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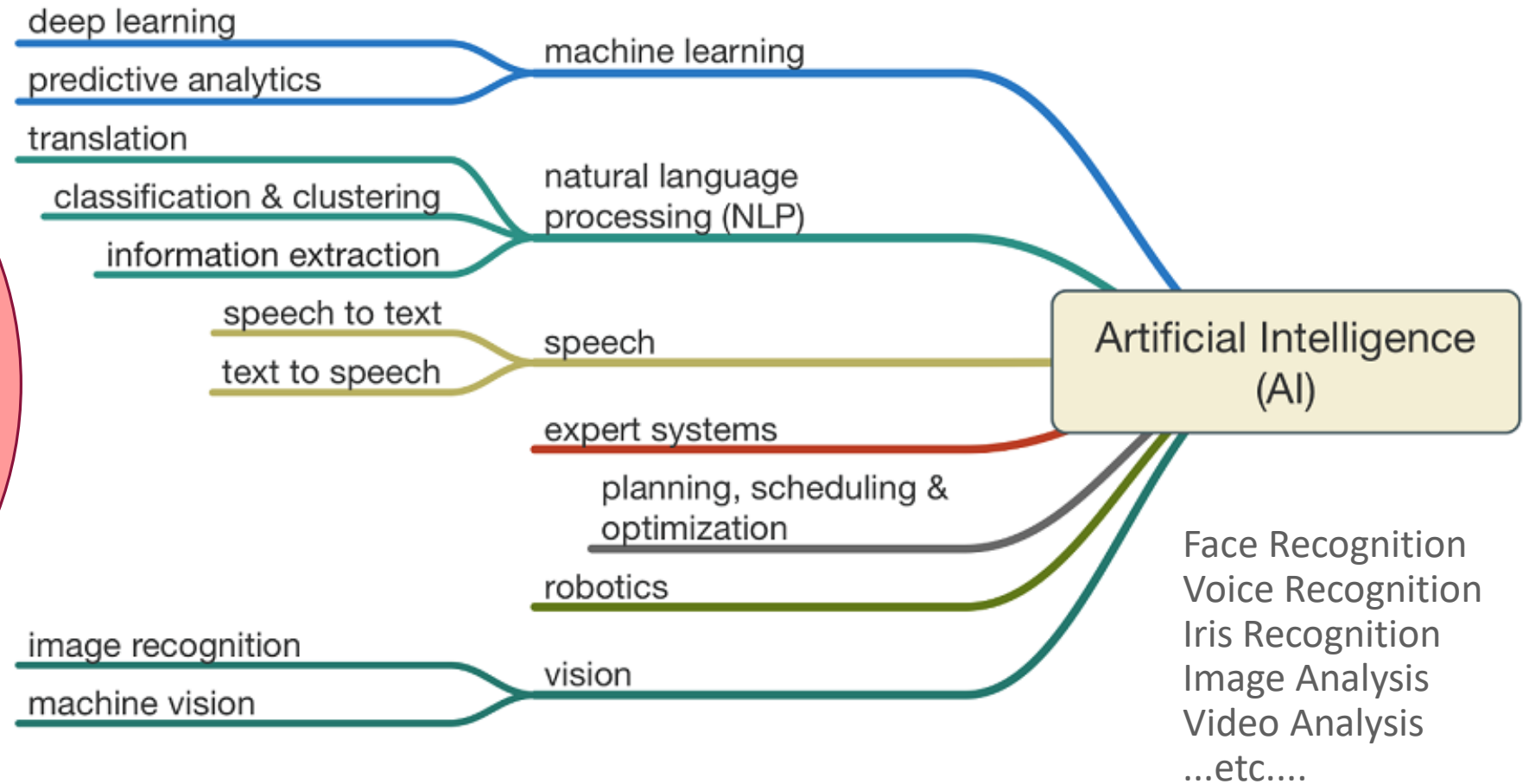
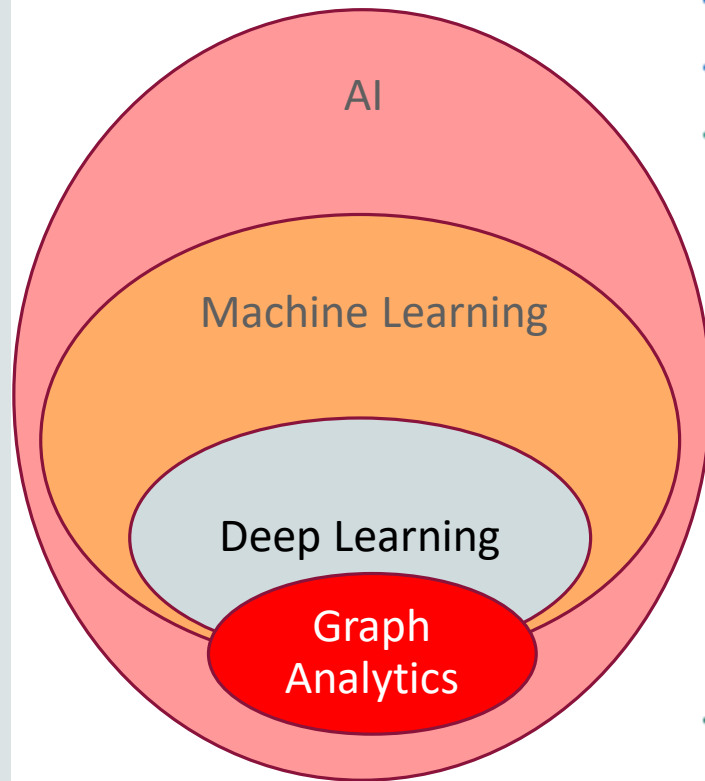
# Oracle's Machine Learning

## Oracle Database 19c Overview

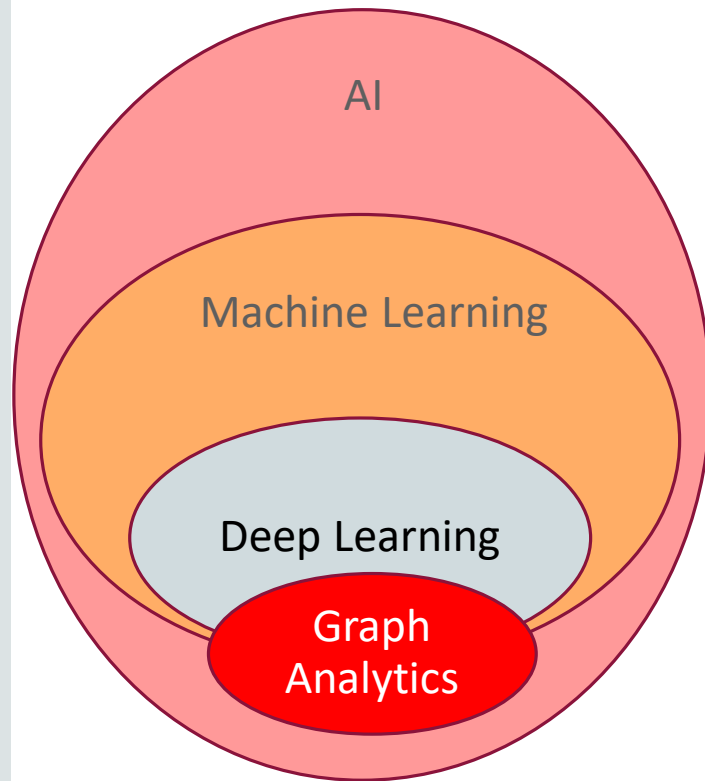
Olivier Perard  
Olivier.perard@oracle.com

Iberia Technology Sales Consulting  
January, 2021

# Artificial Intelligence Concepts



# Machine Learning Concepts



**Analytics models**  
Predictions   **Logistic regression**  
**Symbolic Aggregate approXimation**  
**Support Vector Machine**   **Random Forest**  
**BAYESIAN NETWORK**   **Correlation Analysis**  
**Decision Tree**   **Linear regression**  
Grubb's test   Kernel Density Estimation

