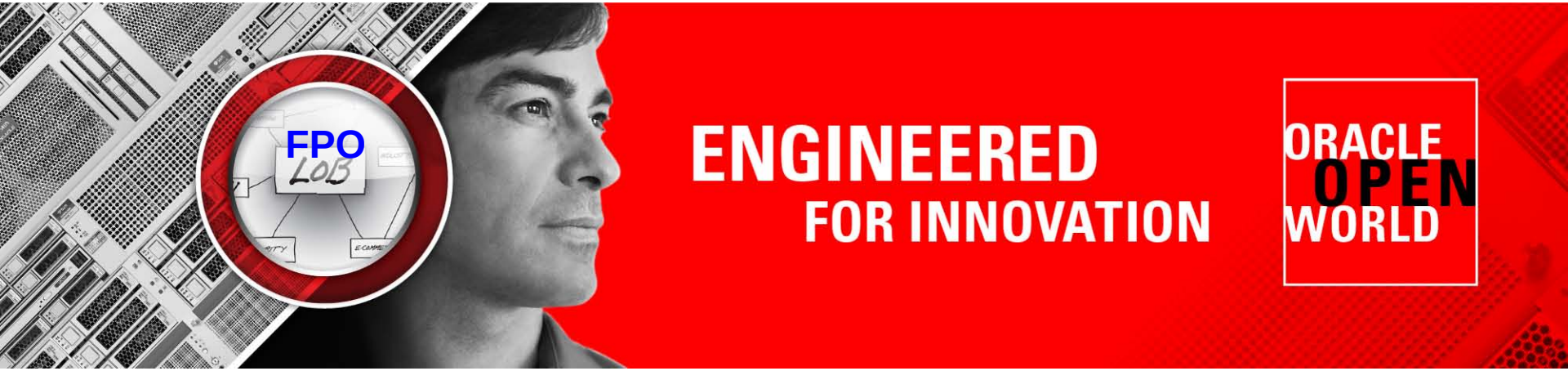
ORACLE®



In-Database Analytics: Predictive Analytics, Data Mining, Exadata & Business Intelligence

Charlie Berger
Sr. Director Product Management, Data Mining and Advanced Analytics
Oracle Corporation
charlie.berger@oracle.com
www.twitter.com/CharlieDataMine

Open Source

The following is intended to outline our general product direction. It is intended for information purposes only, and may not be incorporated into any contract. It is not a commitment to deliver any material, code, or functionality, and should not be relied upon in making purchasing decisions.
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Agenda

- Big Data Analytics
- BI, Data Mining and Predictive Analytics
- Oracle Data Mining
- Example use cases
- Applications Powered by PA and ODM
- P&G ODM presentation
- Q & A

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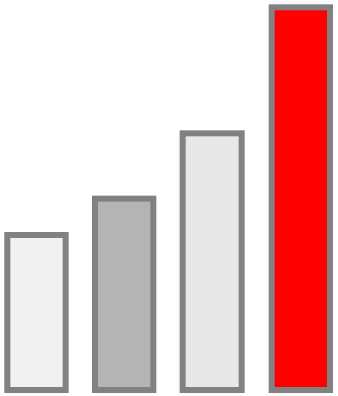
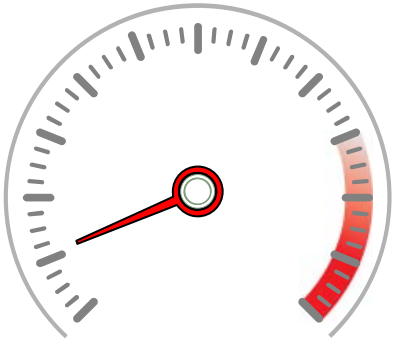
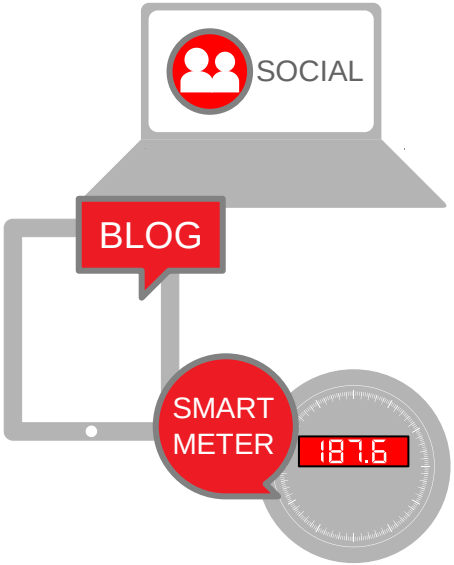
What Makes it Big Data?



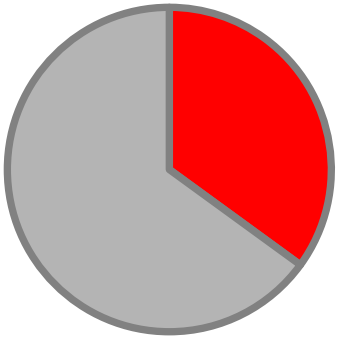
VOLUME



VELOCITY



VARIETY



VALUE

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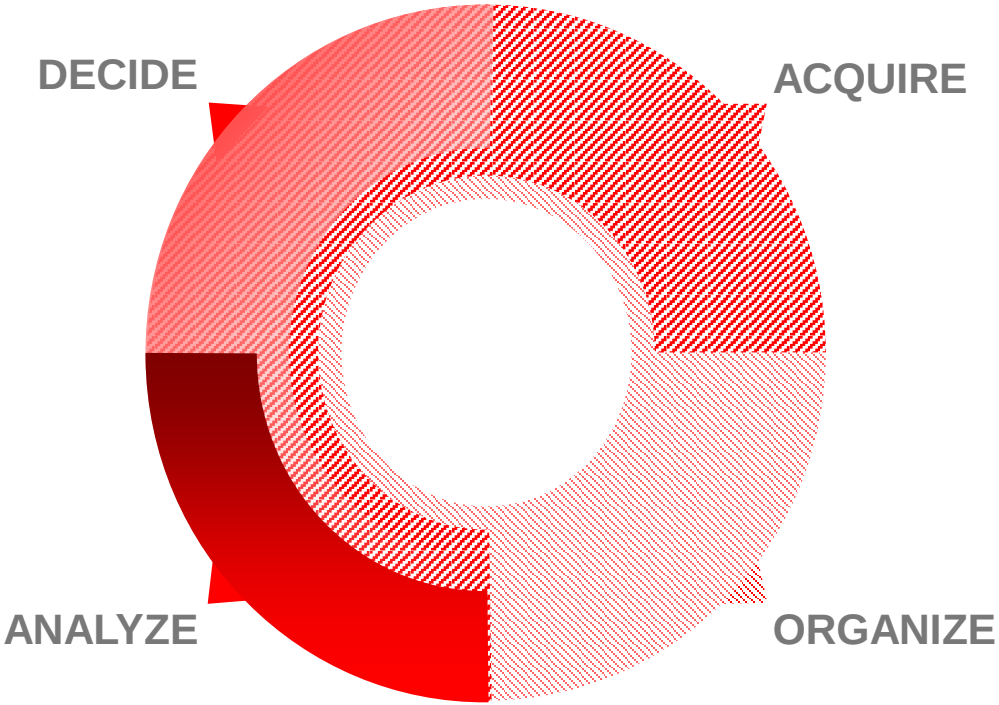
Big Data in Action



Make Better Decisions Using Big Data

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BI & Analytics Spectrum

Queries & Reports	OLAP	Data Mining
Extraction of detailed and roll up data	Summaries, trends and forecasts	Knowledge discovery of hidden patterns
"Information"	*"Analysis"*	*"Insight & Prediction"*
Who purchased mutual funds in the last 3 years?	What is the average income of mutual fund buyers, by region, by year?	Who is likely to mutual fund in the next 6 months and why?

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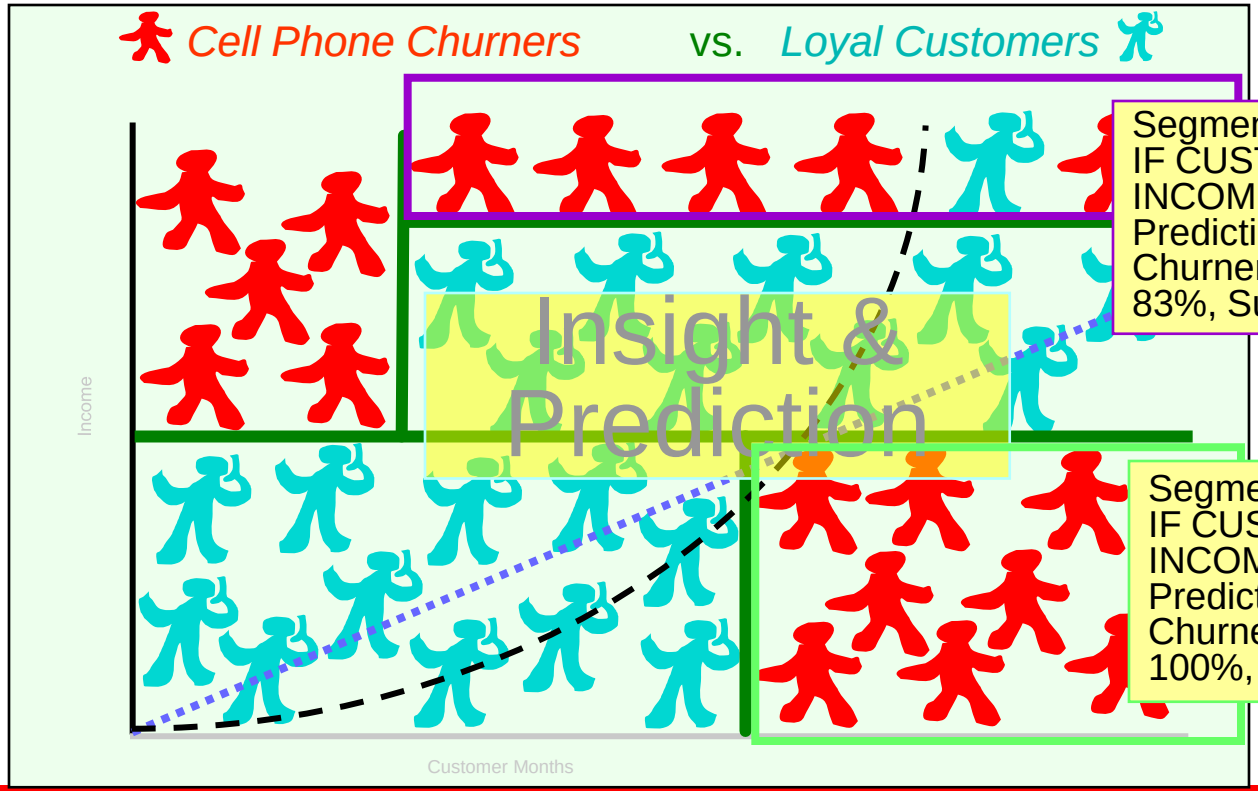
Data Mining Provides

Better Information, Valuable Insights and Predictions



Source: Inspired from *Data Mining Techniques: For Marketing, Sales, and Customer Relationship Management* by Michael J. A. Berry, Gordon S. Linoff

