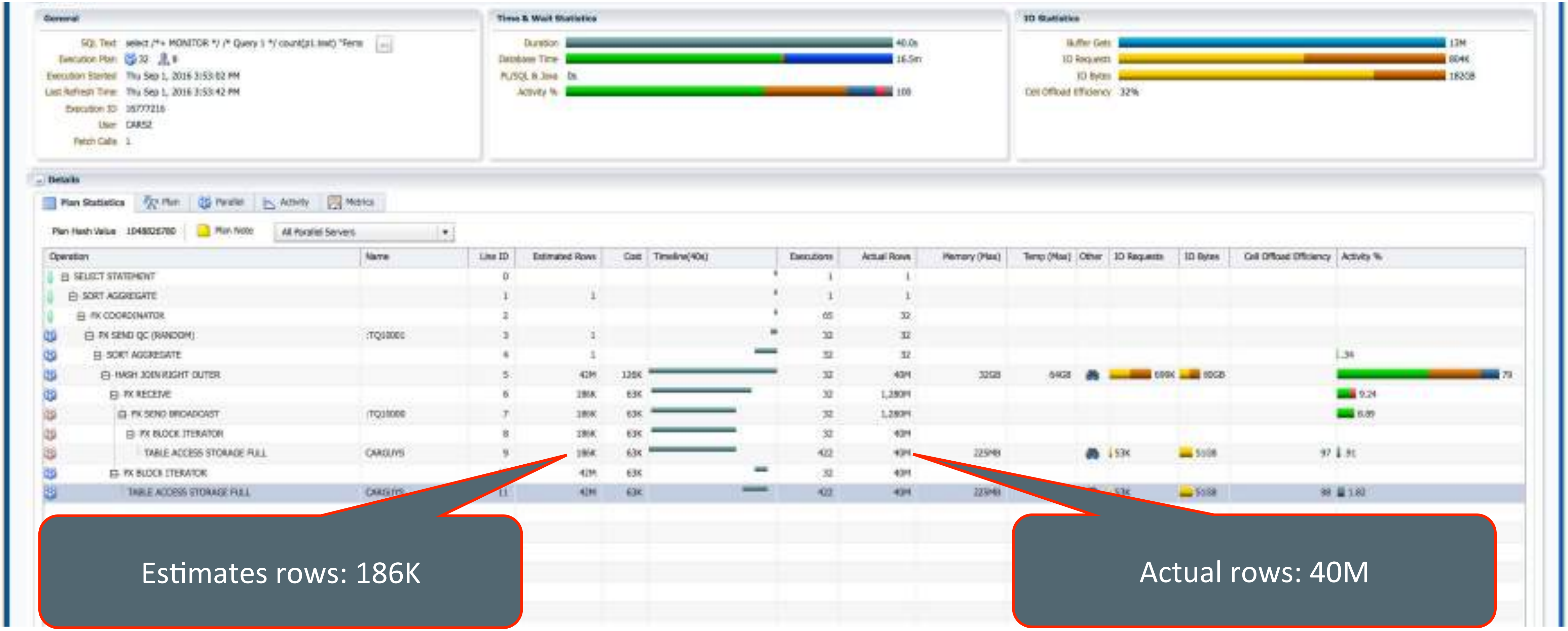
Example 1: Diagnosis



Example 1

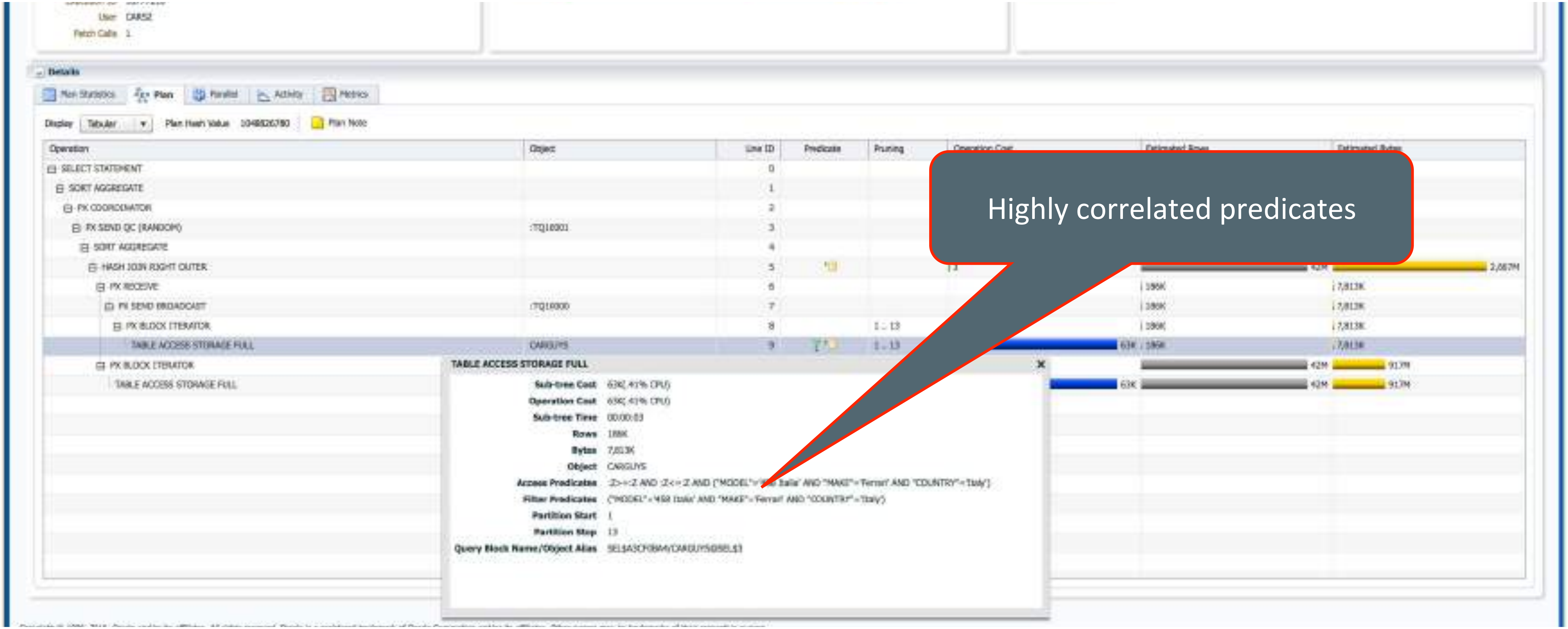
Diagnosis

- What is the cause of the big mis-estimate in cardinality?
  - Examining the predicate information:

Filter Predicates ("MODEL"='458 Italia' AND "MAKE"='Ferrari' AND "COUNTRY"='Italy')

  - All three filter predicates are highly correlated
    - Ferrari's are only made in Italy
    - Only Ferrari makes a model called the '458 Italia'
  - The optimizer has multiplied the selectivity of the individual predicates and underestimated the number of rows that will be retrieved