Machine Learning



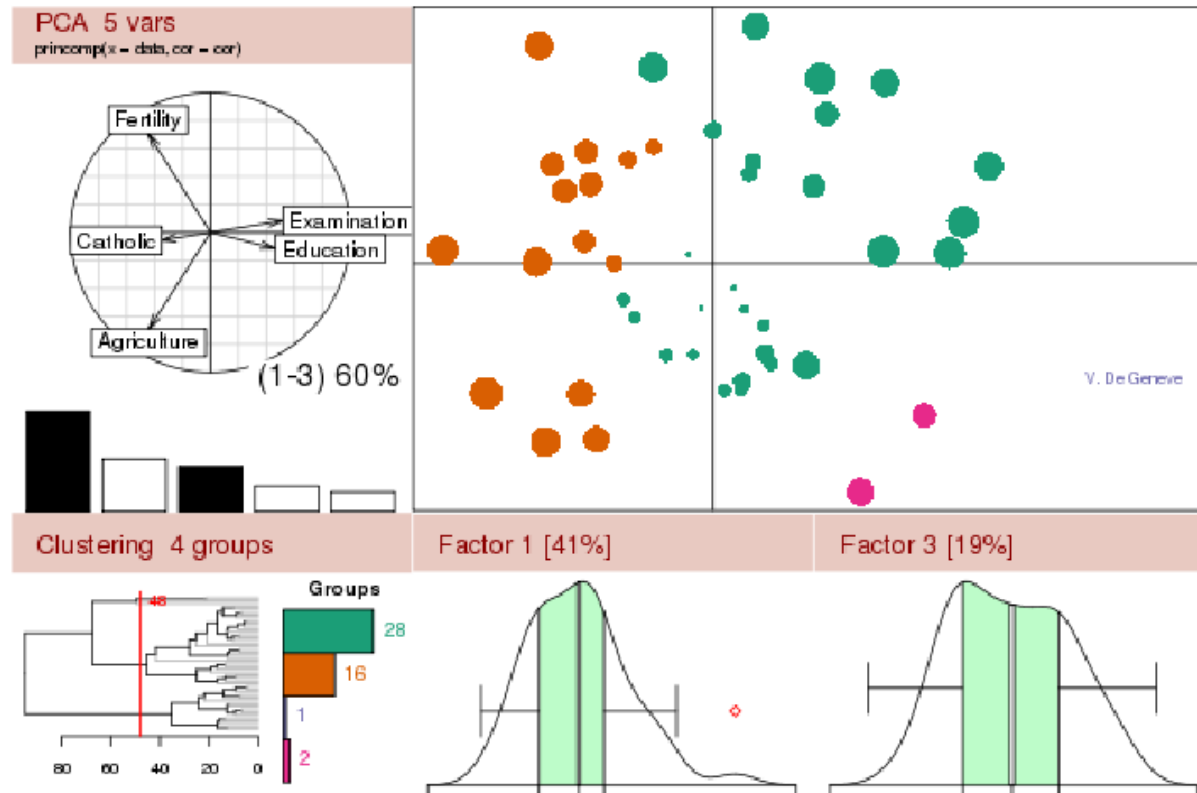
- Neural Network - NN (feed)
- Recurrent Neural Networks -(RNN)
- Recursive Neural Networks
- Convolutional Neural Network -(CNN)
- Long Short Term Memory (LSTM)

Deep Learning





# R Statistical Programming Language



Open source language and environment

Used for statistical computing and graphics

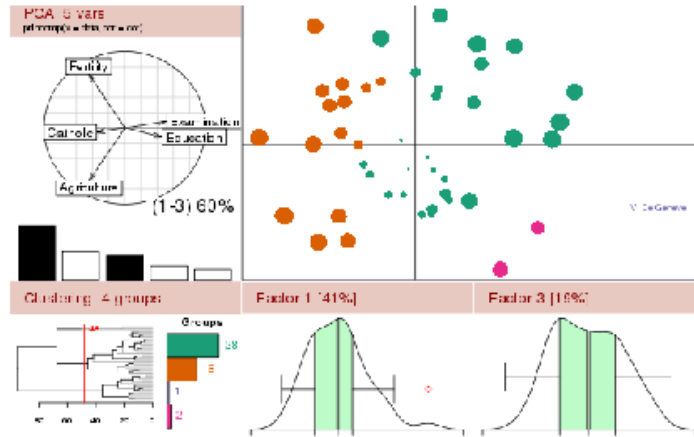
Strength in easily producing publication-quality plots

Highly extensible with open source community R packages



# Growing Popularity

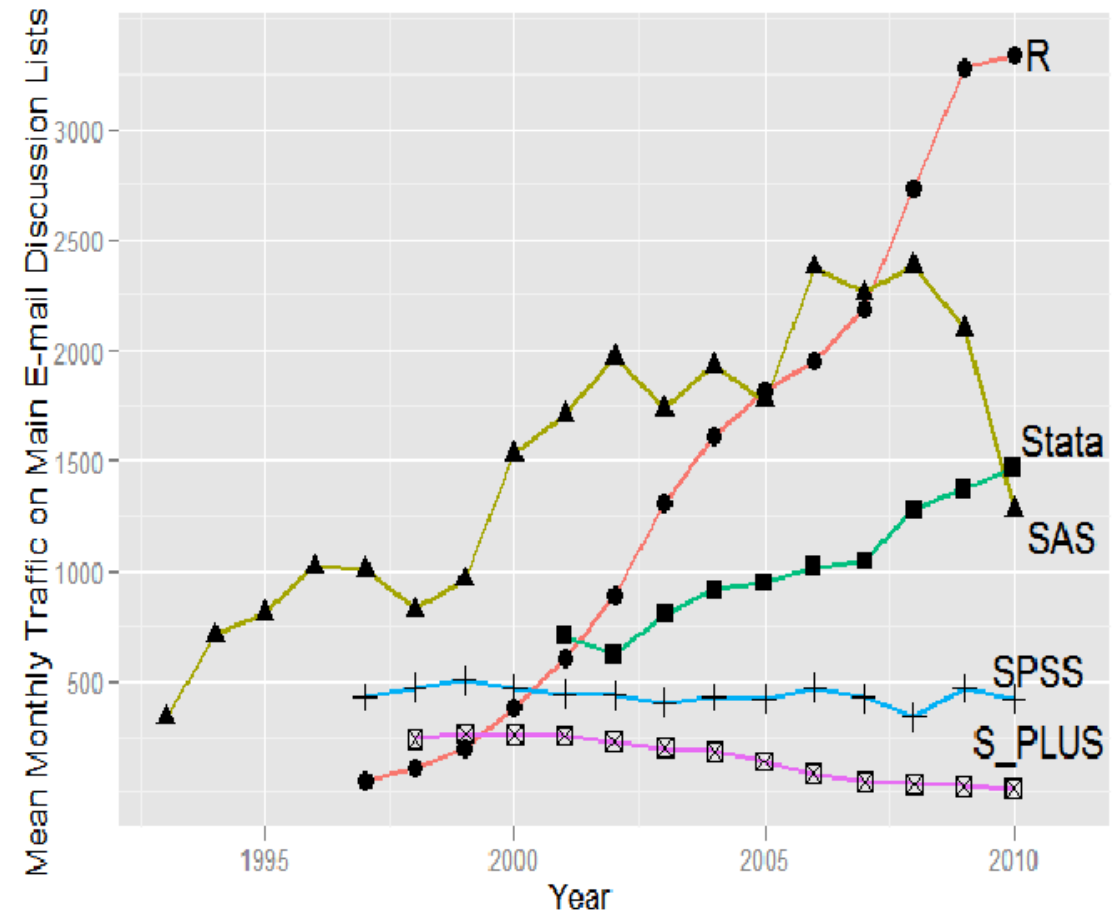
The R Project for Statistical Computing



- R's rapid adoption over several years has earned its reputation as a new statistical software standard
  - Rival to SAS and SPSS

*While it is difficult to calculate exactly how many people use R, those most familiar with the software estimate that close to 250,000 people work with it regularly.*

*"[Data Analysts Captivated by R's Power](#)", New York Times, Jan 6, 2009*



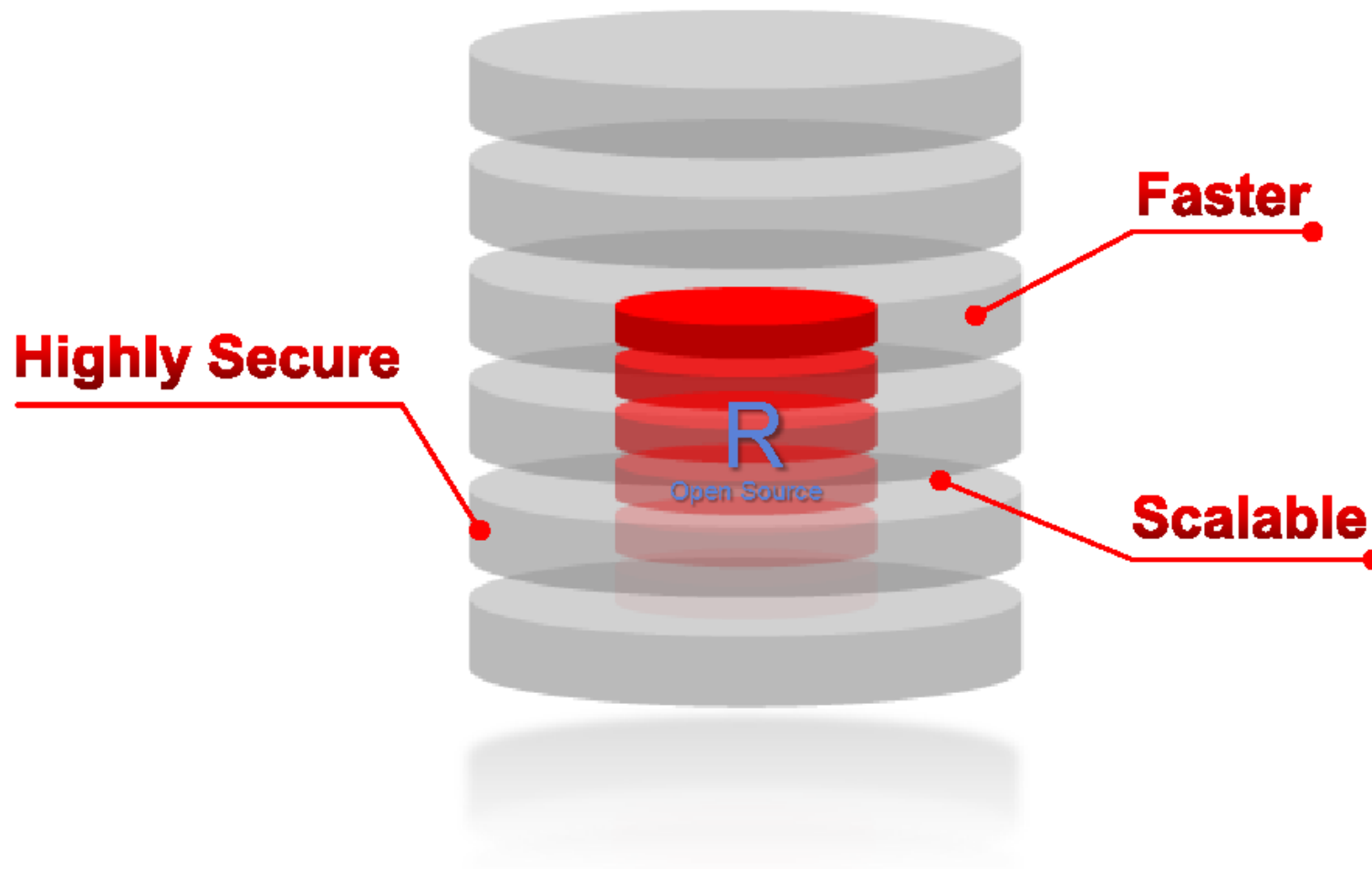
# What Are 's Challenges?