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Data Mining Provides

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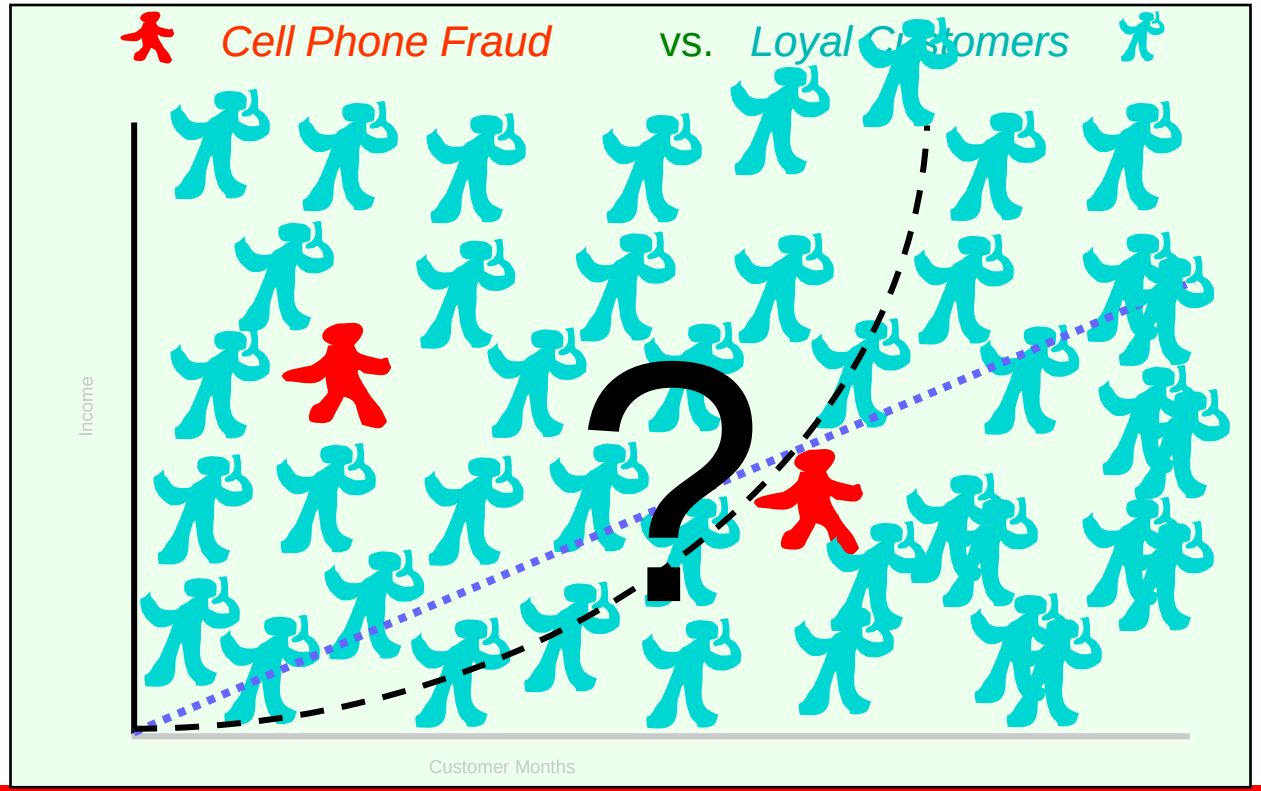

Source: Inspired from *Data Mining Techniques: For Marketing, Sales, and Customer Relationship Management* by Michael J. A. Berry, Gordon S. Linoff

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My Personal Experience

Purchases were made in pairs of $75.00 purchases

May 22	1:14 PM	FOOD	Monaco Café	$127.00
May 22	7:32 PM	WINE	Wine Bistro	$28.00
…				
June 14	2:05 PM	MISC	Mobil Mart	$75.00
June 14	2:06 PM	MISC	Mobil Mart	$75.00
June 15	11:48 AM	MISC	Mobil Mart	$75.00
June 15	11:49 AM	MISC	Mobil Mart	$75.00
May 22	7:32	WINE	Wine Bistro	$28.00
May 22	7:32	WINE	Wine Bistro	$28.00
June 16	11:48 AM	MISC	Mobil Mart	$75.00
June 16	11:49 AM	MISC	Mobil Mart	$75.00

Total purchases exceeds time period average

Gas Station?

France?

Pairs of $75?

All same $75 amount?

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Finding Needles in Haystacks

- Haystacks are usually BIG
- Needles are typically **small** and rare

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Look for What is "*Different*"

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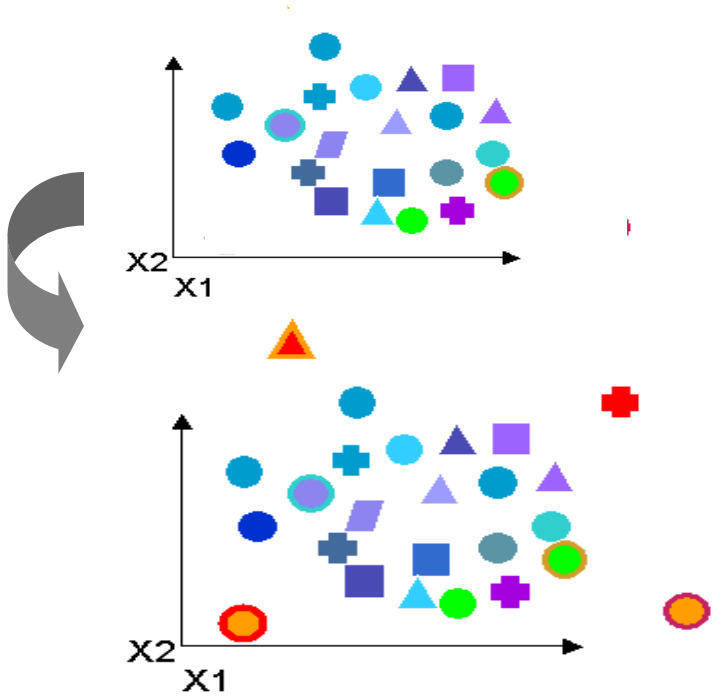
Oracle Data Mining

Anomaly Detection

Problem: Detect rare cases

- "One-Class" SVM Models
  - Fraud, noncompliance
  - Outlier detection
  - Network intrusion detection
  - Disease outbreaks
  - Rare events, true novelty



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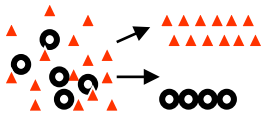
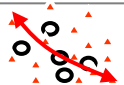
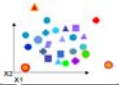
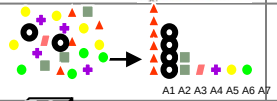
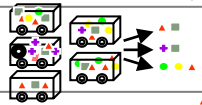
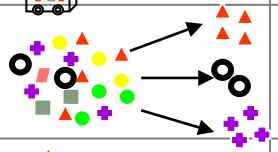
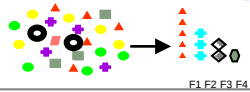
Oracle Data Mining Algorithms

Problem	Algorithm	Applicability
Classification 	Logistic Regression (GLM) Decision Trees Naïve Bayes Support Vector Machine	Classical statistical technique Popular / Rules / transparency Embedded app Wide / narrow data / text
Regression 	Multiple Regression (GLM) Support Vector Machine	Classical statistical technique Wide / narrow data / text
Anomaly Detection 	One Class SVM	Lack examples of target field
Attribute Importance 	Minimum Description Length (MDL)	Attribute reduction Identify useful data Reduce data noise
Association Rules 	Apriori	Market basket analysis Link analysis
Clustering 	Hierarchical K-Means Hierarchical O-Cluster	Product grouping Text mining Gene and protein analysis
Feature Extraction 	Nonnegative Matrix Factorization	Text analysis Feature reduction

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Typical Data Mining Use Cases

- **Retail**
  - Customer segmentation
  - Response modeling
  - Recommend next likely product
  - Profile high value customers
- **Banking**
  - Credit scoring
  - Probability of default
  - Customer profitability
  - Customer targeting
- **Insurance**
  - Risk factor identification
  - Claims fraud
  - Policy bundling
  - Employee retention
- **Higher Education**
  - Alumni donations
  - Student acquisition
  - Student retention
  - At-risk student identification
- **Healthcare**
  - Patient procedure recommendation
  - Patient outcome prediction
  - Fraud detection
  - Doctor & nurse note analysis
- **Life Sciences**
  - Drug discovery & interaction
  - Common factors in (un)healthy patients
  - Cancer cell classification
  - Drug safety surveillance
- **Telecommunications**
  - Customer churn
  - Identify cross-sell opportunities
  - Network intrusion detection
- **Public Sector**
  - Taxation fraud & anomalies
  - Crime analysis
  - Pattern recognition in military surveillance
- **Manufacturing**
  - Root cause analysis of defects
  - Warranty analysis
  - Reliability analysis
  - Yield analysis
- **Automotive**
  - Feature bundling for customer segments
  - Supplier quality analysis
  - Problem diagnosis
- **Chemical**
  - New compound discovery
  - Molecule clustering
  - Product yield analysis
- **Utilities**
  - Predict power line / equipment failure
  - Product bundling
  - Consumer fraud detection

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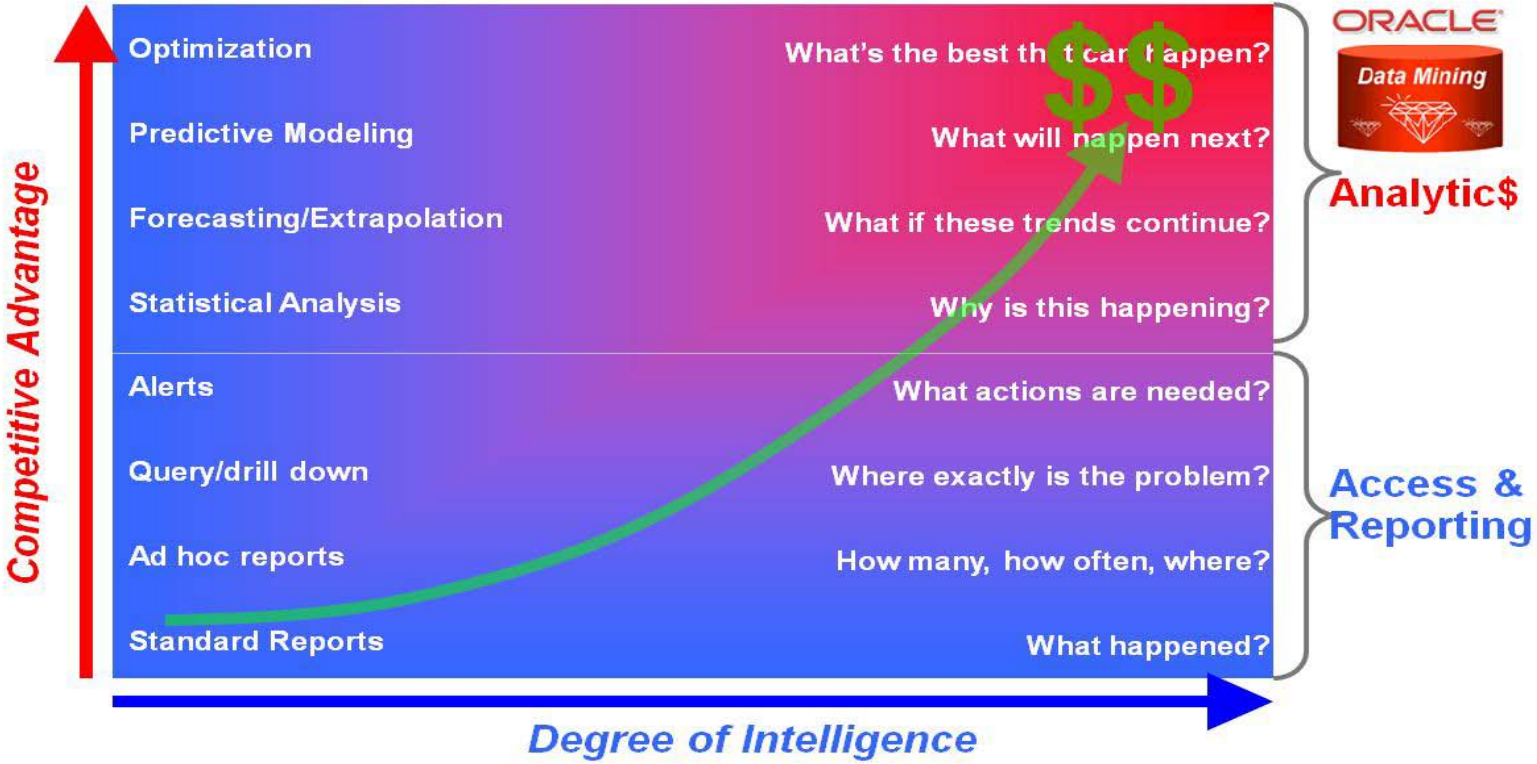
Competitive Advantage