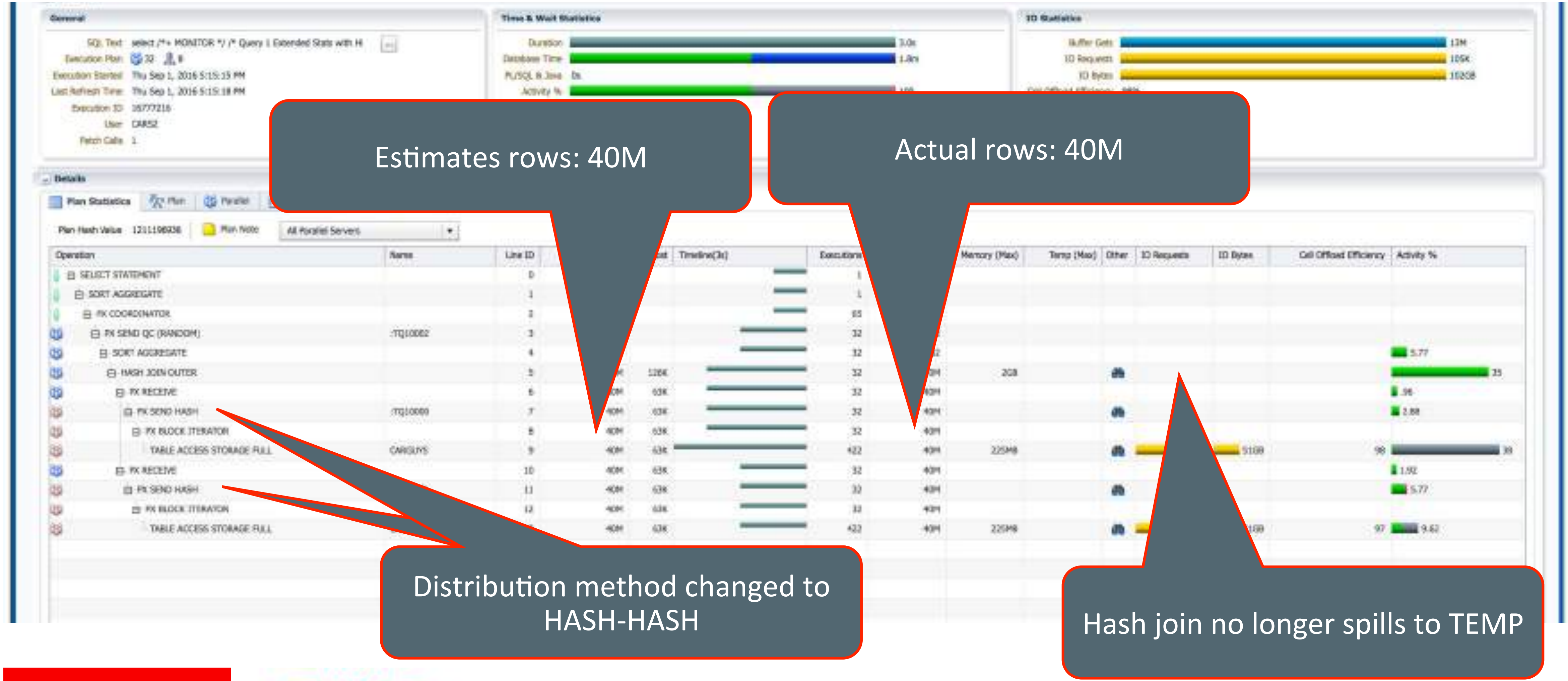
Example 1: Diagnosis



Example 1

- Solution
  - Use extended statistics
    - Build a column group on MAKE, MODEL, COUNTRY
  - The optimizer can now determine the selectivity of the three predicates combined
- Result
  - The cardinality estimate has now changed to 40M rows.
  - Changes distribution method from BROADCAST to HASH-HASH
  - This results in a more efficient HASH JOIN, which does not spill to TEMP
  - Query now runs in 3 seconds.