1. R is memory constrained
  - R processing is single threaded - does not exploit available compute infrastructure
  - R lacks industrial strength for enterprise use cases
2. R has lacked mindshare in Enterprise market
  - R is still met with caution by the long established SAS and IBM/SPSS statistical community
    - However, major university (e.g. Yale ) Statistics courses now taught in R
    - The FDA has recently shown indications for approval of new drugs for which the submission's data analysis was performed using R



# Oracle R Enterprise Approach



Data and statistical analysis are stored and run in-database

Same R user experience & same R clients

Embed in operational systems

Complements Oracle Data Mining

# Vision

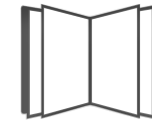
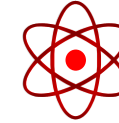


- Big Data + Data Science Platform for the Era of Big Data and Cloud
  - Make Big Data + Machine Learning Model Building Simple
  - Make Big Data + Machine Learning Model Deployment Simple
  - Key Differentiators:
    - Fully integrated into Oracle and Hadoop platforms
    - Scalable and Distributed algorithms run where the data is, in-Database or in-Cluster.
    - Easy to use using familiar interfaces like SQL and R.
    - Support for open-source R packages running in the Database Server or in the Cluster
    - Integrated with Oracle solutions like Graph, OBIEE, BDD, IoT, OSA, RTD
    - Easy GUI provided for SQL Developer; Compatible with 3<sup>rd</sup> party GUIs like RStudio
    - Low TCO, included in Oracle Cloud Services like EXADATA, DBaaS (Extreme and High Performance editions) and BDCS

# Predictive Analytics & Data Mining

## Typical Use Cases

- Targeting the right customer with the right offer
- How is a customer likely to respond to an offer?
- Finding the most profitable growth opportunities
- Finding and preventing customer churn
- Maximizing cross-business impact
- Security and suspicious activity detection
- Understanding sentiments in customer conversations
- Reducing medical errors & improving quality of health
- Understanding influencers in social networks



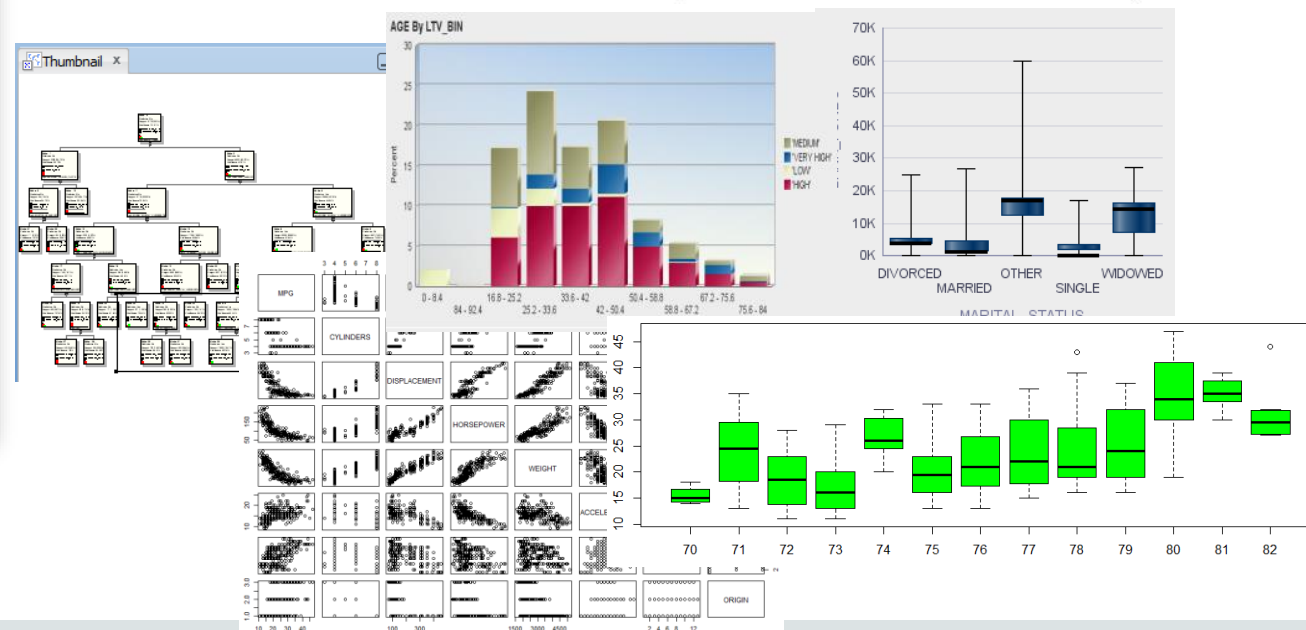
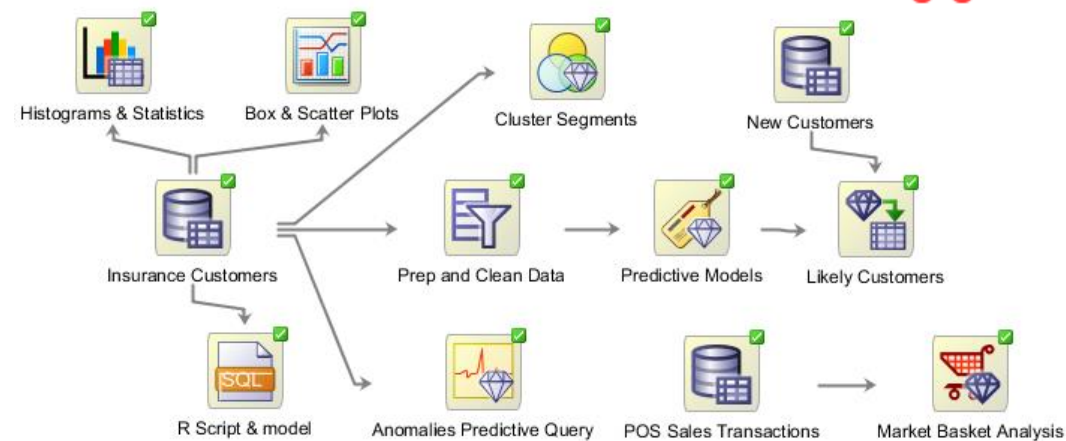
# Oracle Advanced Analytics Database Option

## Fastest Way to Deliver Scalable Enterprise-wide Predictive Analytics



### Key Features

- In-database data mining algorithms and open source R algorithms
- Cuadrilingual component of Oracle Database—**SQL**, SQLDev/**ODMr GUI**, **R**, **Python**
- Scalable, parallel in-database execution
- Workflow GUI and IDEs
- Integrated component of Database
- Enables enterprise analytical applications



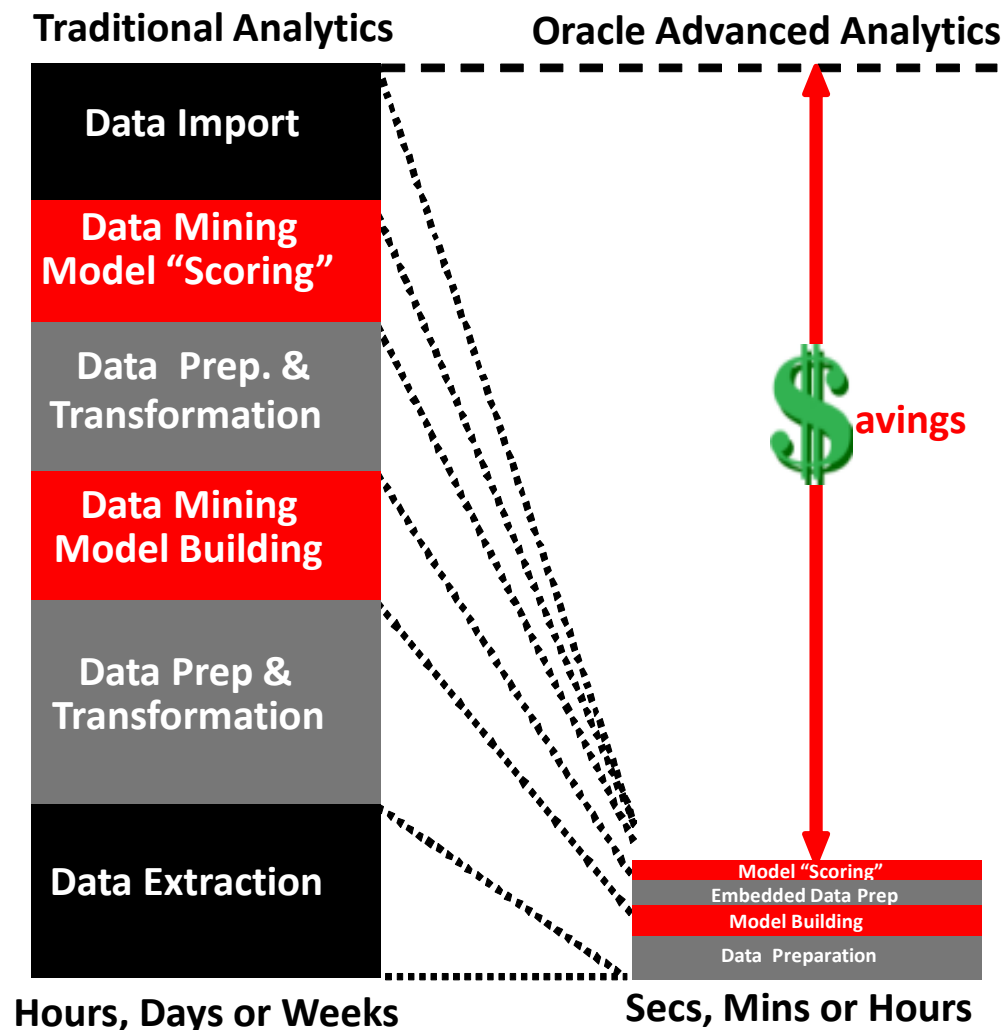
# Oracle Advanced Analytics Database Option