Source: Competing on Analytics, by T. Davenport & J. Harris

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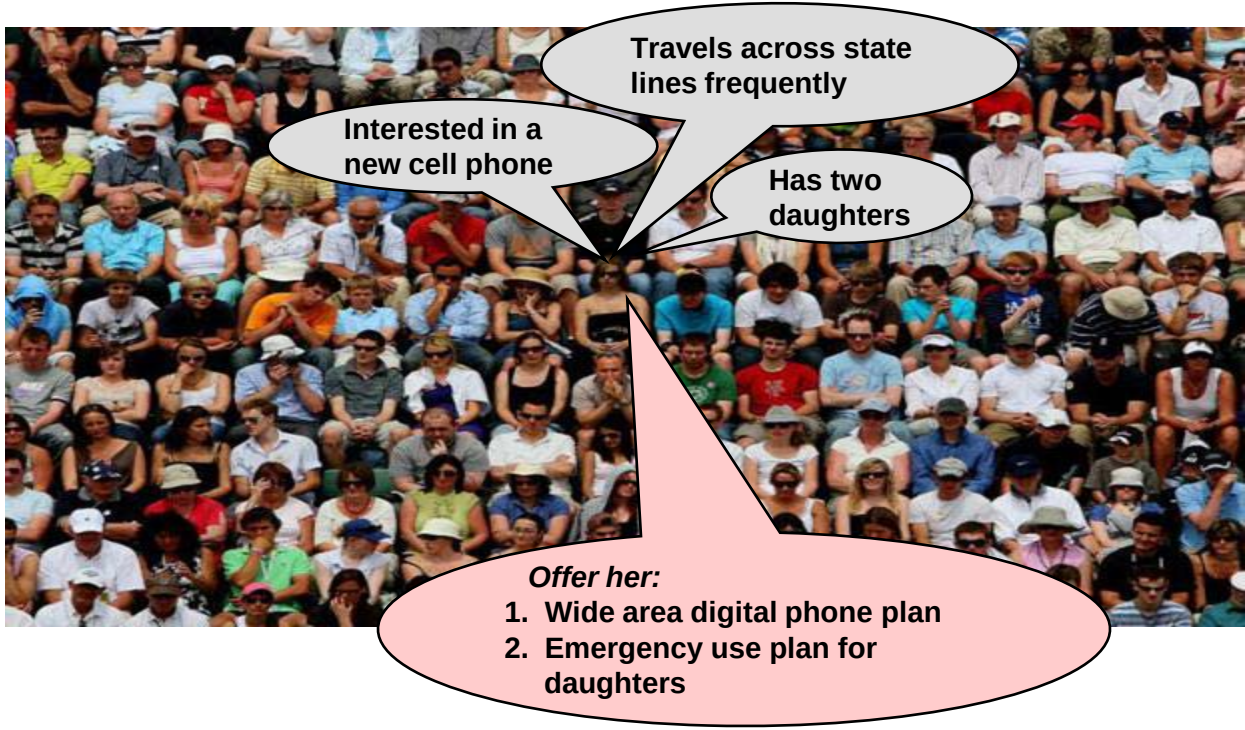
Targeting the Right Customers

- 1:1 Relationships
- Understand and predict individual customer behavior
- Offer products and services that anticipate customer needs
- Build loyalty and increase profitability



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Oracle—Hardware and Software Engineered to Work Together

Hardware and Software
Engineered to Work Together

- Oracle is the world's most complete, open, and integrated business software and hardware systems company
  - **Data Warehousing, VLDB and ILM**
    - Oracle Data Mining Option — New GUI
      - 12- in-DB data mining algorithms
      - In-DB model build
      - In-DB model apply
      - In-DB text mining
      - 50+ in-DB statistical functions
    - Oracle R Enterprise — New
      - R for the Enterprise

Oracle has taught the Database how to do Advanced Math/Statistics/Data Mining, and more…

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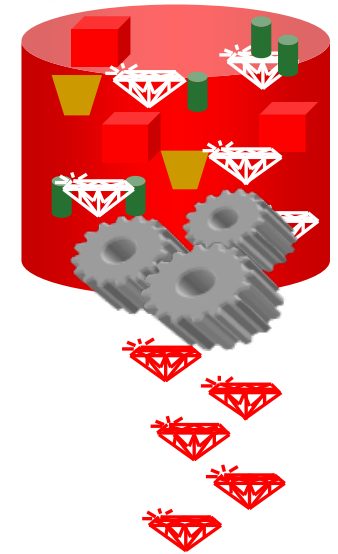
What is Data Mining?



- Automatically sifts through data to find hidden patterns, discover new insights, and make predictions
- Data Mining can provide valuable results:
  - Predict customer behavior *(Classification)*
  - Predict or estimate a value *(Regression)*
  - Segment a population *(Clustering)*
  - Identify factors more associated with a business problem *(Attribute Importance)*
  - Find profiles of targeted people or items *(Decision Trees)*
  - Determine important relationships and “market baskets” within the population *(Associations)*
  - Find fraudulent or “rare events” *(Anomaly Detection)*

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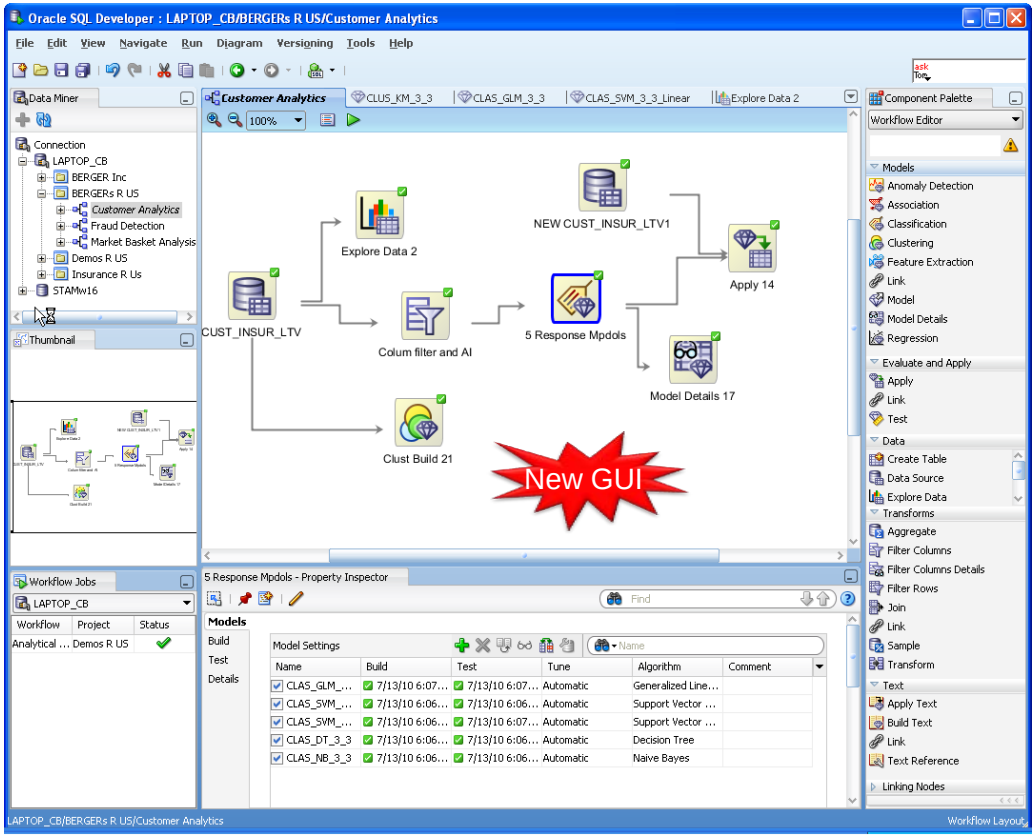
SQL Developer 3.0/Oracle Data Miner 11g Release 2 GUI

- Graphical User Interface for data analyst
- SQL Developer Extension (OTN download)
- Explore data—discover new insights
- Build and evaluate data mining models
- Apply predictive models
- Share analytical workflows
- Deploy SQL Apply code/scripts



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- 12 years “stem celling analytics” into Oracle
  - Designed advanced analytics into database kernel to leverage relational database strengths
  - Naïve Bayes and Association Rules—1st algorithms added
  - Leverages counting, conditional probabilities, and much more
- Now, analytical database platform
  - 12 cutting edge machine learning algorithms and 50+ statistical functions
  - A data mining model is a schema object in the database, built via a PL/SQL API and scored via built-in SQL functions.
  - When building models, leverage existing scalable technology
    - (e.g., parallel execution, bitmap indexes, aggregation techniques) and add new core database technology (e.g., recursion within the parallel infrastructure, IEEE float, etc.)
  - True power of embedding within the database is evident when scoring models using built-in SQL functions (incl. Exadata)

```
select cust_id
from customers
where region = ‘US’
and prediction_probability(churnmod, ‘Y’ using *) > 0.8;
```


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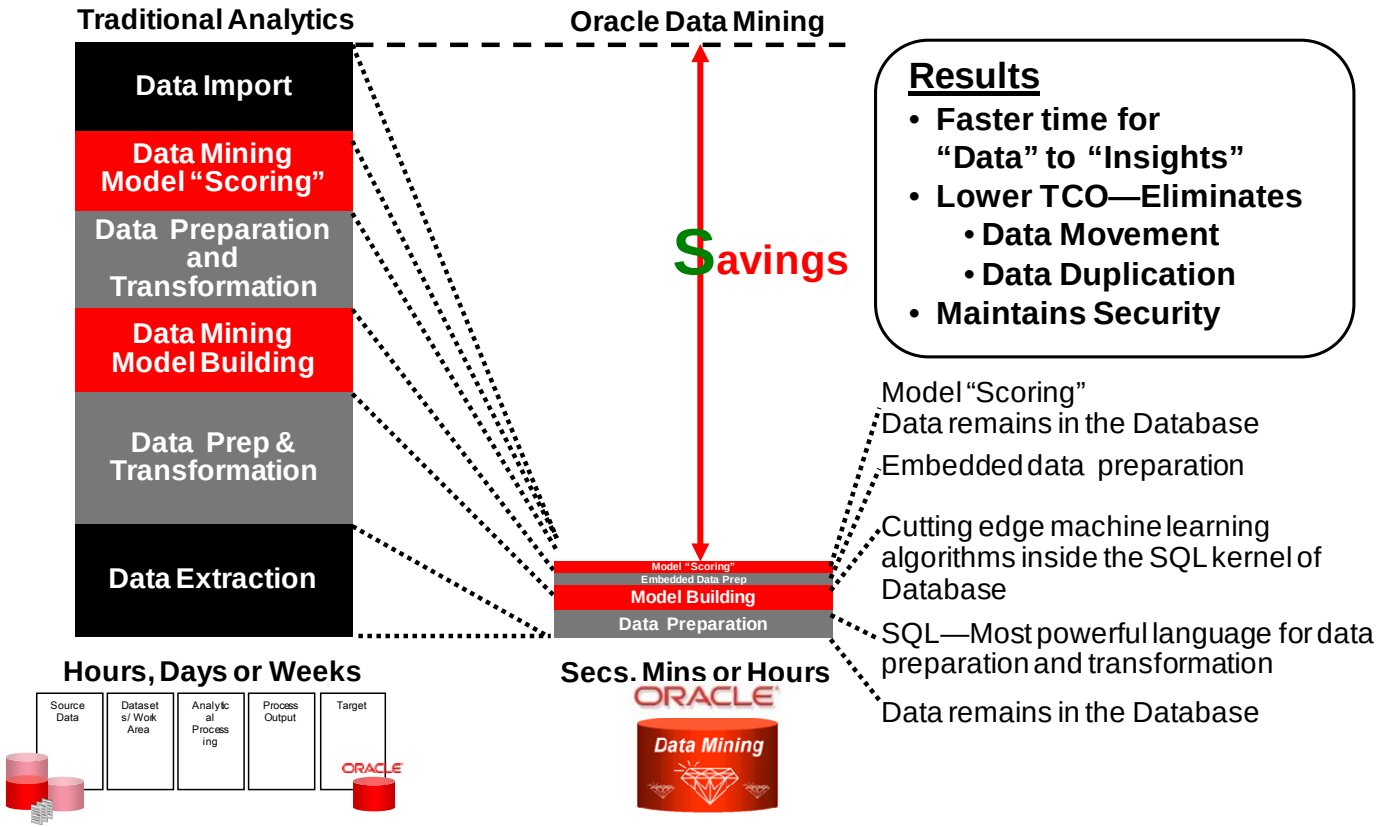
In-Database Data Mining