Example 1: Solution

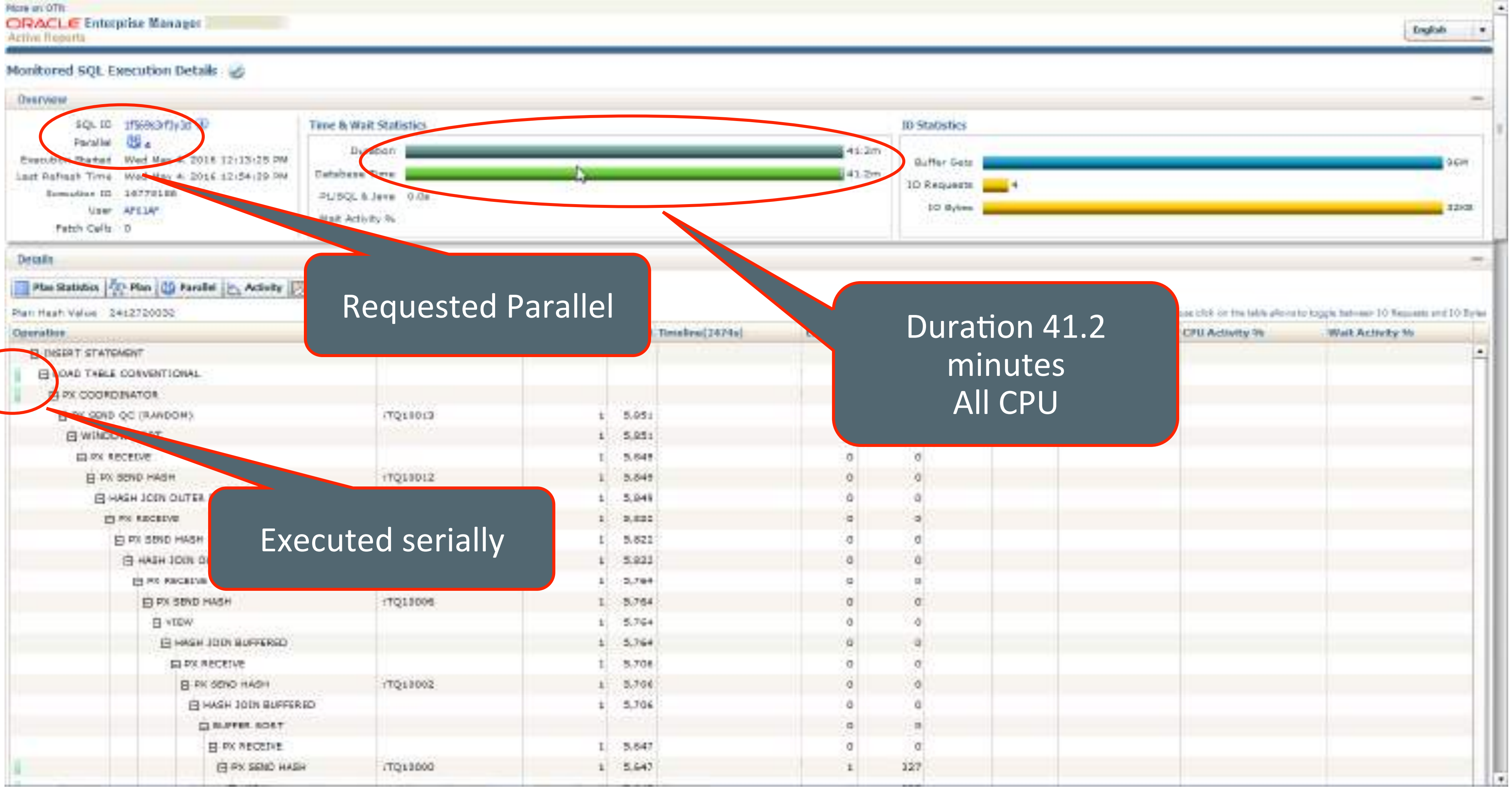


Example 2

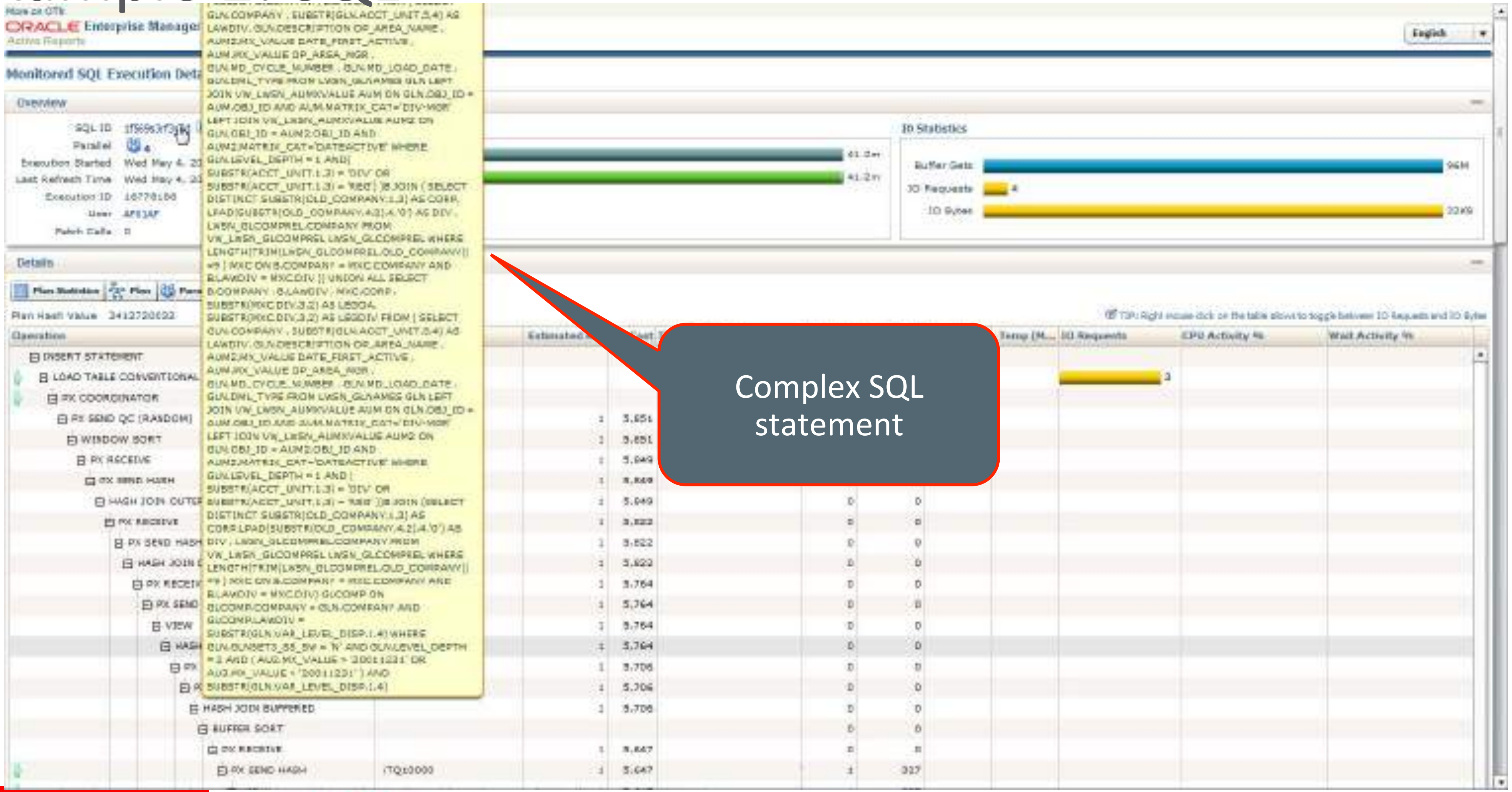
Observations

- Query takes 42 minutes
  - Almost all CPU
- Complex SQL statement
- Parallel execution requested
- Time spent in nested full table scans
- Optimizer estimated it would perform one table scan
  - Actually performed 5776 table scans