Fastest way to deliver enterprise-wide predictive analytics

## Key Features

### Data remains in the Database

- Scalable, parallel Data Mining algorithms in SQL kernel
- Fast parallelized native SQL data mining functions, SQL data preparation and efficient execution of R open-source packages
- High-performance parallel scoring of SQL data mining functions and R open-source models



# Oracle Advanced Analytics Database Option

Fastest way to deliver enterprise-wide predictive analytics

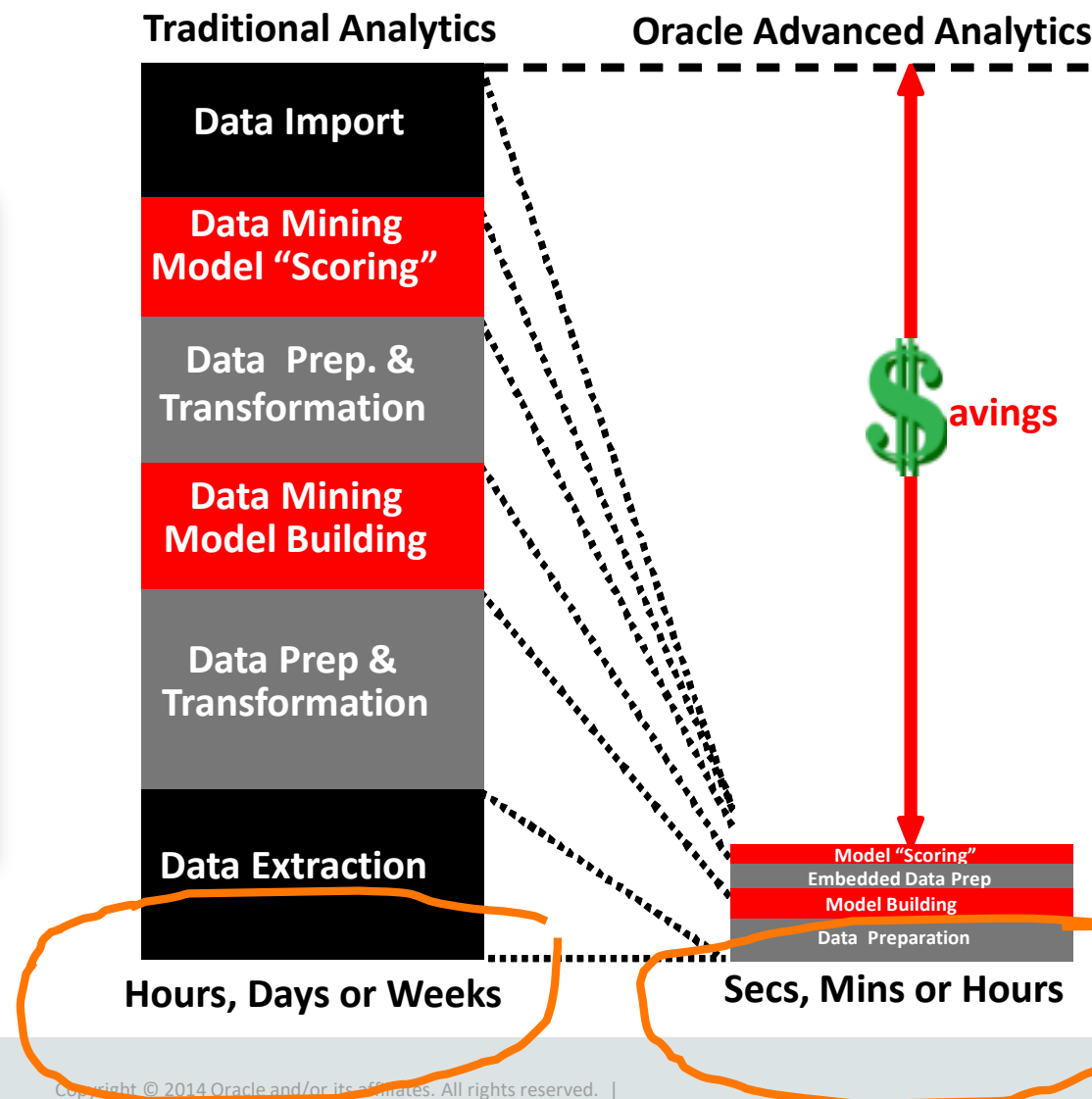
## Key Features

### Lowest Total Cost of Ownership

- Eliminate data duplication
- Eliminate separate analytical servers
- Leverage investment in Oracle IT

### Fastest way to deliver *enterprise-wide* predictive analytics

- Integrated GUI for Predictive Analytics
- Database scoring engine





# You Can Think of Oracle Advanced Analytics Like This...

## Traditional SQL

- “Human-driven” queries
- Domain expertise
- Any “rules” must be defined and managed

### SQL Queries

- SELECT
- DISTINCT
- AGGREGATE
- WHERE
- AND OR
- GROUP BY
- ORDER BY
- RANK



+

## Oracle Advanced Analytics (**SQL** & **R**)

- Automated knowledge discovery, model building and deployment
- Domain expertise to assemble the “right” data to mine/analyze

### Analytical SQL “Verbs”

- PREDICT
- DETECT
- CLUSTER
- CLASSIFY
- REGRESS
- PROFILE
- IDENTIFY FACTORS
- ASSOCIATE



# Oracle Advanced Analytics Database Architecture

## Trilingual Component of Oracle Database—SQL, SQLDev/ODMr GUI, R

**Users**

**Data & Business Analysts**

**R,Python  
programmers**

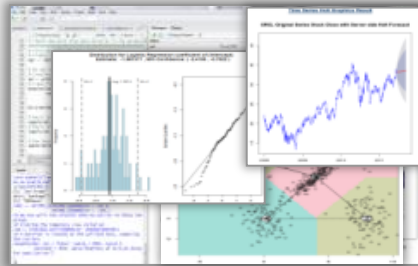
**Business Analysts/Mgrs**

**Domain End Users**

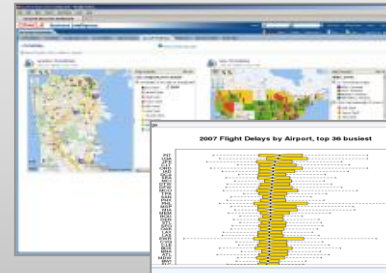
### SQL Developer



### R, Python Client



### OBIEE



### Applications



**Platform**

## Oracle Database Enterprise Edition

### Oracle Advanced Analytics

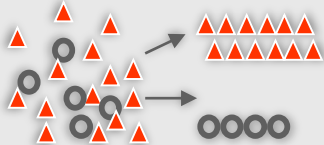
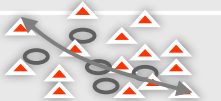
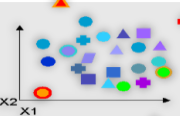
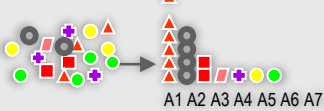
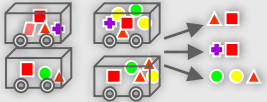
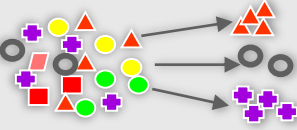
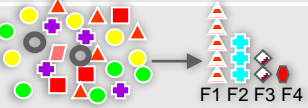
*Native SQL Data Mining/Analytic Functions + High-performance  
R & Python Integration for Scalable, Distributed, Parallel Execution*