Results

- Faster time for "Data" to "Insights"
- Lower TCO—Eliminates
  - Data Movement
  - Data Duplication
- Maintains Security

Model "Scoring"
Data remains in the Database

Embedded data preparation

Cutting edge machine learning algorithms inside the SQL kernel of Database

SQL—Most powerful language for data preparation and transformation

Data remains in the Database

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You Can Think of It 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 Data Mining

- Automated knowledge discovery, model building and deployment
- Domain expertise to assemble the "right" data to mine

- ODM "Verbs"
  - **PREDICT**
  - **DETECT**
  - **CLUSTER**
  - **CLASSIFY**
  - **REGRESS**
  - **PROFILE**
  - **IDENTIFY FACTORS**
  - **ASSOCIATE**

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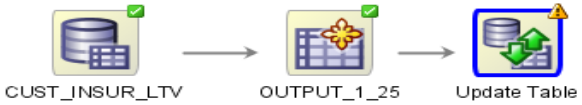
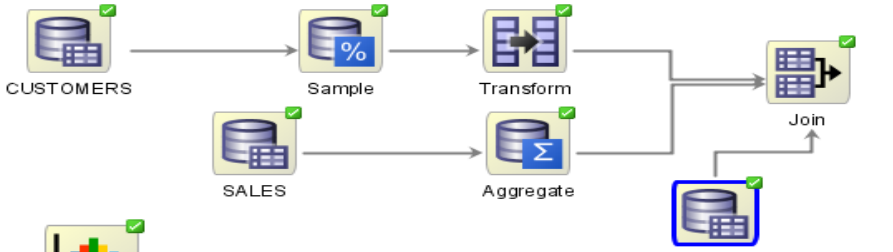
Oracle Data Miner Nodes (Partial List)

Tables and Views

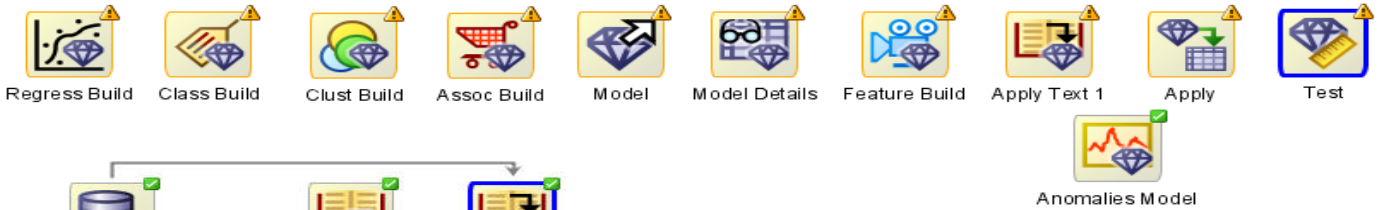


Transformations

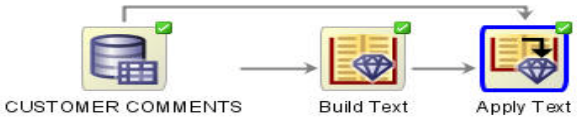


Explore Data

Modeling



Text



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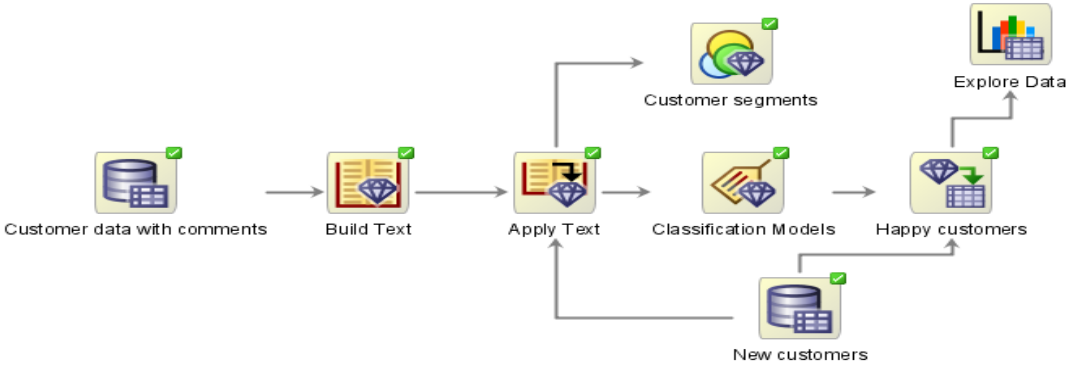
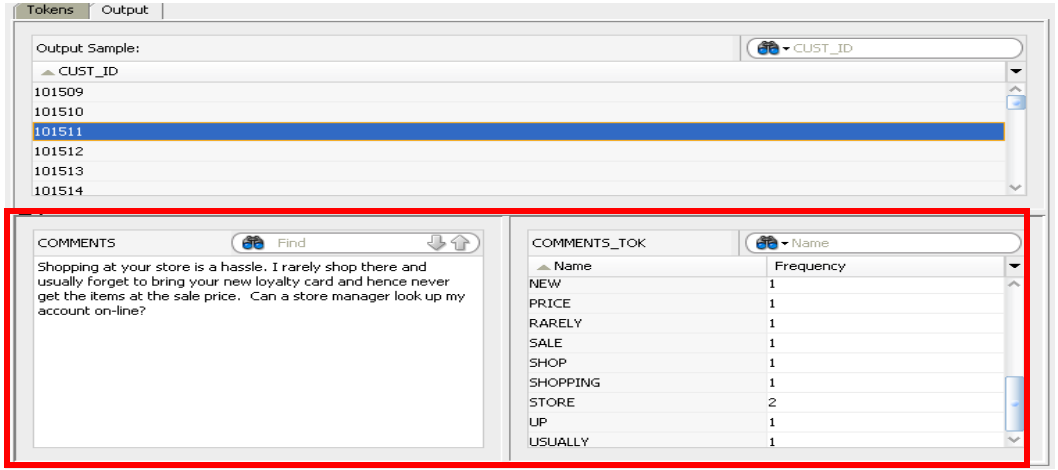
Oracle Data Mining and Unstructured Data

- Oracle Data Mining mines unstructured i.e. “text” data
- Include free text and comments in ODM models
- Cluster and Classify documents
- Oracle Text used to preprocess unstructured text





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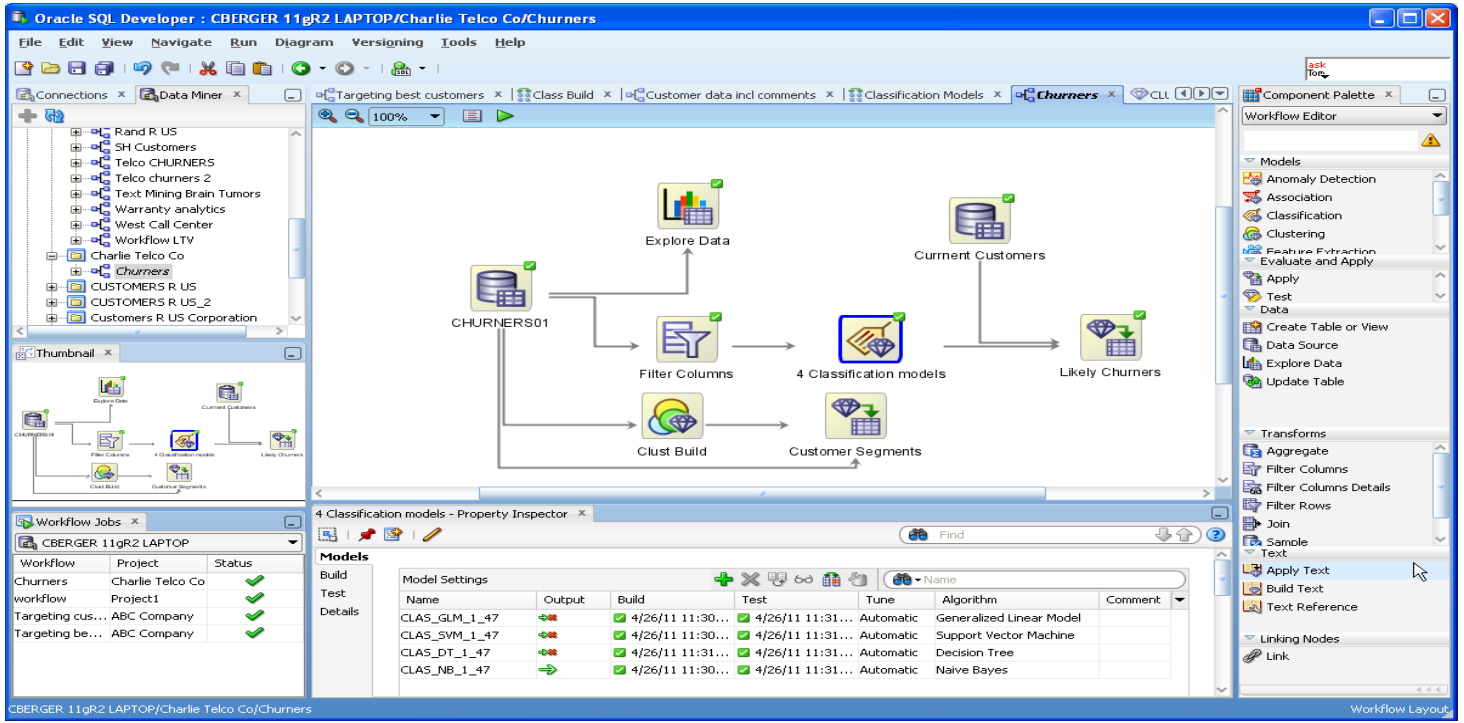
Easier
Churn Demos
SOFTWARE.
HARDWARE.
COMPLETE.
TAPE
STANDBY
XSCF
ORACLE