Example 2: Overview

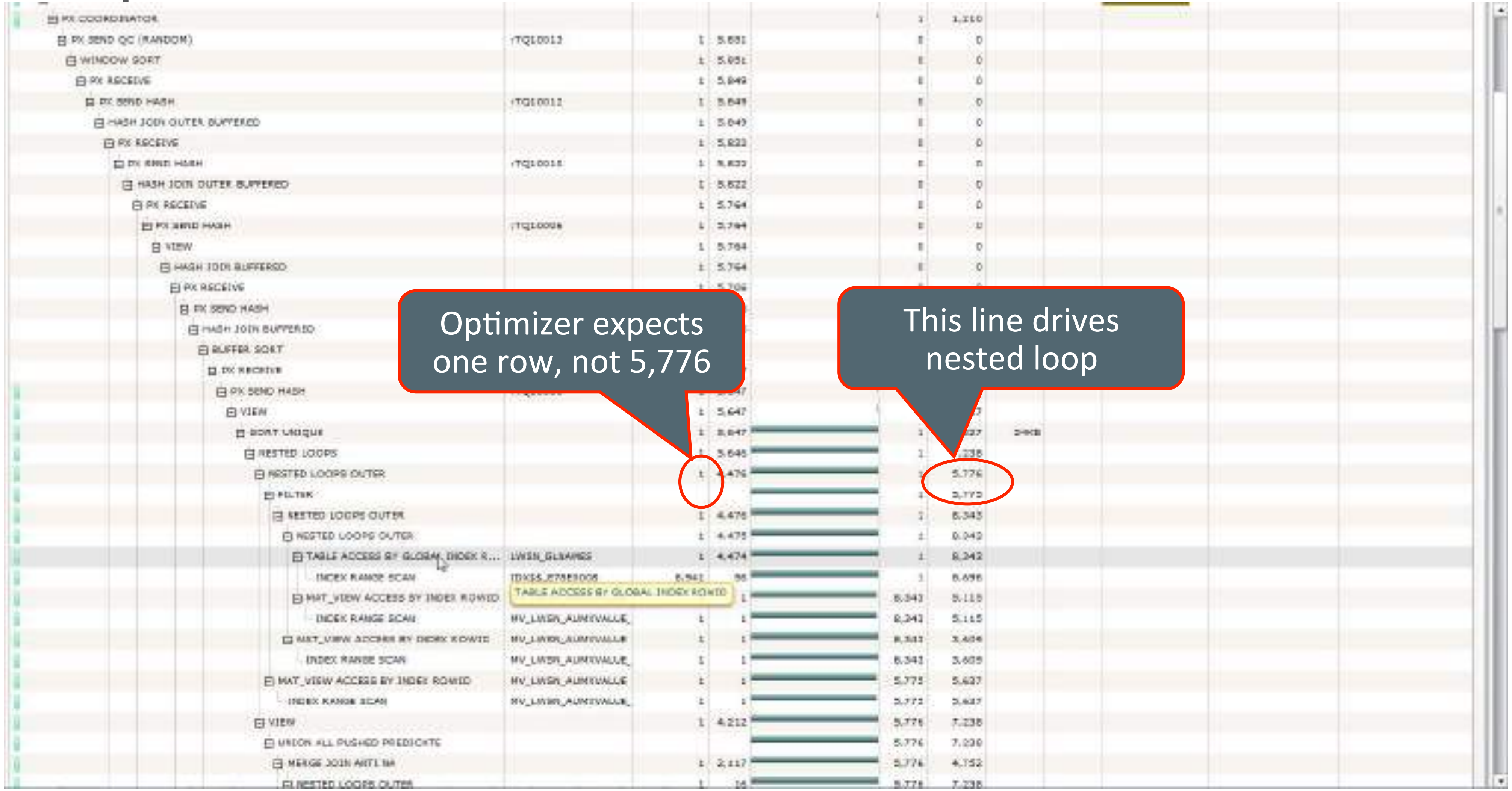


Example 2: SQL

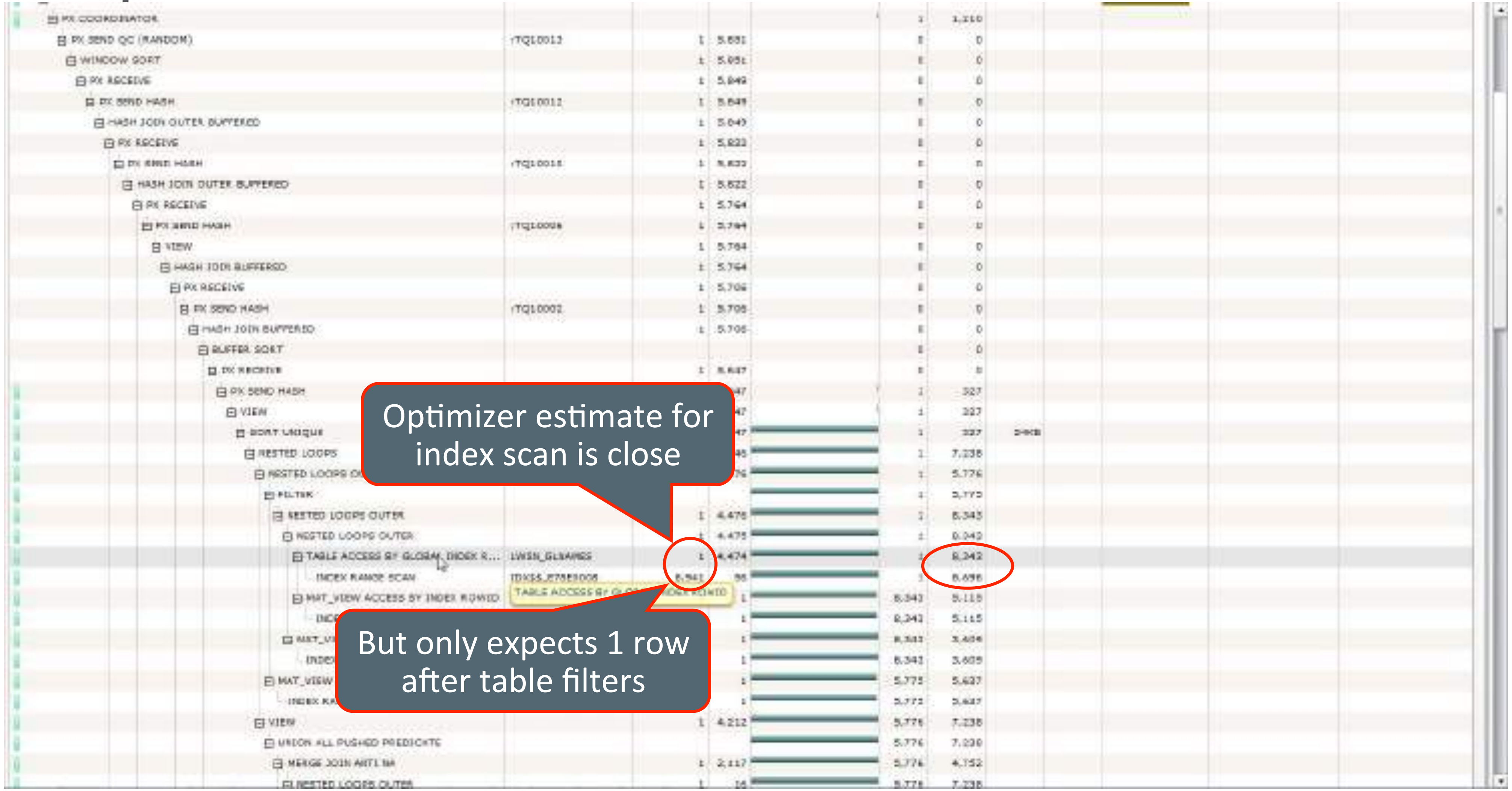


Example 2: Plan statistics shows where time spent