# Oracle Advanced Analytics

## In-Database Data Mining Algorithms—SQL & R & GUI Access



| Function             |   | Algorithms  | Applicability  |
|----------------------|---|---|--|
| Classification       |    | Logistic Regression (GLM)<br>Decision Trees<br>Naïve Bayes<br>Support Vector Machines (SVM) | Classical statistical technique<br>Popular / Rules / transparency<br>Embedded app<br>Wide / narrow data / text |
| Regression           |    | Linear Regression (GLM)<br>Support Vector Machine (SVM)                                     | Classical statistical technique<br>Wide / narrow data / text   |
| Anomaly Detection    |    | One Class SVM   | Unknown fraud cases or anomalies   |
| Attribute Importance |    | Minimum Description Length (MDL)<br>Principal Components Analysis (PCA)                     | Attribute reduction, Reduce data noise   |
| Association Rules    |   | Apriori   | Market basket analysis / Next Best Offer   |
| Clustering           |  | Hierarchical k-Means<br>Hierarchical O-Cluster<br>Expectation-Maximization Clustering (EM)  | Product grouping / Text mining<br>Gene and protein analysis  |
| Feature Extraction   |  | Nonnegative Matrix Factorization (NMF)<br>Singular Value Decomposition (SVD)                | Text analysis / Feature reduction  |

# Oracle Advanced Analytics In-Database Option

## Wide Range of In-Database Data Mining and Statistical Functions



- **Data Understanding & Visualization**

- Summary & Descriptive Statistics
- Histograms, scatter plots, box plots, bar charts
- R graphics: 3-D plots, link plots, special R graph types
- Cross tabulations
- Tests for Correlations (t-test, Pearson's, ANOVA)
- Selected Base SAS equivalents

- **Data Selection, Preparation and Transformations**

- Joins, Tables, Views, Data Selection, Data Filter, SQL time windows, Multiple schemas
- Sampling techniques
- Re-coding, Missing values
- Aggregations
- Spatial data
- SQL Patterns
- R to SQL transparency and push down

- **Classification Models**

- Logistic Regression (GLM)
- Naive Bayes
- Decision Trees
- Support Vector Machines (SVM)
- Neural Networks (NNs)

- **Regression Models**

- Multiple Regression (GLM)
- Support Vector Machines

- **Clustering**

- Hierarchical K-means
- Orthogonal Partitioning
- Expectation Maximization

- **Anomaly Detection**

- Special case Support Vector Machine (1-Class SVM)

- **Associations / Market Basket Analysis**

- A Priori algorithm

- **Feature Selection and Reduction**

- Attribute Importance (Minimum Description Length)
- Principal Components Analysis (PCA)
- Non-negative Matrix Factorization
- Singular Vector Decomposition

- **Text Mining**

- Most OAA algorithms support unstructured data (i.e. customer comments, email, abstracts, etc.)

- **Transactional & Spatial Data**

- All OAA algorithms support transactional data (i.e. purchase transactions, repeated measures over time, distances from location, time spent in area A, B, C, etc.)

- **R packages—ability to run open source**

- Broad range of R CRAN packages can be run as part of database process via R to SQL transparency and/or via Embedded R mode

A woman with long brown hair and glasses is sitting at a wooden table in a cafe. She is wearing a brown leather jacket over a blue patterned scarf. She is holding a black smartphone to her ear with her left hand and looking down at an open magazine or book on the table with her right hand. The background is a blurred interior of a cafe with other tables and chairs.

# Oracle Advanced Analytics

Brief Demos

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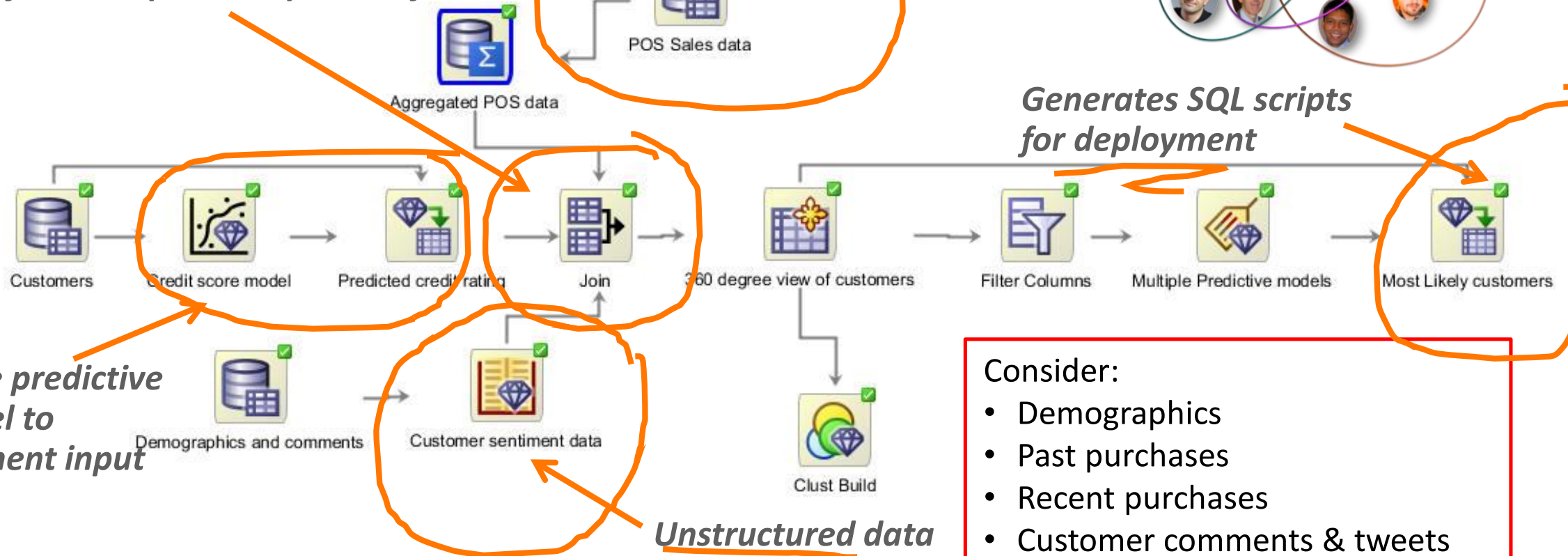
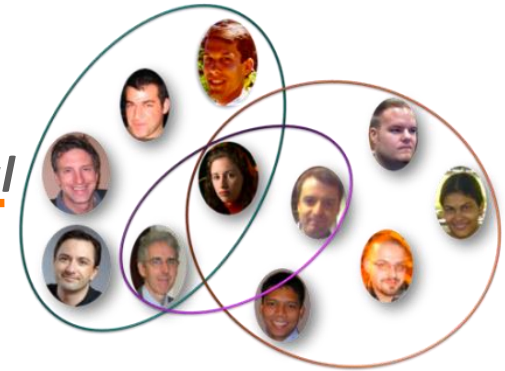


# Predicting Behavior

Identify “Likely Behavior” and their Profiles

*SQL Joins and arbitrary SQL transforms & queries – power of SQL*

*Transactional POS data*



*Inline predictive model to augment input data*

*Unstructured data also mined by algorithms*

Consider:

- Demographics
- Past purchases
- Recent purchases
- Customer comments & tweets



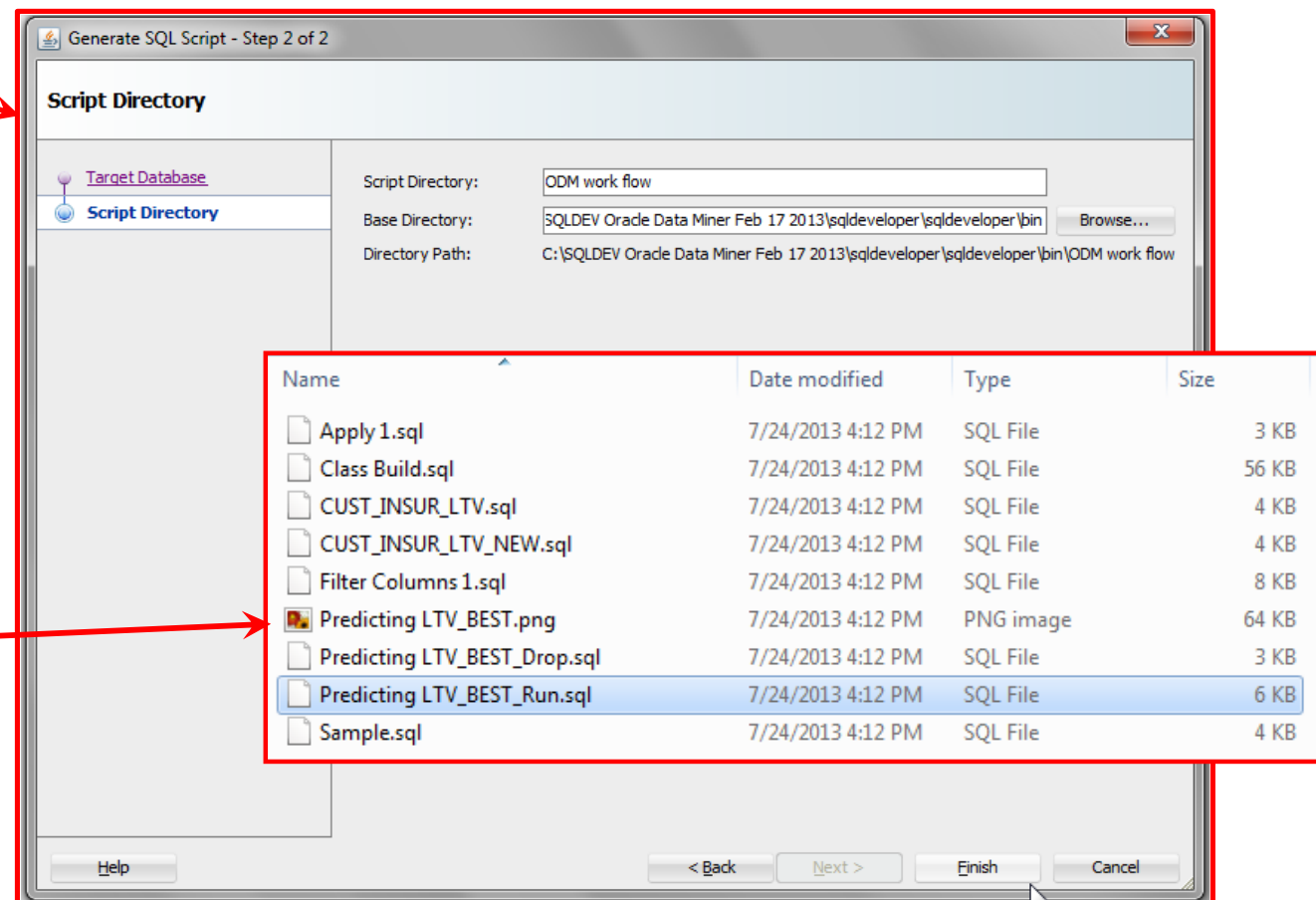
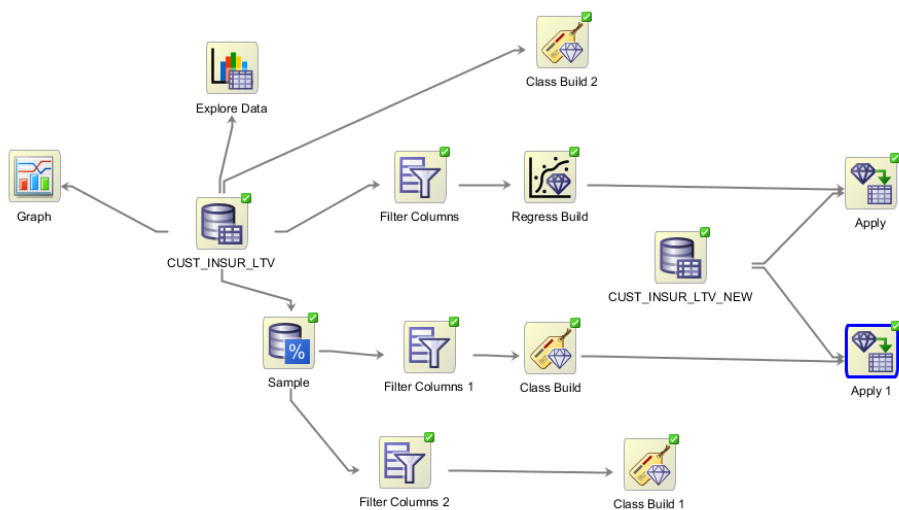
# SQL Developer/Oracle Data Miner 4.0