Oracle Data Miner 11g Release 2 GUI

Churn Demo—Simple Conceptual Workflow



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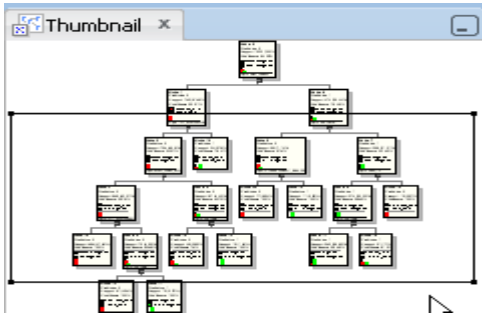
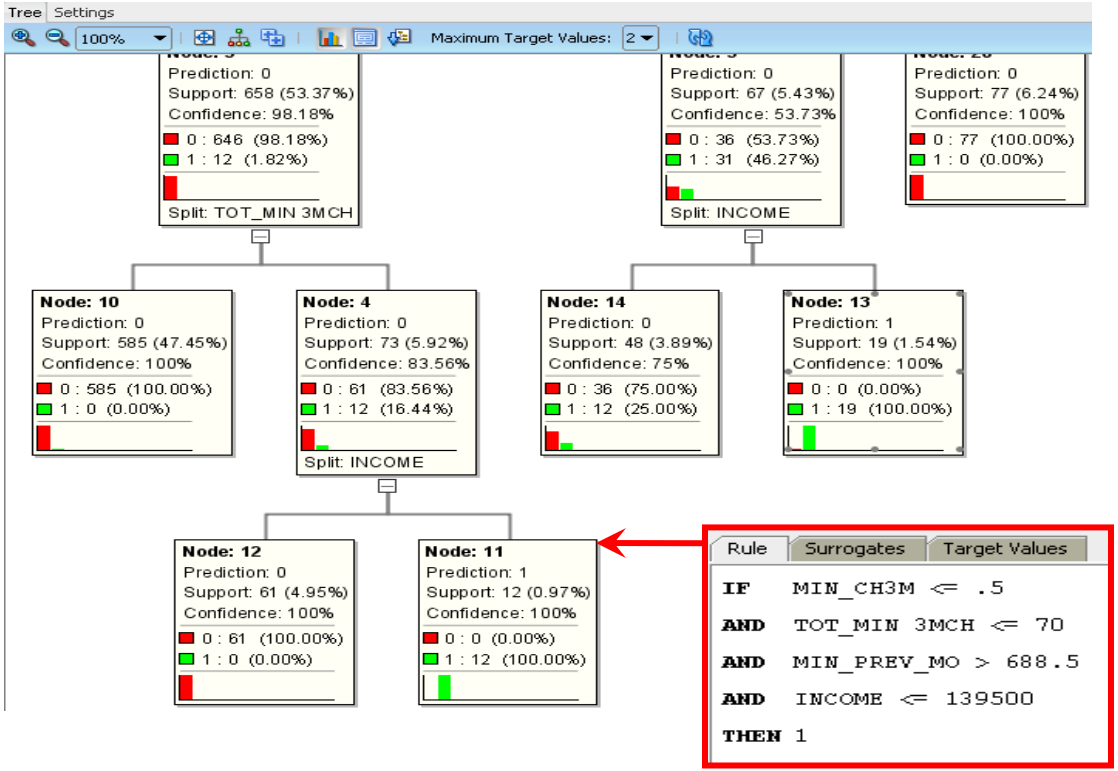
Oracle Data Miner 11g Release 2 GUI

Churn Demo—Simple Conceptual Workflow



Churn models to product and “profile” likely churners



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Oracle Data Miner 11g Release 2 GUI

Churn Demo—Simple Conceptual Workflow

Market Basket Analysis to identify potential product bundless

Rules | Itemsets | Settings

Sort by: Lift Descending

Fetch Size: 1,000

Rule Content: Name,Subname

Rules: 1,000 out of 20,988

ID	Antecedent	Consequent	Lift	Confidence(%)	Support(%
17313	PROD_ID.137 AND PROD_ID.143 AND PROD_ID.138	PROD_ID.144	29.1235	70.8661	1.0689
17849	PROD_ID.138 AND PROD_ID.143 AND PROD_ID.139	PROD_ID.144	28.7389	69.9304	1.0528
17673	PROD_ID.137 AND PROD_ID.143 AND PROD_ID.142	PROD_ID.144	28.3021	68.8675	1.1003
20557	PROD_ID.139 AND PROD_ID.143 AND PROD_ID.142	PROD_ID.144	27.8527	67.7739	1.0975
17314	PROD_ID.137 AND PROD_ID.144 AND PROD_ID.138	PROD_ID.143	27.8265	77.5469	1.0689
18071	PROD_ID.138 AND PROD_ID.146 AND PROD_ID.144	PROD_ID.143	27.5925	76.8947	1.0207
17942	PROD_ID.138 AND PROD_ID.144 AND PROD_ID.140	PROD_ID.143	27.5082	76.6599	1.0486
18075	PROD_ID.138 AND PROD_ID.148 AND PROD_ID.144	PROD_ID.143	27.4991	76.6346	1.0563

Rule Details:

ID: 17313
IF
PROD_ID.137 AND
PROD_ID.143 AND
PROD_ID.138
THEN
PROD_ID.144

Lift	29.1235
Confidence(%)	70.8661
Support(%)	1.0689
Antecedent Support(%)	2.4333
Consequent Support(%)	1.5083
Item Count	3

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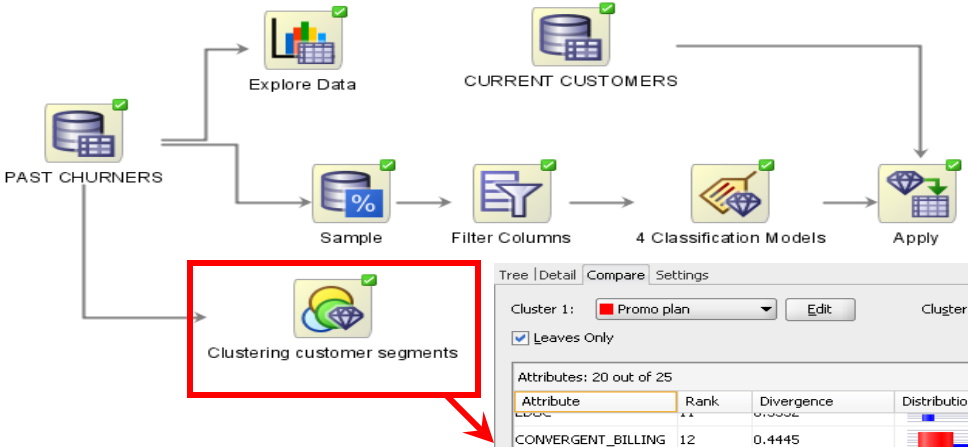
Oracle Data Miner 11g Release 2 GUI

Churn Demo—Simple Conceptual Workflow



Clustering analysis to discover customer segments based on behavior, demograhics, plans, equipment, etc.

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Fraud Prediction Demo

```
drop table CLAIMS_SET;
exec dbms_data_mining.drop_model('CLAIMSMODEL');
create table CLAIMS_SET (setting_name varchar2(30), setting_value varchar2(4000));
insert into CLAIMS_SET values
     ('ALGO_NAME','ALGO_SUPPORT_VECTOR_MACHINES');
insert into CLAIMS_SET values ('PREP_AUTO','ON');
commit;
```

```
begin
dbms_data_mining.create_model('CLAIMSMODEL', 'CLASSIFICATION',
 'CLAIMS2', 'POLICYNUMBER', null, 'CLAIMS_SET');
end;
/
```

```
-- Top 5 most suspicious fraud policy holder claims
select * from
(select POLICYNUMBER, round(prob_fraud*100,2) percent_fraud,
     rank() over (order by prob_fraud desc) rnk from
(select POLICYNUMBER, prediction_probability(CLAIMSMODEL, '0' using *) prob_fraud
from CLAIMS2
where PASTNUMBEROFCLAIMS in ('2 to 4', 'more than 4')))
where rnk <= 5
order by percent_fraud desc;
```

POLICYNUMBER	PERCENT_FRAUD	RNK
6532	64.78	1
2749	64.17	2
3440	63.22	3
654	63.1	4
12650	62.36	5

Automated Monthly "Application"! *Just add:*

```
Create
View CLAIMS2_30
As
Select * from CLAIMS2
Where mydate > SYSDATE – 30
```

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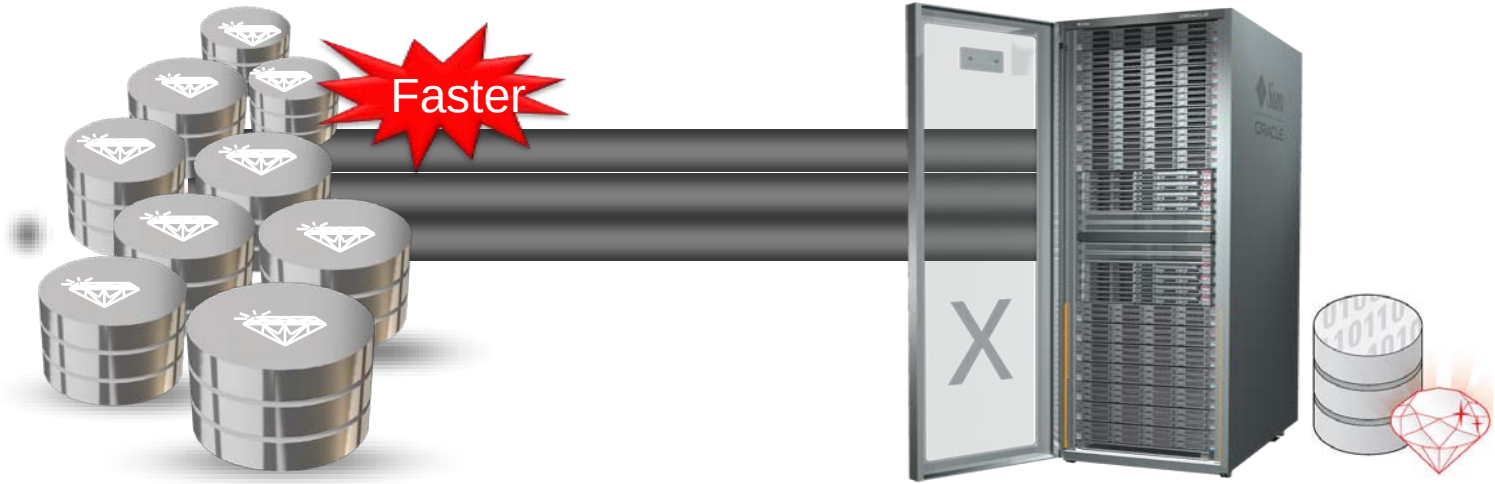
Exadata + Data Mining 11g Release 2

"DM Scoring" Pushed to Storage!