Example 2: Plan statistics leads to source of scan iterations



Example 2: Plan Statistics screen shows estimate and actual



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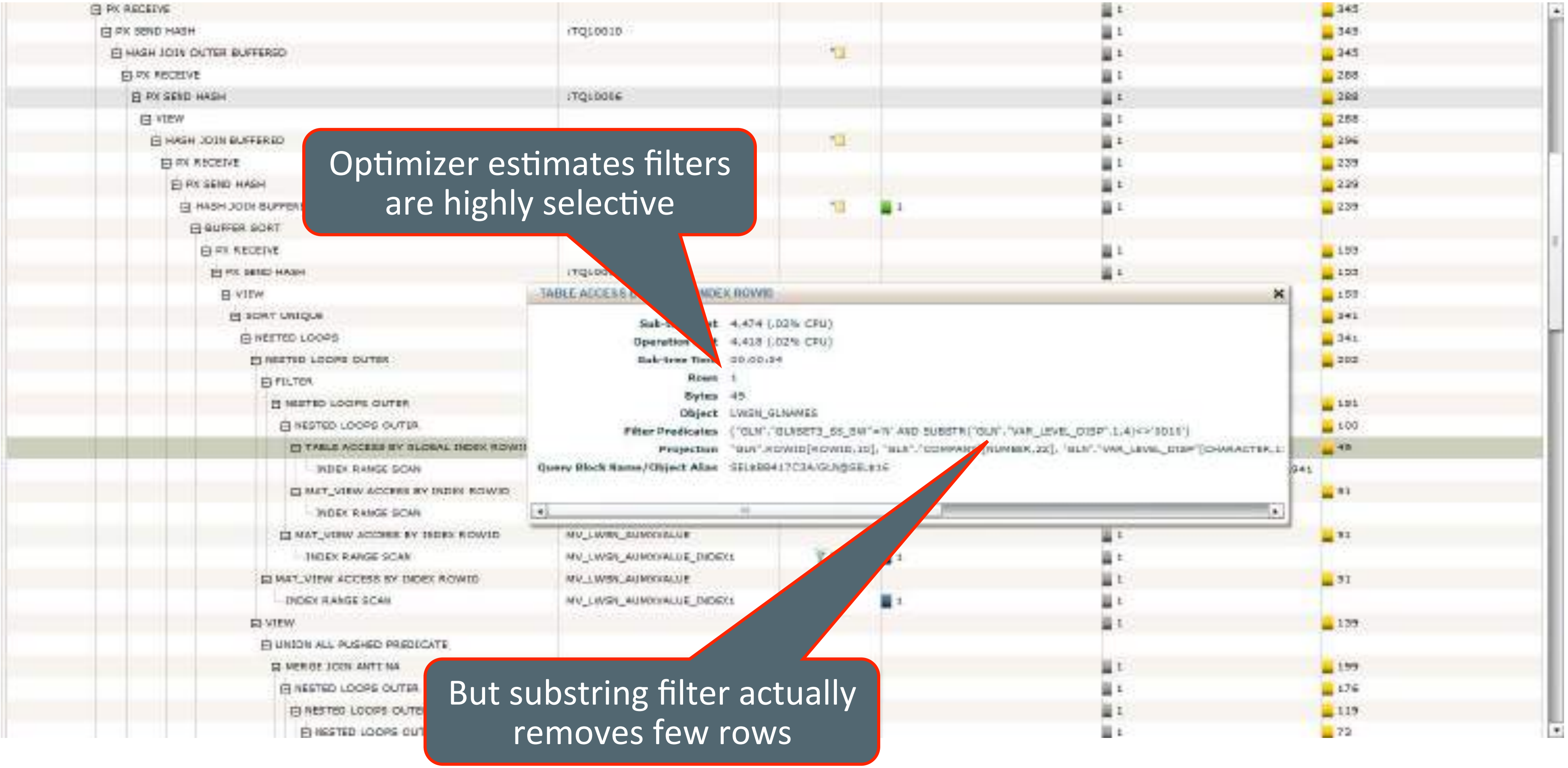
Example 2