## New Features



### ■ SQL Script Generation

- Deploy entire methodology as a SQL script
- Immediate deployment of data analyst's methodologies



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# Oracle Advanced Analytics

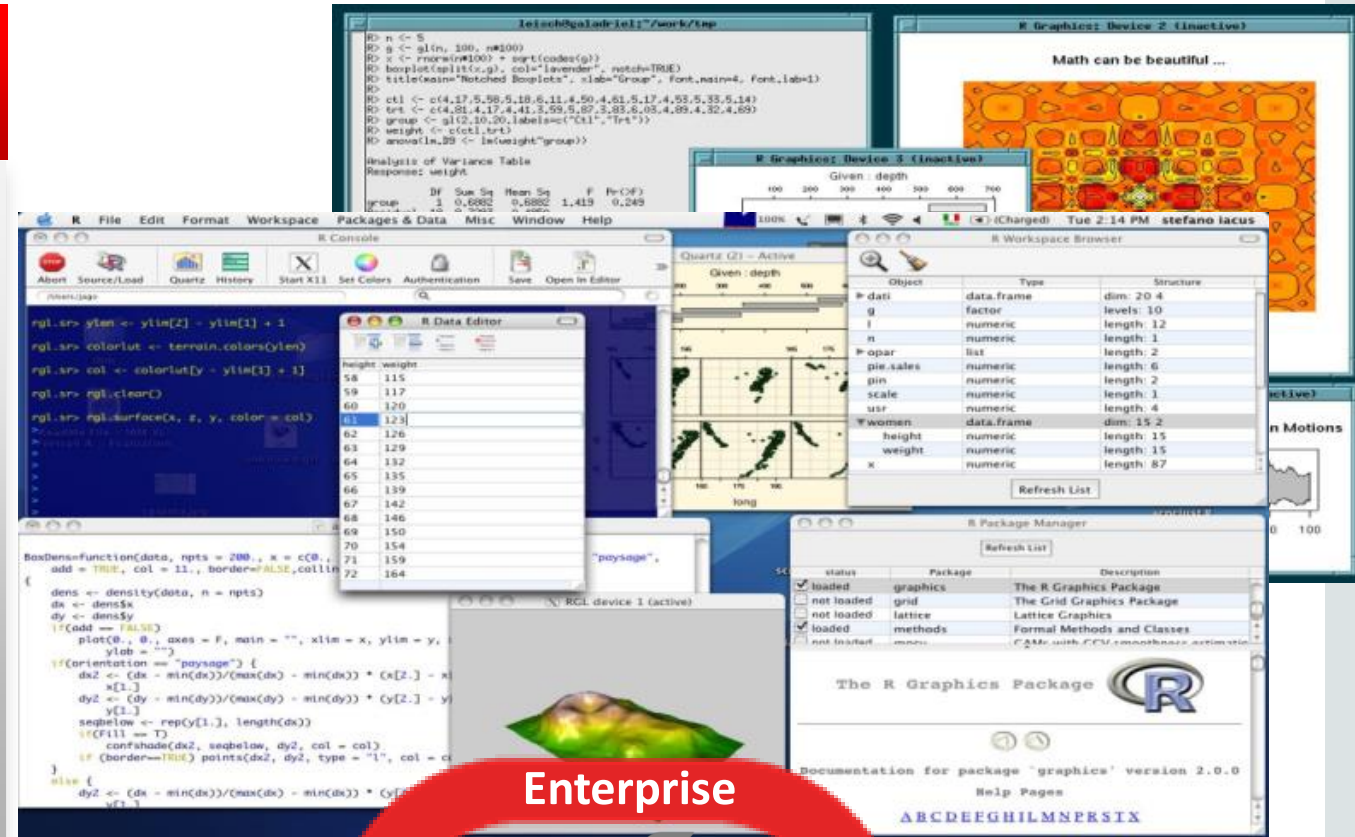
OAA/Oracle R Enterprise (R integration)

# R—Widely Popular

R is a statistics language similar to Base SAS or SPSS statistics

## R environment

- Strengths
  - Powerful & Extensible
  - Graphical & Extensive statistics
  - Free—open source (CRAN + 9000 components)
  - Standard for Data Scientist
- Challenges
  - Memory constrained
  - Single threaded
  - Outer loop—slows down process
  - Not Enterprise Oriented



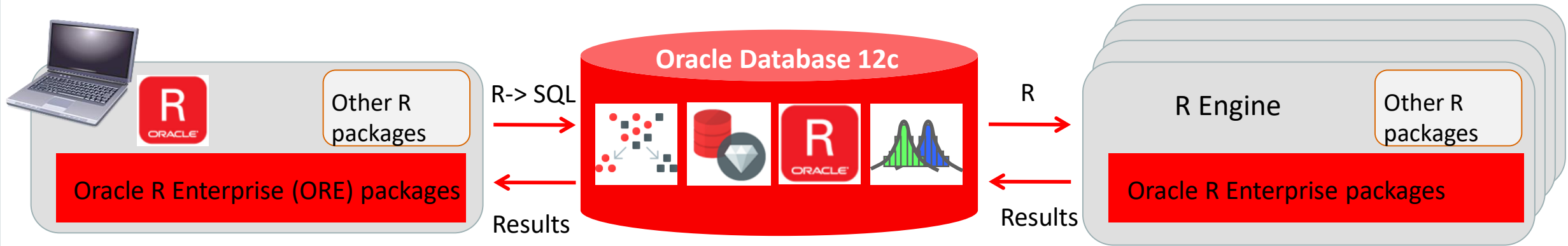
Enterprise



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# Oracle Advanced Analytics

## How Oracle R Enterprise Compute Engines Work



### 1 R-> SQL Transparency “Push-Down”

- R language for interaction with the database
- R-SQL Transparency Framework overloads R functions for scalable in-database execution
- Function overload for data selection, manipulation and transforms
- Interactive display of graphical results and flow control as in standard R
- Submit user-defined R functions for execution at database server under control of Oracle Database

### 2 In-Database Adv Analytical SQL Functions

- 15+ Powerful data mining algorithms (regression, clustering, AR, DT, etc.\_)
- Run Oracle Data Mining SQL data mining functioning (ORE.odmSVM, ORE.odmDT, etc.)
- Speak “R” but executes as proprietary in-database SQL functions—machine learning algorithms and statistical functions
- Leverage database strengths: SQL parallelism, scale to large datasets, security
- Access big data in Database and Hadoop via SQL, R, and Big Data SQL

### 3 Embedded R Package Callouts

- R Engine(s) spawned by Oracle DB for database-managed parallelism
- ore.groupApply high performance scoring
- Efficient data transfer to spawned R engines
- Emulate map-reduce style algorithms and applications
- Enables production deployment and automated execution of R scripts



## 08. Advanced Analytics

### 8.0 Oracle BI EE 12c Advanced Analytics

#### 8.00 Advanced Analytics:

Overview, Binning, Trendline, Forecast, Outlier, Cluster, Regression

#### 8.01 Visualizing using R:

Interactive Boxplot, Interactive 3D Scatter, Bubble Chart Grid, Variable Width Bar, Random Dots