- In 11g Release 2, SQL predicates and Oracle Data Mining models are pushed to storage level for execution
  For example, find the US customers likely to churn:

```
select cust_id
from customers
where region = 'US'
and prediction_probability(churnmod,'Y' using *) > 0.8;
```

Scoring function executed in Exadata

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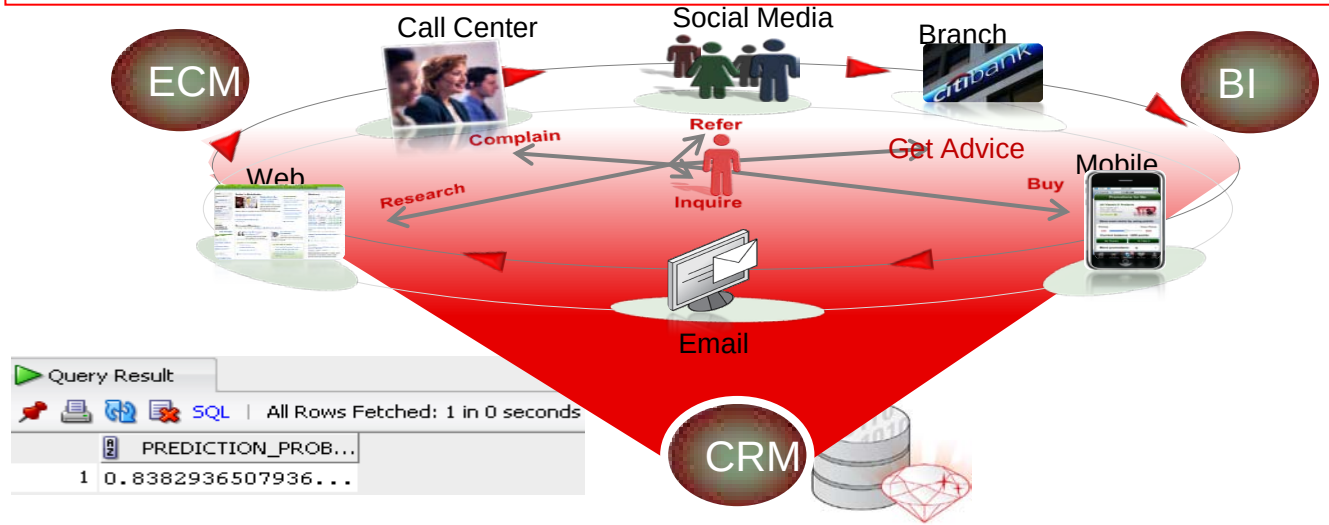
Real-time Prediction for a Customer

- On-the-fly, single record apply with new data (e.g. from call center)

```
Select prediction_probability(CLAS_DT_5_2, 'Yes'
  USING 7800 as bank_funds, 125 as checking_amount, 20 as
  credit_balance, 55 as age, 'Married' as marital_status,
    250 as MONEY_MONTLY_OVERDRAWN, 1 as house_ownership)
from dual;
```



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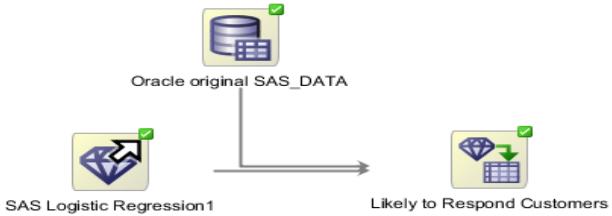
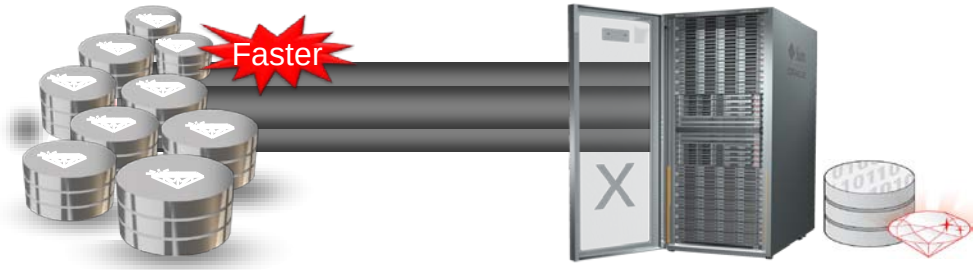
Ability to Import/Export 3rd Party DM Models

- ODM 11g Release 2 adds ability to import 3rd party models (PMML), convert to native ODM models and score them in-DB
  - Supported models for ODM model export:
    - Decision Trees (PMML)
  - Supported algorithms for ODM model import:
    - Multiple regression models (PMML)
    - Logistic regression models (PMML)



- Benefits
  - SAS, SPSS, R, etc. data mining models can scored on Exadata
    - Imported dm models become native ODM models and inherit all ODM benefits including scoring at Exadata storage layer, 1st class objects, security, etc.



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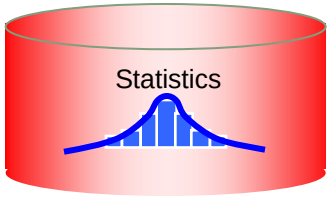
11g Statistics & SQL Analytics (Free)



- Ranking functions
  - rank, dense_rank, cume_dist, percent_rank, ntile
- Window Aggregate functions (moving and cumulative)
  - Avg, sum, min, max, count, variance, stddev, first_value, last_value
- LAG/LEAD functions
  - Direct inter-row reference using offsets
- Reporting Aggregate functions
  - Sum, avg, min, max, variance, stddev, count, ratio_to_report
- Statistical Aggregates
  - Correlation, linear regression family, covariance
- Linear regression
  - Fitting of an ordinary-least-squares regression line to a set of number pairs.
  - Frequently combined with the COVAR_POP, COVAR_SAMP, and CORR functions

Descriptive Statistics

- DBMS_STAT_FUNCS: summarizes numerical columns of a table and returns count, min, max, range, mean, median, stats_mode, variance, standard deviation, quantile values, +/- n sigma values, top/bottom 5 values

- Correlations
  - Pearson's correlation coefficients, Spearman's and Kendall's (both nonparametric).
- Cross Tabs
  - Enhanced with % statistics: chi squared, phi coefficient, Cramer's V, contingency coefficient, Cohen's kappa
- Hypothesis Testing
  - Student t-test , F-test, Binomial test, Wilcoxon Signed Ranks test, Chi-square, Mann Whitney test, Kolmogorov-Smirnov test, One-way ANOVA
- Distribution Fitting
  - Kolmogorov-Smirnov Test, Anderson-Darling Test, Chi-Squared Test, Normal, Uniform, Weibull, Exponential

Note: Statistics and SQL Analytics are included in Oracle Database Standard Edition

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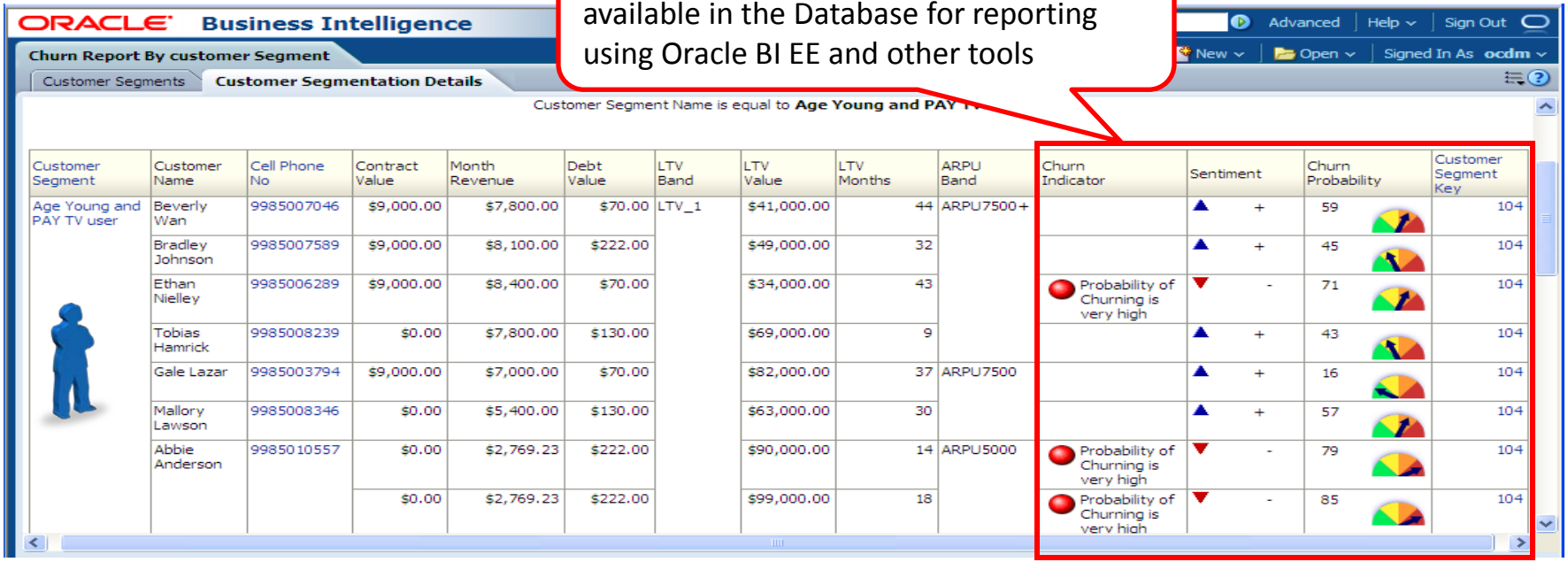
Oracle Communications Industry Data Model Example

Better Information for OBIEE Dashboards

ODM's predictions & probabilities are available in the Database for reporting using Oracle BI EE and other tools



Customer Segment	Customer Name	Cell Phone No	Contract Value	Month Revenue	Debt Value	LTV Band	LTV Value	LTV Months	ARPU Band	Churn Indicator	Sentiment	Churn Probability	Customer Segment Key
Age Young and PAY TV user	Beverly Wan	9985007046	$9,000.00	$7,800.00	$70.00	LTV_1	$41,000.00	44	ARPU7500+		+	59	104
	Bradley Johnson	9985007589	$9,000.00	$8,100.00	$222.00		$49,000.00	32			+	45	104
	Ethan Nielley	9985006289	$9,000.00	$8,400.00	$70.00		$34,000.00	43		Probability of Churning is very high	-	71	104
	Tobias Hamrick	9985008239	$0.00	$7,800.00	$130.00		$69,000.00	9			+	43	104
	Gale Lazar	9985003794	$9,000.00	$7,000.00	$70.00		$82,000.00	37	ARPU7500		+	16	104
	Mallory Lawson	9985008346	$0.00	$5,400.00	$130.00		$63,000.00	30			+	57	104
	Abbie Anderson	9985010557	$0.00	$2,769.23	$222.00		$90,000.00	14	ARPU5000	Probability of Churning is very high	-	79	104
			$0.00	$2,769.23	$222.00		$99,000.00	18		Probability of Churning is very high	-	85	104

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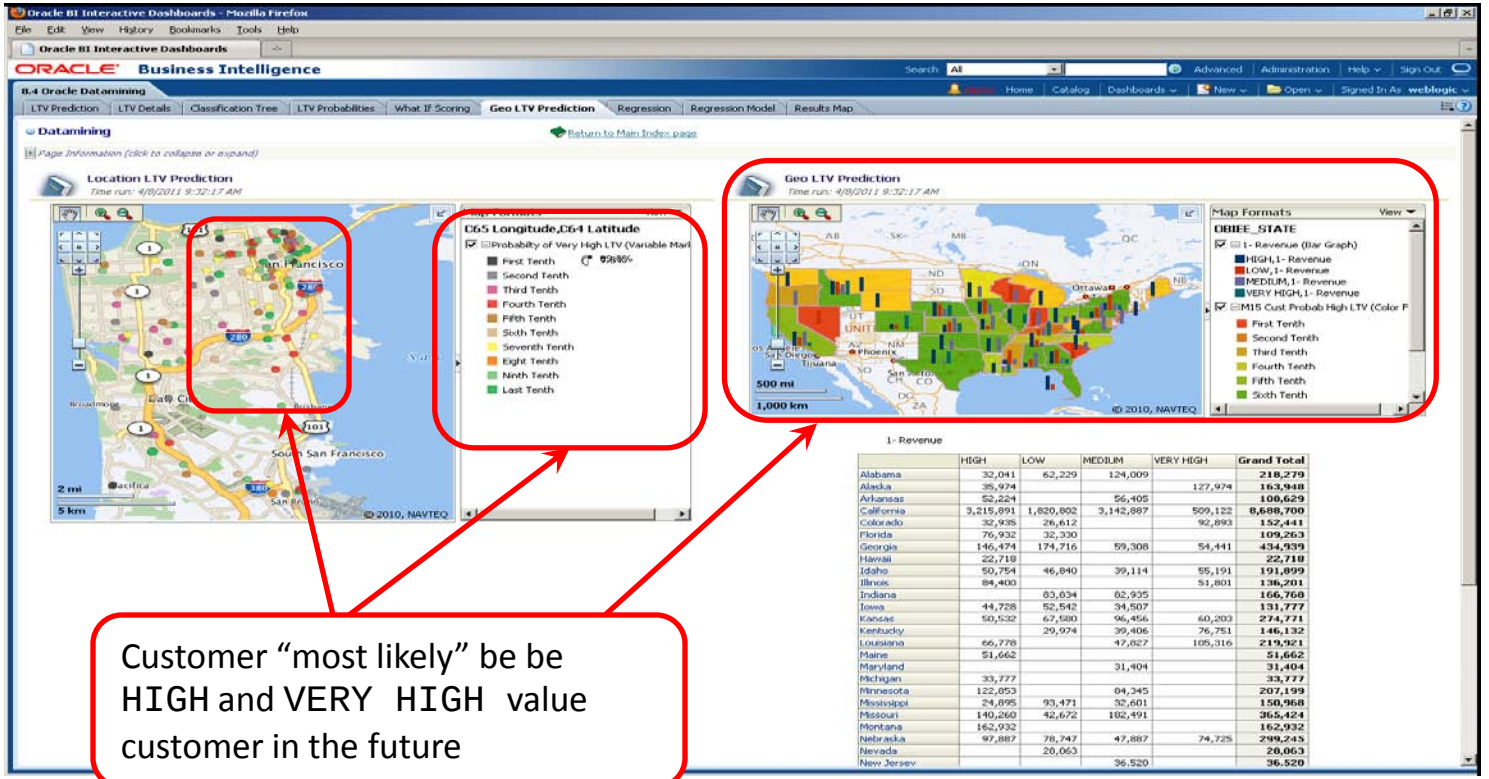
Exadata with Analytics and Business Intelligence