Diagnosis

- Poor cardinality estimate caused by SUBSTR() function

Example 2: SQL Monitor Plan Screen Shows Predicates

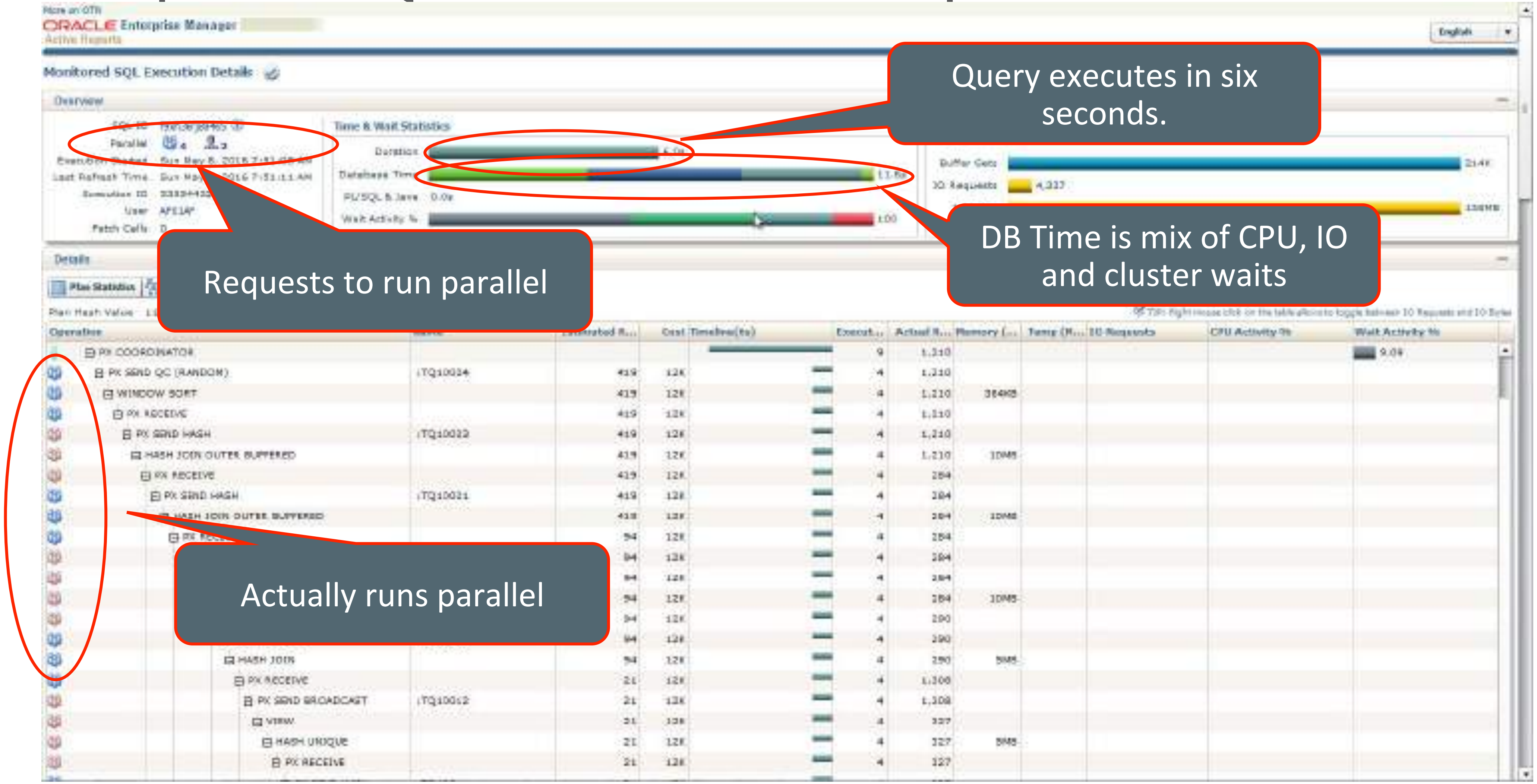


Example 2

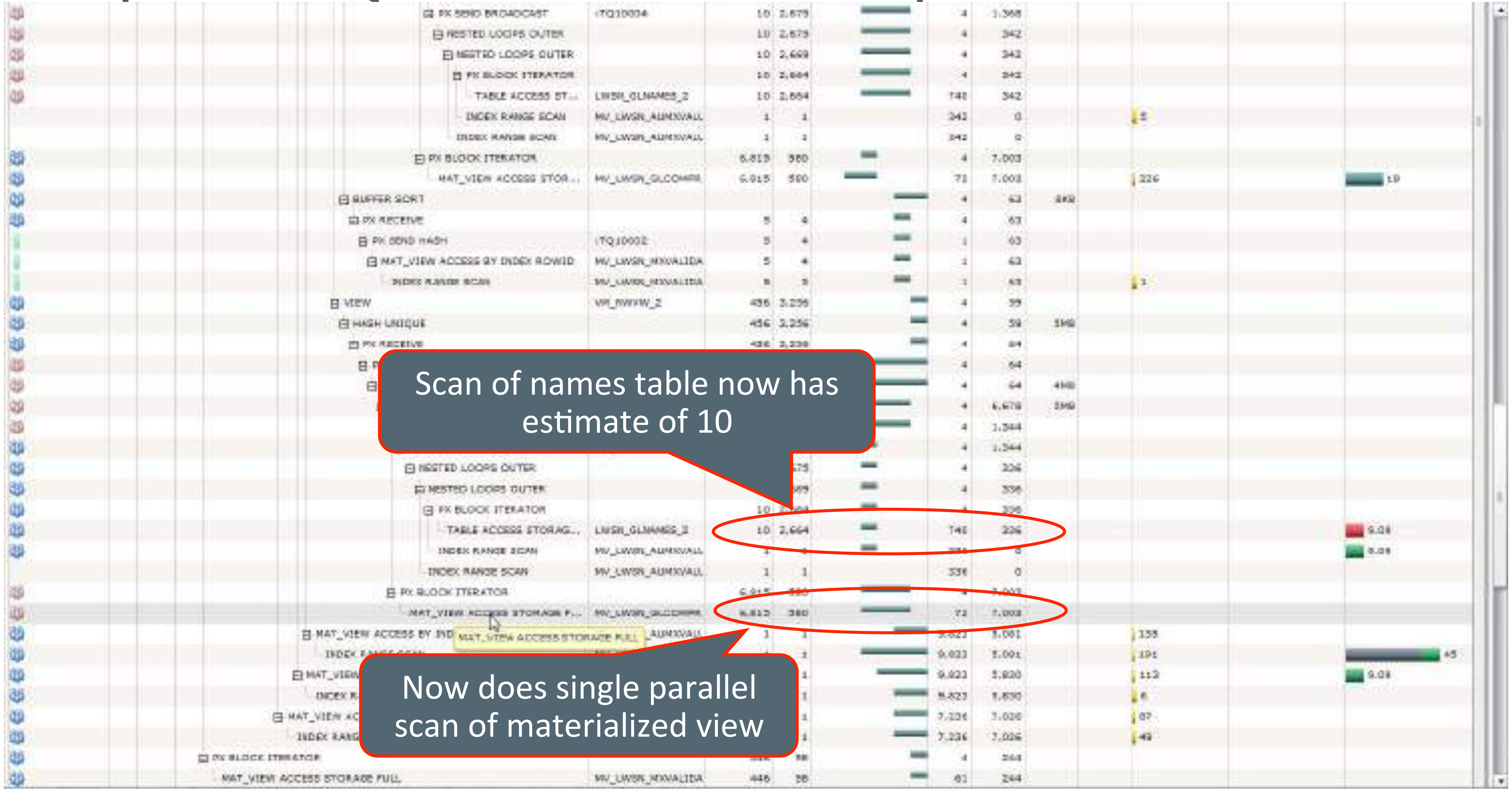
Solution

- Extended statistics on SUBSTR() function
- Optimizer now estimated 10 rows rather than 1
- Optimizer uses hash join rather than nested loop
- Accesses table with single scan
- Elapsed time: 6 seconds