#### 8.02 Functional Examples (Evaluate Script):

Text Sentiment, Text Term Frequency, Timeseries Decomposition, Market Basket Analysis, Collaborative Filtering, Delay Prediction (Precomputed Model)

### 8.1 Descriptive Analytics

#### 8.10 Binning and Tiling:

Comparative Dist, Distr. II, Distribution, Large Data, Ntiling, Percentiles, Width Bucket

#### 8.11 Comparative Analysis:

Age Pyramid, Benchmark, Index To Avg, Indexing, Lift, Tiering, TopN, TopN History

#### 8.12 Descriptive Stats:

8020, Control Chart, Correlation, Data Density, Deviants, Scatter, See Also, StdDev, Variability

#### 8.13 History and Trend:

History, Seasonality, Trend Lines, Trending

### 8.2 Oracle Database Analytics

#### 8.20 Text Analytics:

Cost Analysis per Token, Cost Per Token Frequency, Text Aggregation, Text Classes, Text Classification, Text Filtering, Words Distribution

#### 8.21 Temporal and Time:

Months Between, Temporal Query (12c Session), Temporal Query (12c), TimeZone with DST, Timezone Conversion

#### 8.22 Analytic Clauses:

Frequent Itemset, Model Projection, Pattern Detection (12c), Projection Interactive

#### 8.23 Other DB Analytics:

CLOB Datatype, Column Statistics, DB Web Services, Text Aggregation, JSON Parsing, Approximate Count Distinct

### 8.3 Oracle Data Mining

#### 8.30 ODM Classification:

Classification Tree, Geo LTV Prediction, LTV Details, LTV Prediction, LTV Probabilities, LTV What If Scoring, Dynamic Classification (12c)

#### 8.31 ODM Regression:

Regression, Regression Variance, Variance Heatmap, Dyn Predictive Regression (12c)

#### 8.32 ODM Clustering, Association and Attribute Importance:

Clustering, Market Basket Analysis, Attribute Importance

#### 8.33 ODM Mining On-the-fly:

Anomaly Influencers (12c), Dyn Anomaly Detection (12c), Dyn Predictive Regression (12c), Dynamic Classification (12c), Dyn Prediction Delay Grp (12c In-mem), Dyn Anomaly Analysis (12c In-mem)

#### 8.34 ODM Data Miner Workflows:

List of Examples, Overview

### 8.4 Oracle R Enterprise

#### 8.40 ORE Integration:

R Integration, R End-User Interaction, R Workbench, R Results Object in RPD, BIP Sourcing from R, Quality Control Chart (BIP)

#### 8.41 ORE Time Series:

T. Series Decomposition, T. Series Forecasting, T. Series Moving Average, T. Series Auto ARIMA, T. Series Holt, T. Series SES, T. Series ACF PACF

#### 8.42 ORE Datamining:

Multivariate Adaptive Regression Splines, Support Vector Machines, Association Rules, Variable Importance, Clustering with k-Means++, In-Database Associations, ORE GroupApply, ORE IndexApply

#### 8.43 ORE Visualizations:

Quality Control Chart, Boxplot, Cond. Histogram, Corr. Matrix Circles, Corr. Matrix Ellipses, Heatmap, Multipanel Geo Lattice, Volcano, sinc Perspective

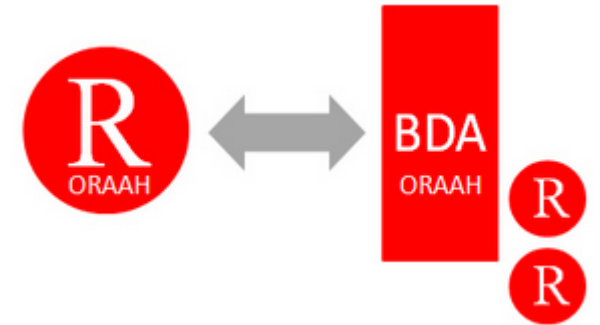


# Oracle Advanced Analytics for Hadoop

Predictive algorithms that execute in a parallel/distributed manner on Hadoop with data in HDFS



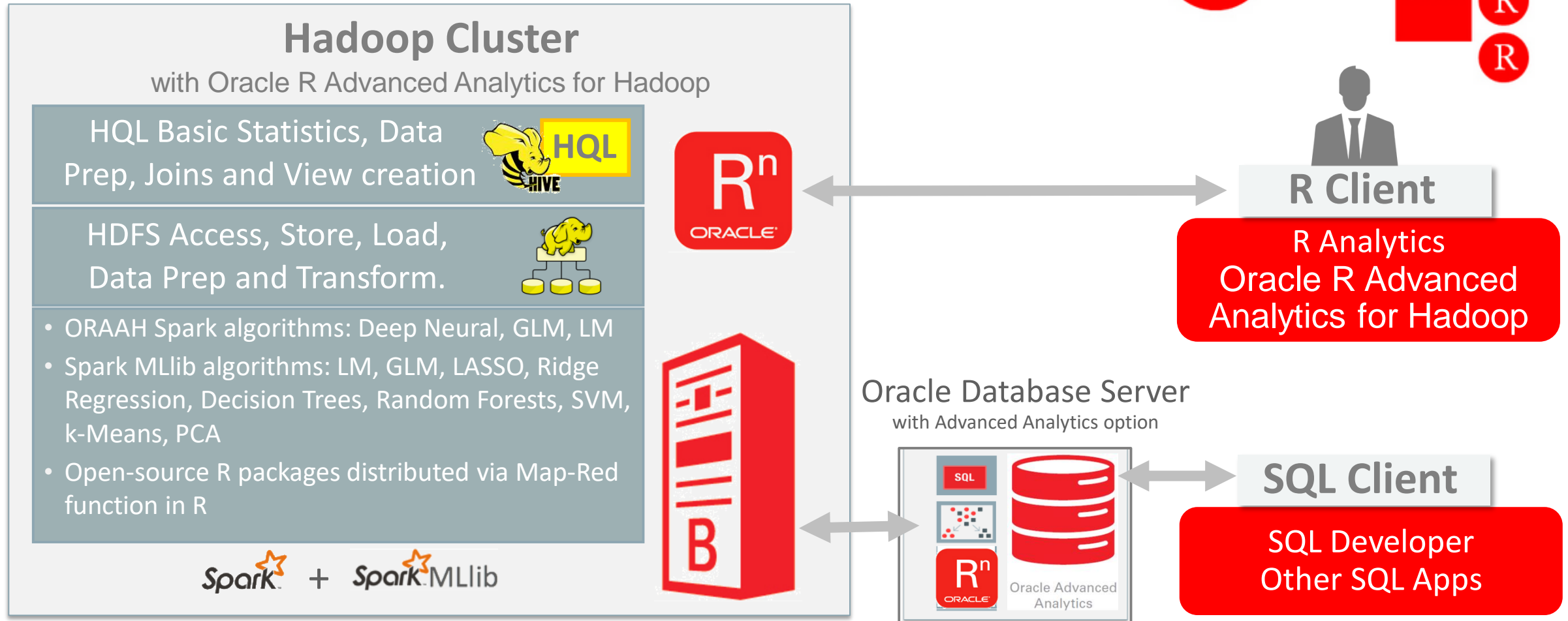
# Oracle R Advanced Analytics for Hadoop



- ORAAH = Oracle R Advanced Analytics for Hadoop, part of Big Data Software Connectors Suite (Oracle Big Data Appliance Option)
- ORAAH transparency layer enables certain overloaded R functions to operate on Hive tables using R syntax and behavior (transparently translating R to HiveQL)
- R interface for manipulating HDFS data and writing mapper and reducer functions in R – where you can leverage open source CRAN packages – and invoke those Hadoop jobs from R
- Provides a range of predictive algorithms that execute on the Hadoop cluster with data in HDFS in a parallel/distributed manner.

# Oracle R Advanced Analytics for Hadoop:

## Using Hadoop and HIVE, plus R Engine and Open-Source R Packages



# Oracle's Advanced Analytics

Multiple interfaces across platforms — SQL, R, GUI, Dashboards, Apps

## Information Producers

Users

R programmers

Data & Business Analysts

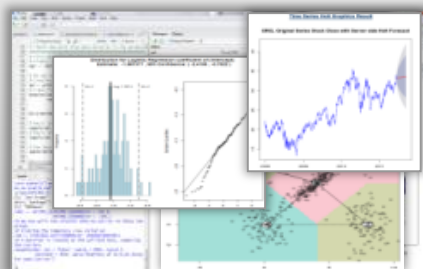
## Information Consumers

Business Analysts/Mgrs

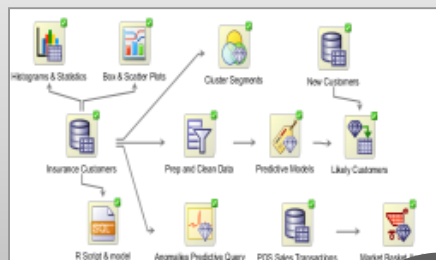
Domain End Users



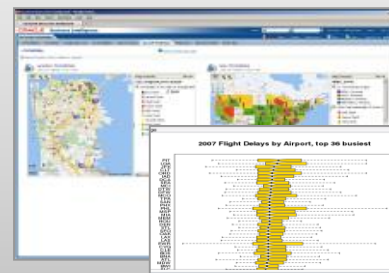
R Client



SQL Developer/  
Oracle Data Miner



OBIEE



Applications



Platform

Hadoop

Oracle R Advanced Analytics for Hadoop  
*Parallel, distributed algorithms*

Oracle Database Enterprise Edition

Oracle R enterprise in Database  
*SQL Data Mining & Analytic Functions  
+ R Integration for Scalable,  
Distributed, Parallel in-Database ML  
Execution*