Better Together

- In-database data mining builds predictive models that predict customer behavior
- OBIEE's integrated spatial mapping shows where



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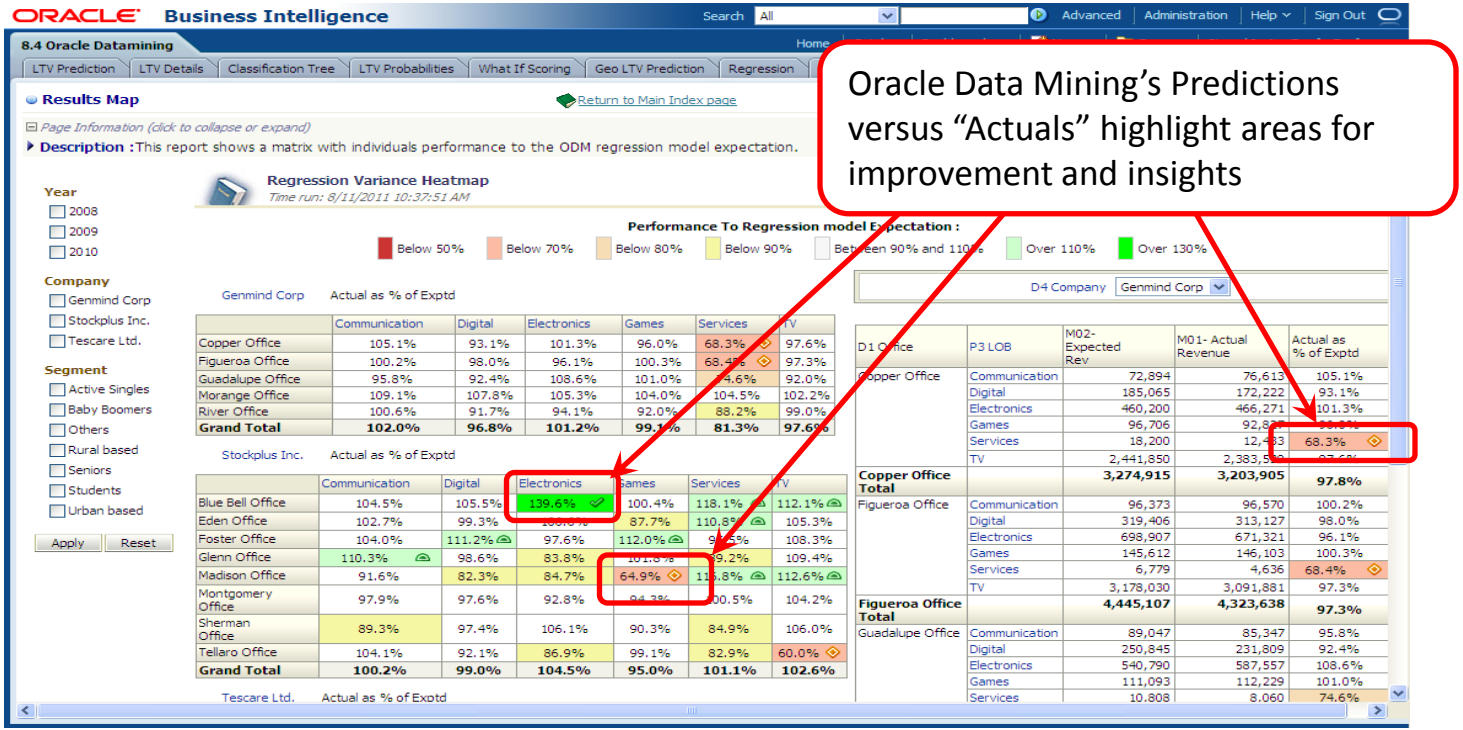
Exadata with Analytics and Business Intelligence

Better Together

- Deliver advanced in-database analytics through OBIEE
- Ability to drill-through for detail
- Harness the power of Exadata for "Better BI & analytics"



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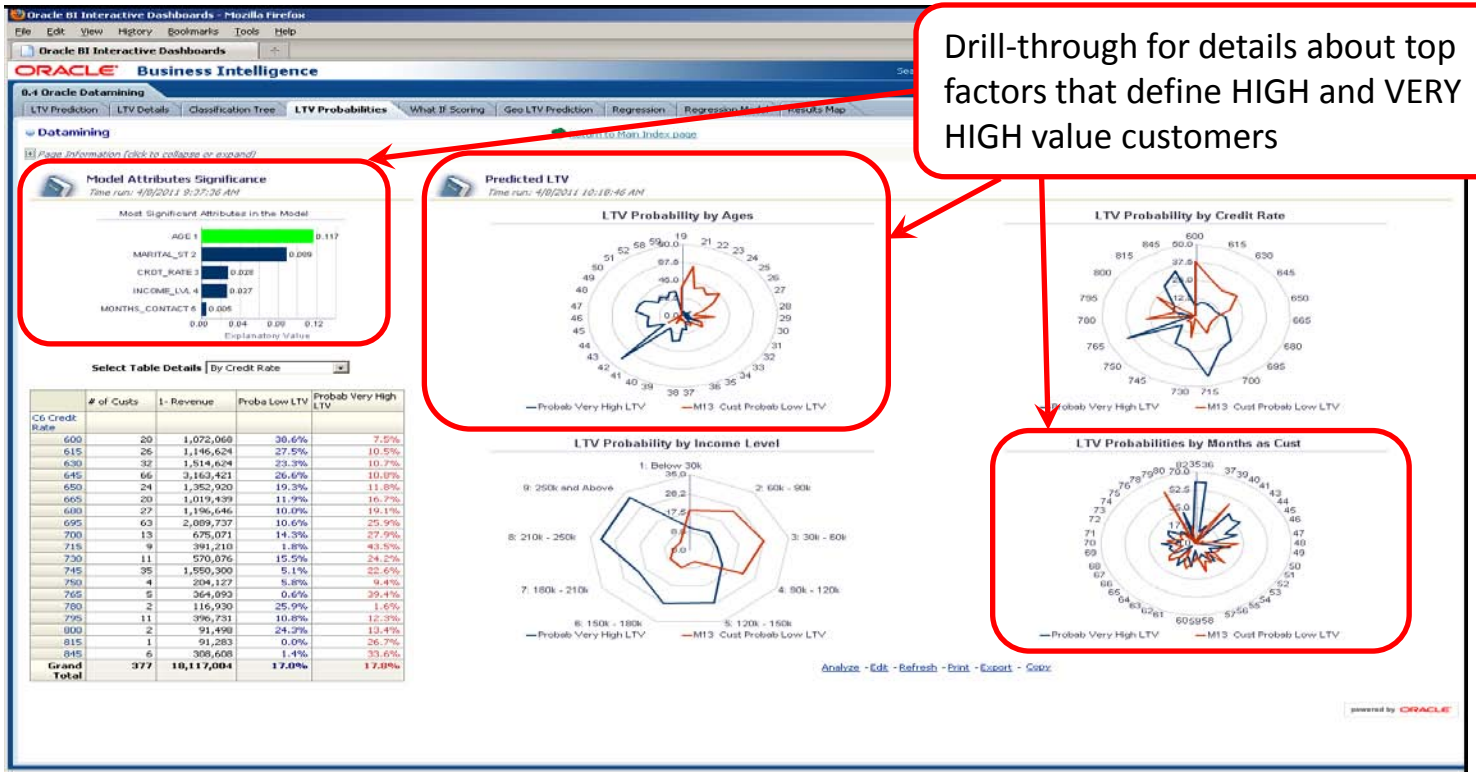
Exadata with Analytics and Business Intelligence

Better Together

- Exadata power
- OBIEE ease-of-use



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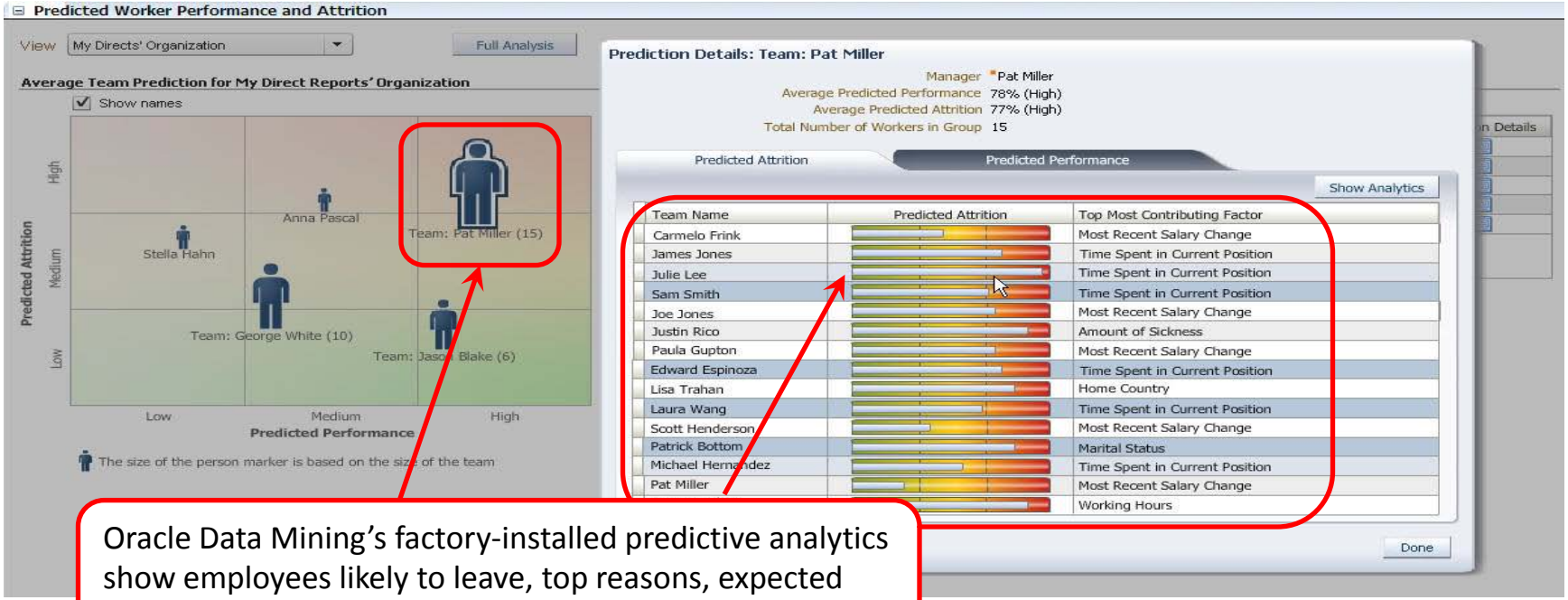
Fusion HCM Predictive Analytics