Example 2: SQL Monitor After Expression Statistics Added



Example 2: SQL Monitor After Expression Statistics Added

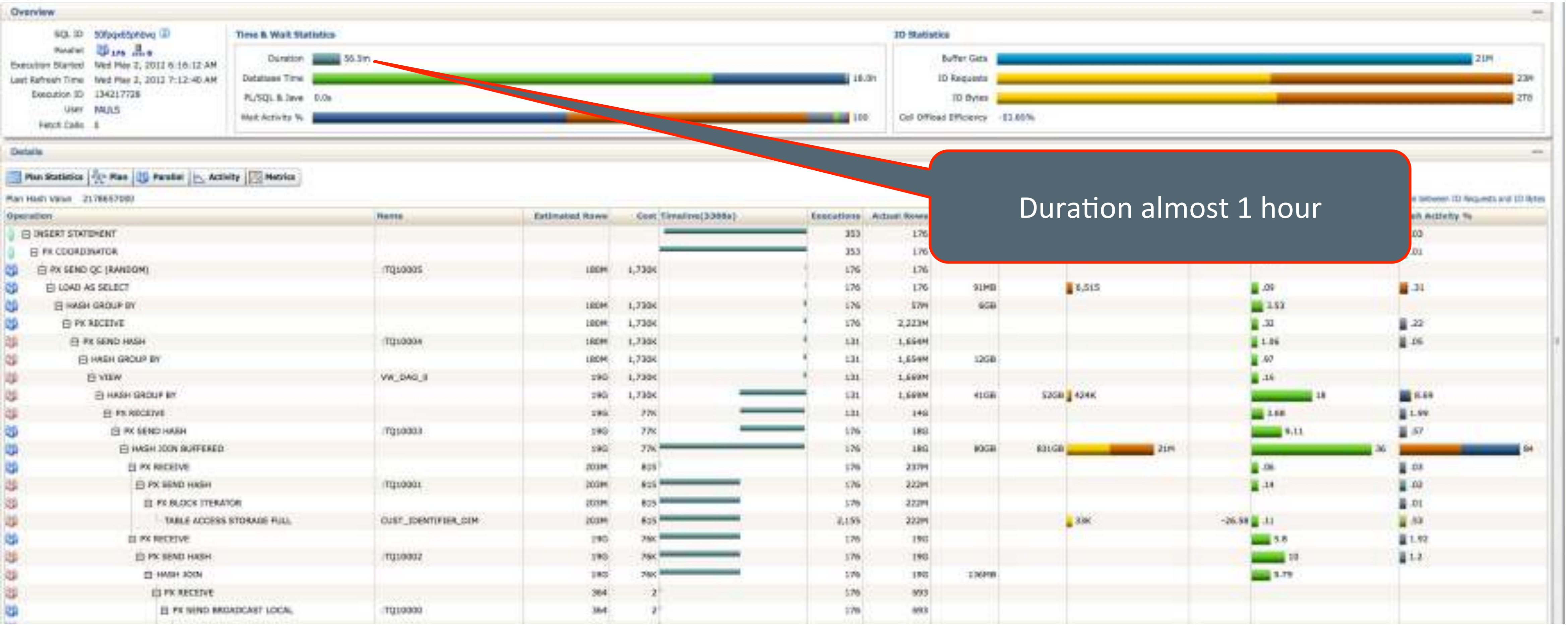


Example 3

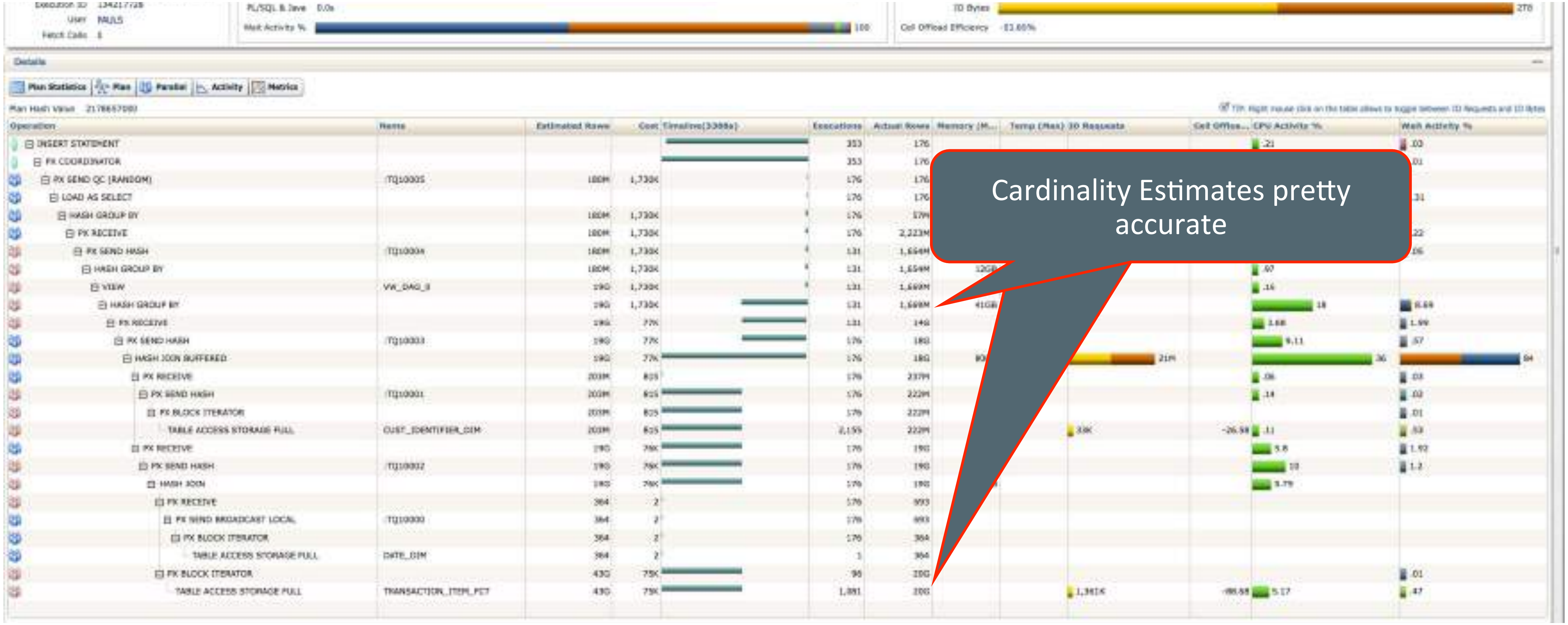
Observations

- Query takes 56 minutes
- Time spent in HASH JOIN BUFFERED
- Cardinality estimates are accurate
- Large amount of TEMP IO
- Table Scan of 1TB table ran for 1800's.
  - Scan rate for the platform is much higher than that
    - Scan is constrained by the buffering of the HASH JOIN

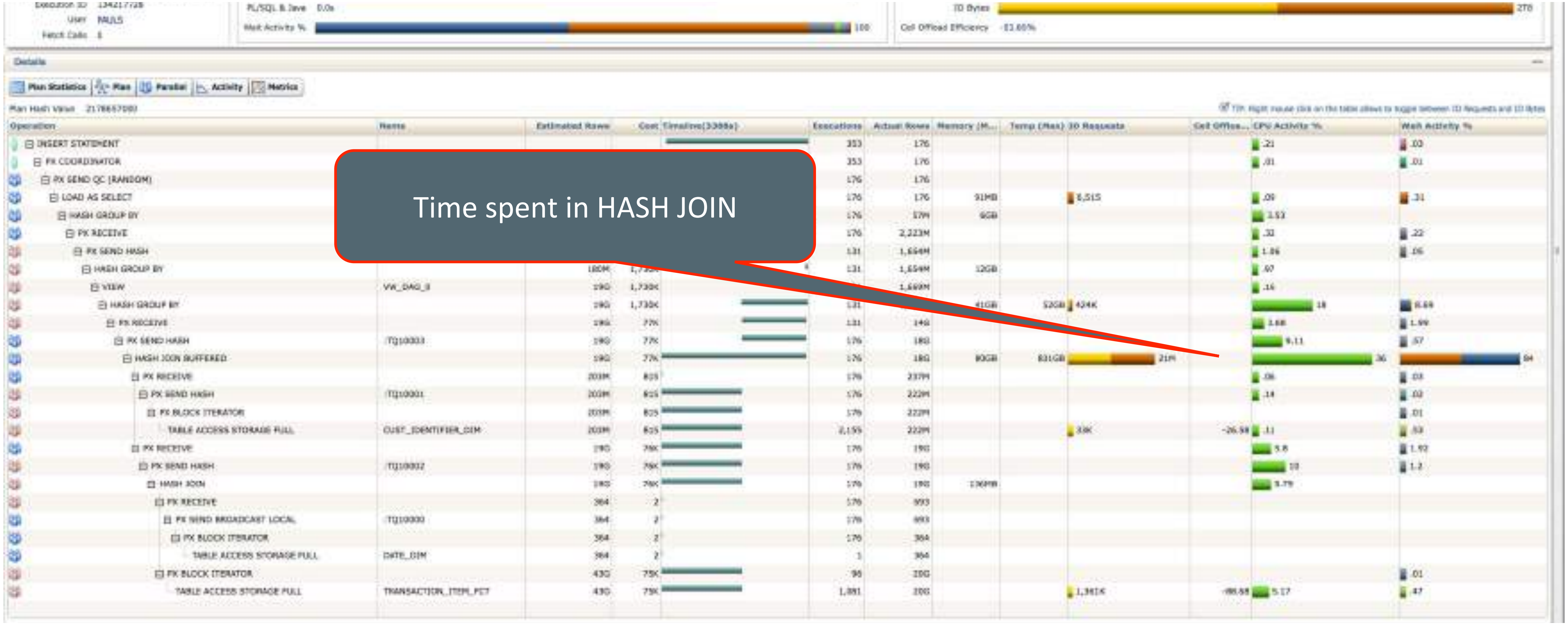
Example 3: Observations



Example 3: Observations



Example 3: Observations



Example 3

Diagnosis

- Examining the Parallel Tab
  - Database time for PX servers on instance 6 is much higher
  - Expanding the Instance 6 node and expanding Parallel Set 1, we observe one PX server with a DB Time of 53 mins
  - A large part of the query was executed by a single PX server.