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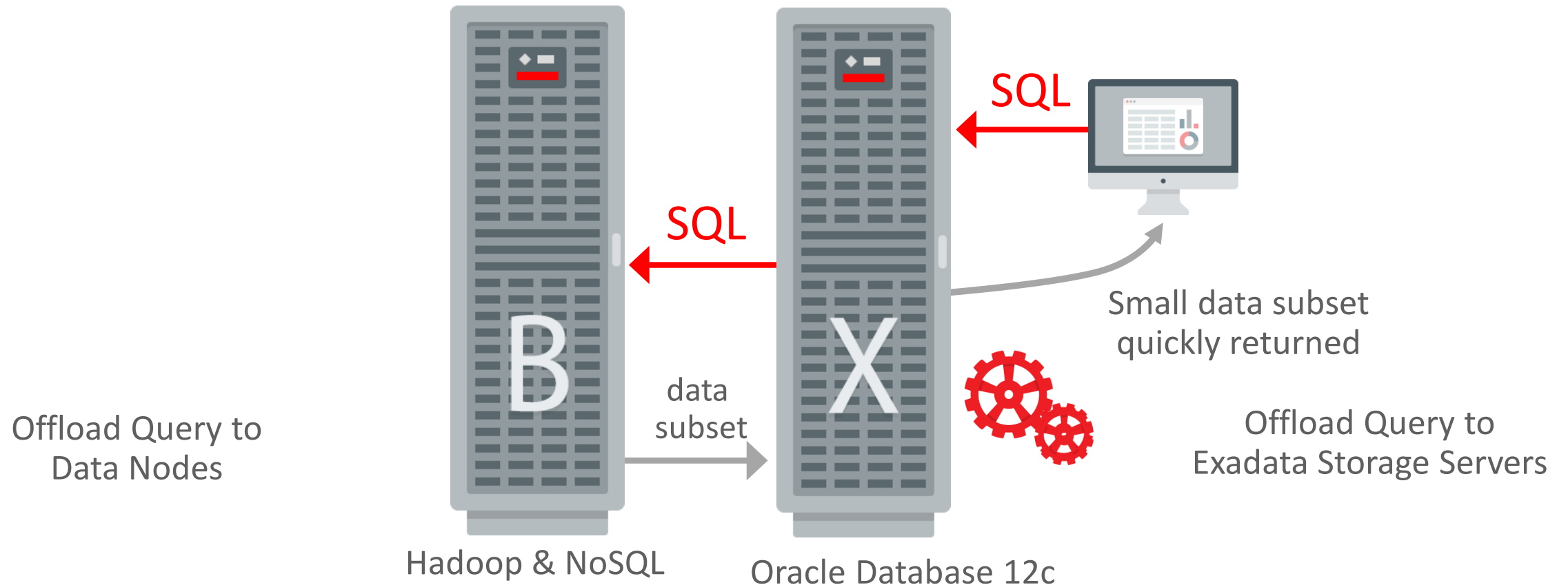
A woman with long brown hair and glasses is sitting at a wooden table in a cafe. She is wearing a brown leather jacket over a blue patterned scarf. She is holding a black smartphone to her ear with her left hand and looking down at an open book or magazine on the table with her right hand. The background is a blurred interior of a cafe with other tables and chairs.

# Big Data SQL

**Push down SQL predicts to storage layers**

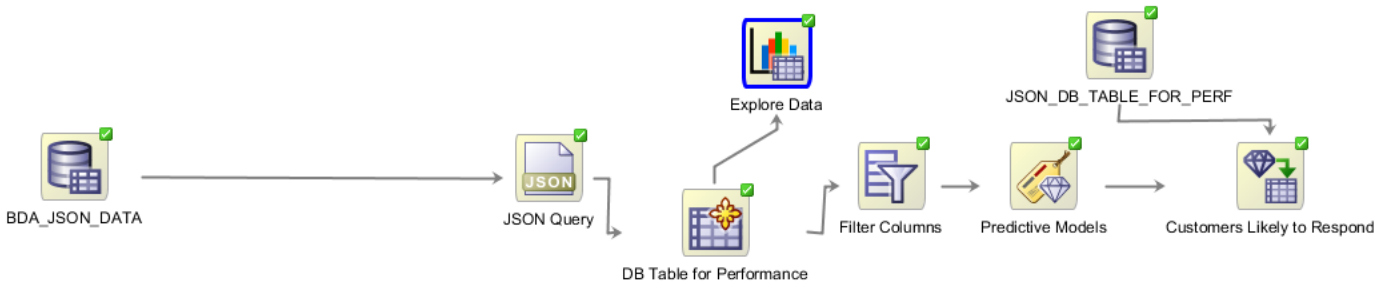
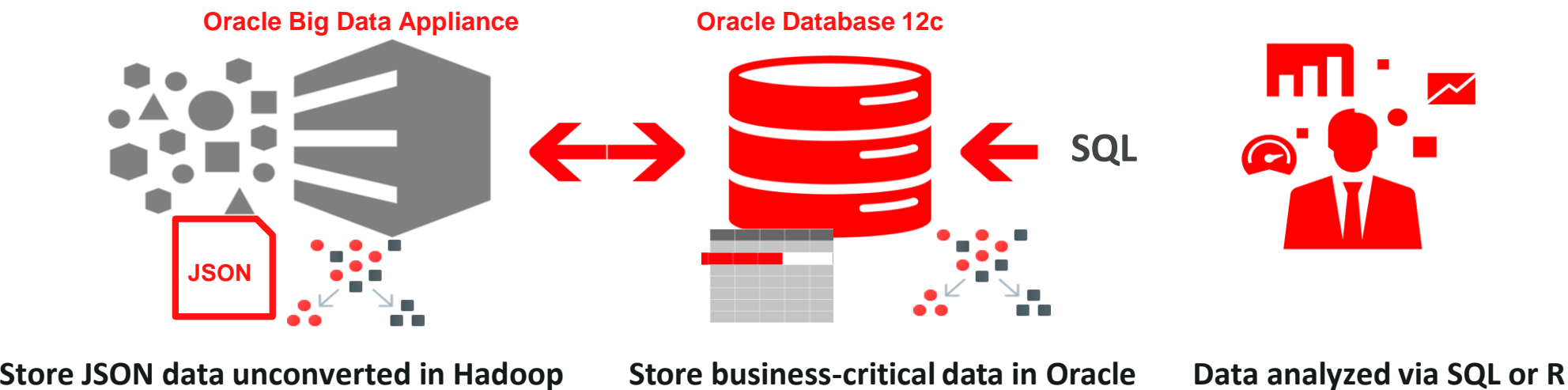
# Introducing Oracle Big Data SQL

## Massively Parallel SQL Query across Oracle, Hadoop and NoSQL



# Manage and **Analyze** All Data—SQL & Oracle Big Data SQL

SQL





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# Oracle's Advanced Analytics

**Predictive Applications + OBIEE Integration**

# Enabling “Predictive” Enterprise Applications

## Oracle Applications Using Oracle Advanced Analytics—Partial List

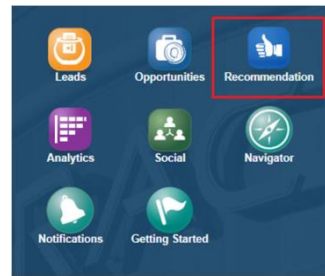
- **Oracle HCM Fusion**

- Employee turnover and performance prediction and “What if?” analysis



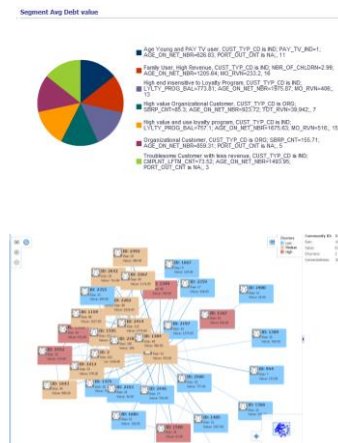
- **Oracle CRM Fusion**

- Prediction of sales opportunities, what to sell, amount, timing, etc.



- **Oracle Industry Data Models**

- **Communications Data Model** churn prediction, segmentation, profiling, etc.
- **Retail Data Model** loyalty and market basket analysis
- **Airline Data Model** analysis frequent flyers, loyalty, etc.
- **Utilities Data Model** customer churn, cross-sell, loyalty, etc.



- **Oracle Retail Customer Analytics**

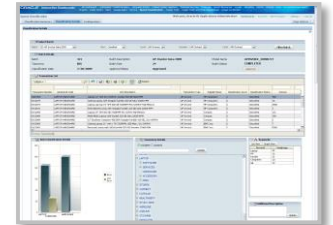
- “Shopping cart analysis” and next best offers

- **Oracle Customer Support**

- Predictive Incident Monitoring (PIM)

- **Oracle Spend Classification**

- Real-time and batch flagging of noncompliance and anomalies in expense submissions



- **Oracle FinServ Analytic Applications**

- Customer Insight, Enterprise Risk Management, Enterprise Performance, Financial Crime and Compliance

- **Oracle Adaptive Access Manager**

- Real-time security and fraud analytics



# **Hardware and Software Engineered to Work Together**

ORACLE®