Factory Installed PA/ODM Methodologies



Oracle Data Mining's factory-installed predictive analytics show employees likely to leave, top reasons, expected performance and real-time "What if?" analysis

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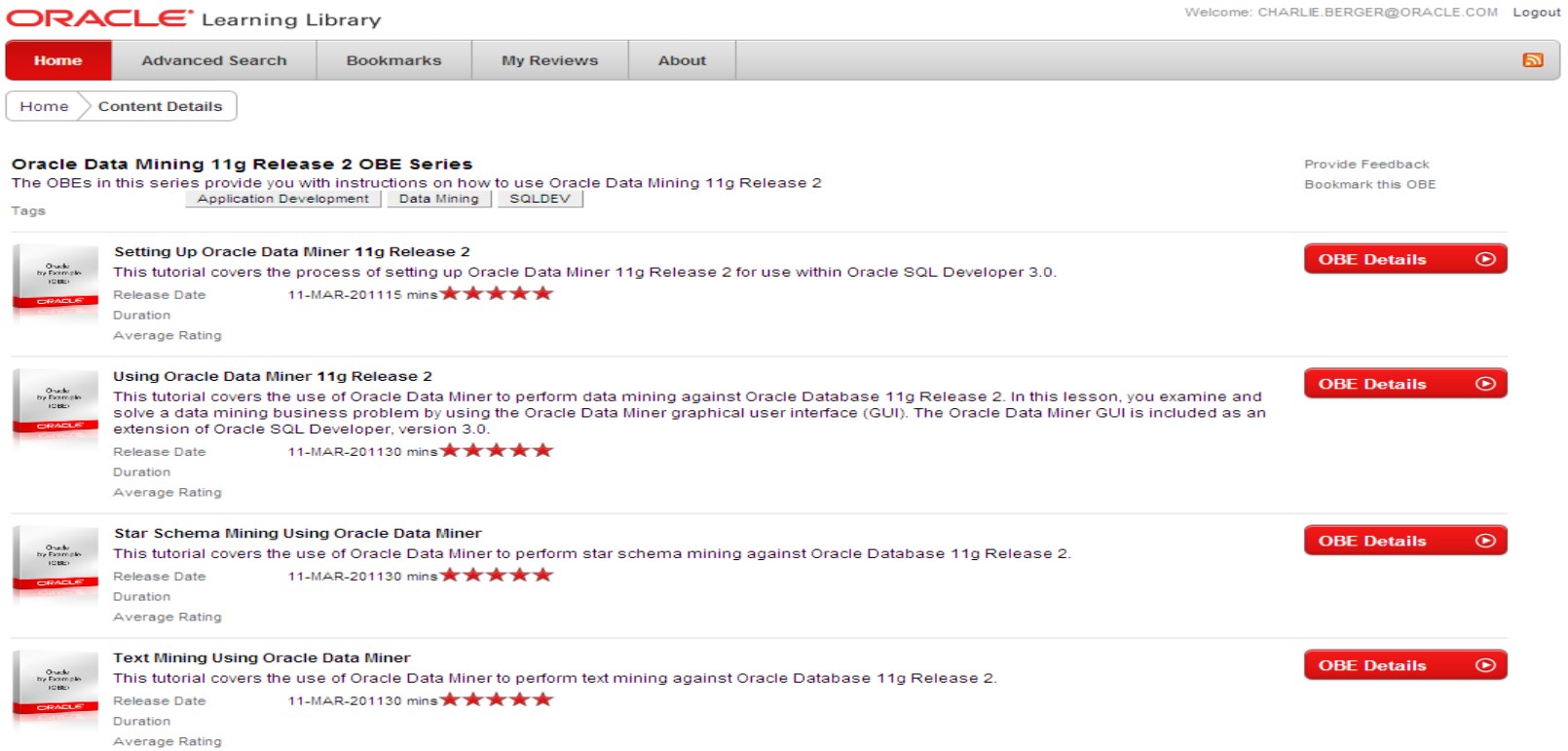
Learn More



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Oracle Data Mining PL/SQL Sample Programs

- The PL/SQL Sample Programs provide examples of mini-solutions and use cases for Oracle Data Mining
  - Excellent starting point when developing an ODM Application

Mining Function	Algorithm	Sample Program
Anomaly Detection	One-Class Support Vector Machine	dmsvodem.sql
Association Rules	Apriori	dmardemo.sql
Attribute Importance	Minimum Descriptor Length	dmaidemo.sql
Classification	Decision Tree	dmdtdemo.sql
Classification	Decision Tree (cross validation)	dmdtxvlddemo.sql
Classification	Logistic Regression	dmglcdem.sql
Classification	Naive Bayes	dmnbdemo.sql
Classification	Support Vector Machine	dmsvcdem.sql
Clustering	k-Means	dmkmdemo.sql
Clustering	O-Cluster	dmocdemo.sql
Feature Extraction	Non-Negative Matrix Factorization	dmnmdemo.sql
Regression	Linear Regression	dmglrdem.sql
Regression	Support Vector Machine	dmsvrdem.sql
Text Mining	Text transformation using Oracle Text	dmtxtfe.sql
Text Mining	Non-Negative Matrix Factorization	dmtxtnmf.sql
Text Mining	Support Vector Machine (Classification)	dmtxtsvm.sql

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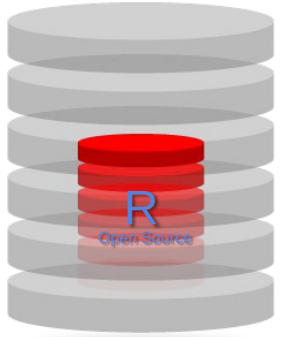
What is ORACLE R Enterprise?



- Oracle R Enterprise brings R's statistical functionality closer to the Oracle Database

1. Eliminate R's memory constraint by enabling R to work directly & transparently on database objects
   - Allows R to run on very large data sets
2. Architected for Enterprise production infrastructure
   - Automatically exploits database parallelism without require parallel R programming
   - Build and immediately deploy
3. Oracle R leverages the latest R algorithms and packages
   - R is an embedded component of the DBMS server

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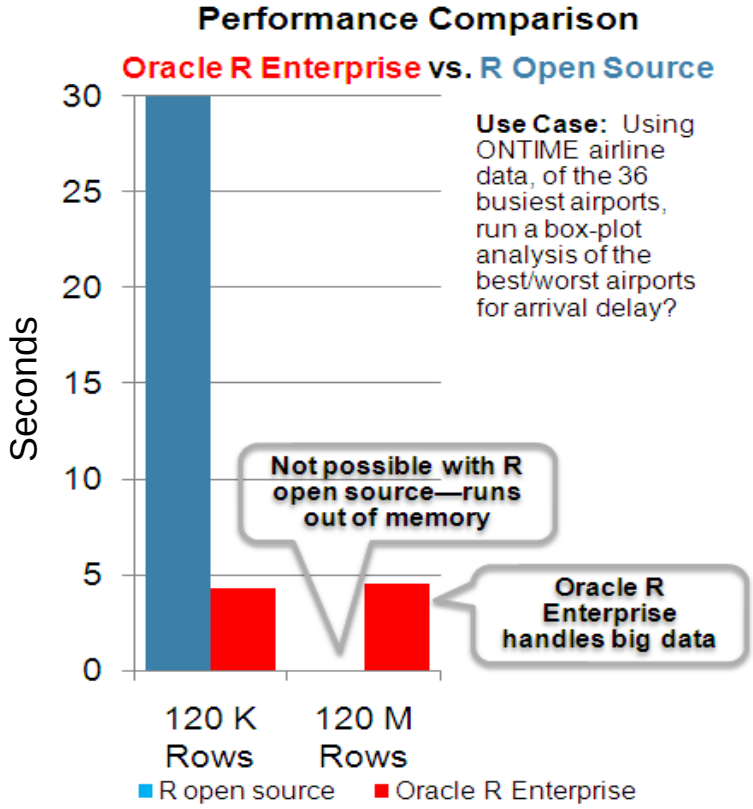
Architecture and Performance

- Transparently function-ships R constructs to database via R → SQL translation
  - –Data structures
  - –Functions
    - Data manipulation functions (select, project, join)
    - Basic statistical functions (avg, sum, summary)
    - Advanced statistical functions(gamma, beta)
- Performs data-heavy computations in database
  - –R for summary analysis and graphics
- Transparent implementation enables using wide range of R “packages” from open source community



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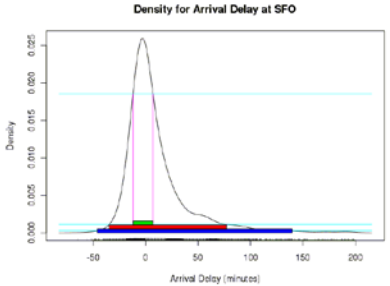
Big Data Appliance + R

For Compute Intensive Operations Using R

R workspace console



ORACLE

Oracle statistics engine

OBIEE, Web Services

Function push-down
— data transformation & statistics

```
logreg <- function(input, iterations, dims, alpha){
  plane = rep(0, dims)
  g = function(z) 1/(1 + exp(-z))
  for (i in 1:iterations) {
    z = hdfs.get(hadoop.run( input,
          export = c(plane, g),
          map =  logisticRegressionMapper,
          reduce =  logisticRegressionReducer))
    gradient = c(z$val[1], z$val[2])
    plane = plane + alpha * gradient
  }
  plane
}
x = hdfs.push(WEBSESSIONS)
logreg(x, 10, 2, 0.05)
```

hadoop

Massively parallel computations

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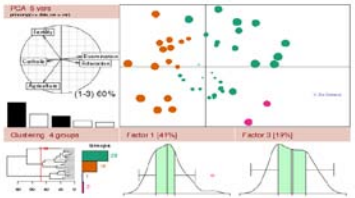
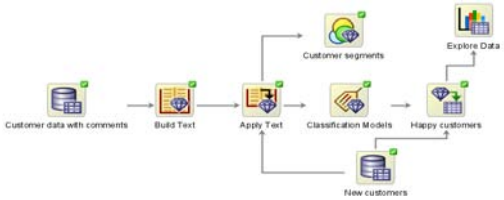
Oracle In-Database Advanced Analytics

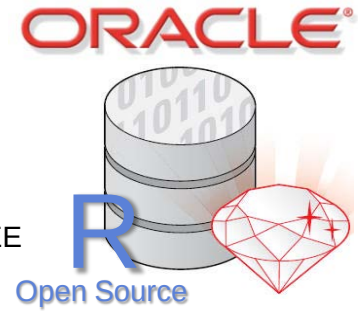
Comprehensive Advanced Analytics Platform





Oracle R Enterprise

- Popular open source statistical programming language & environment
- Integrated with database for scalability
- Wide range of statistical and advanced analytical functions
- R embedded in enterprise appls & OBIEE
- Exploratory data analysis
- Extensive graphics
- Open source R (CRAN) packages
- Integrated with Hadoop for HPC



Oracle Data Mining

- Automated knowledge discovery inside the Database
- 12 in-database data mining algorithms
- Text mining
- Predictive analytics applications development environment
- Star schema and transactional data mining
- Exadata "scoring" of ODM models
- SQL Developer/Oracle Data Miner GUI

Statistics Advanced Analytics Data & Text Mining Predictive Analytics

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Together… You Can Think of It 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**

+

In-Database Analytics

- Wide range of Oracle R Enterprise statistical functions
- Automated ODM knowledge discovery, model building and deployment

- ORE Statistics/Adv. Analytics
  - **CORR**
  - **SUMMARY**
  - **ARIMA Time Series**

- ODM "Verbs"
  - **PREDICT**
  - **DETECT**
  - **CLUSTER**

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Q&A

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