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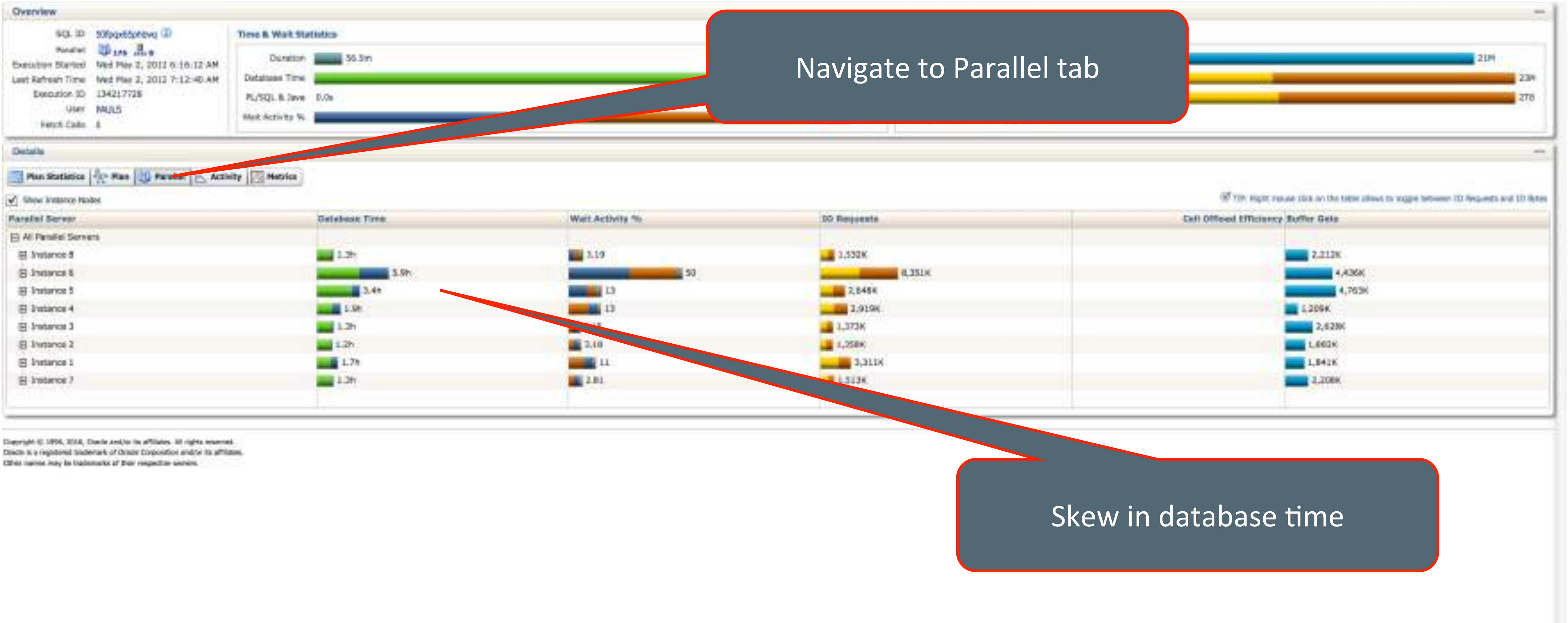
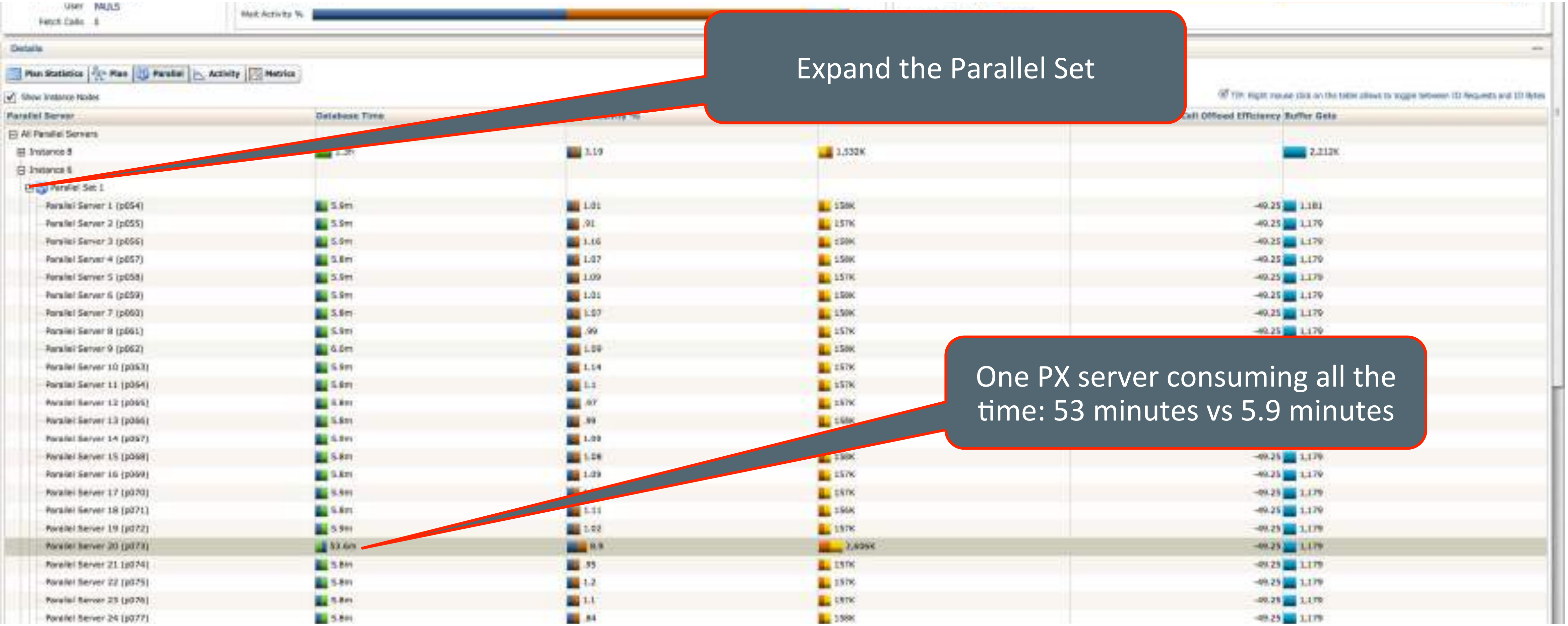
Example 3: Diagnosis



Example 3: Diagnosis



Example 3

Diagnosis

- Some domain knowledge was applied to this problem
  - The application supports loyalty cards
  - Majority of the customers ids are unknown or not identifiable
    - Implemented as a userID = -1
  - This value from the CUST_IDENTIFIER_DIM table hashes to a single hash bucket and so the HASH JOIN for that value is executed by a single PX slave

Example 3

Diagnosis

- Some domain knowledge was applied to this problem
  - The application supports loyalty cards
  - Majority of the customers ids are unknown or not identifiable
    - Implemented as a UserID = -1
  - UserID= -1 hashes to a single hash bucket
  - HASH JOIN for UserID= -1 is executed by a single PX slave

Example 3

Solution(s)

- Have the unknown customers be identified by a negative sequence number
- Run two separate queries
  - A query for known customers, ie CUST_IDENTIFIER_ID > 0
    - This query executes with HASH HASH distribution, like the original
  - A query for unknown customers CUST_IDENTIFIER_ID = -1
    - This query executes with a BROADCAST distribution
- Similar to above
  - Write the query as a UNION-ALL of the above
- In 12c, SKEW detection may generate a HYBRID plan that will automatically broadcast popular values, and Hash distribute non-popular values

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SQL Monitor gotcha’s

- Beware of cardinality estimates of 1 except for unique index lookup
- Execution count
  - Parallel operations
  - Partitioned operations
  - Nested loop
  - Or combination!
- For Nested loop plan
  - Estimated rows is for a single execution
  - Actual rows is for all executions (so far)
- Parallel server elapsed time bars not a good indication of time
- Fixed size in memory buffer means statements age out
- Plan lines limit defaults to 300
  - _sqlmon_max_planlines to change

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SQL Monitor Conclusions

SQL Monitor is the best tool to understand why SQL is running slowly

- Always on
- Detailed data on where the time is going
- Shows cardinality estimates vs actuals
- Top SQL captured into AWR in 12c

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PANEL

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