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Introduction to Data Warehousing and Business Reporting

University of Washington : May 9, 2006

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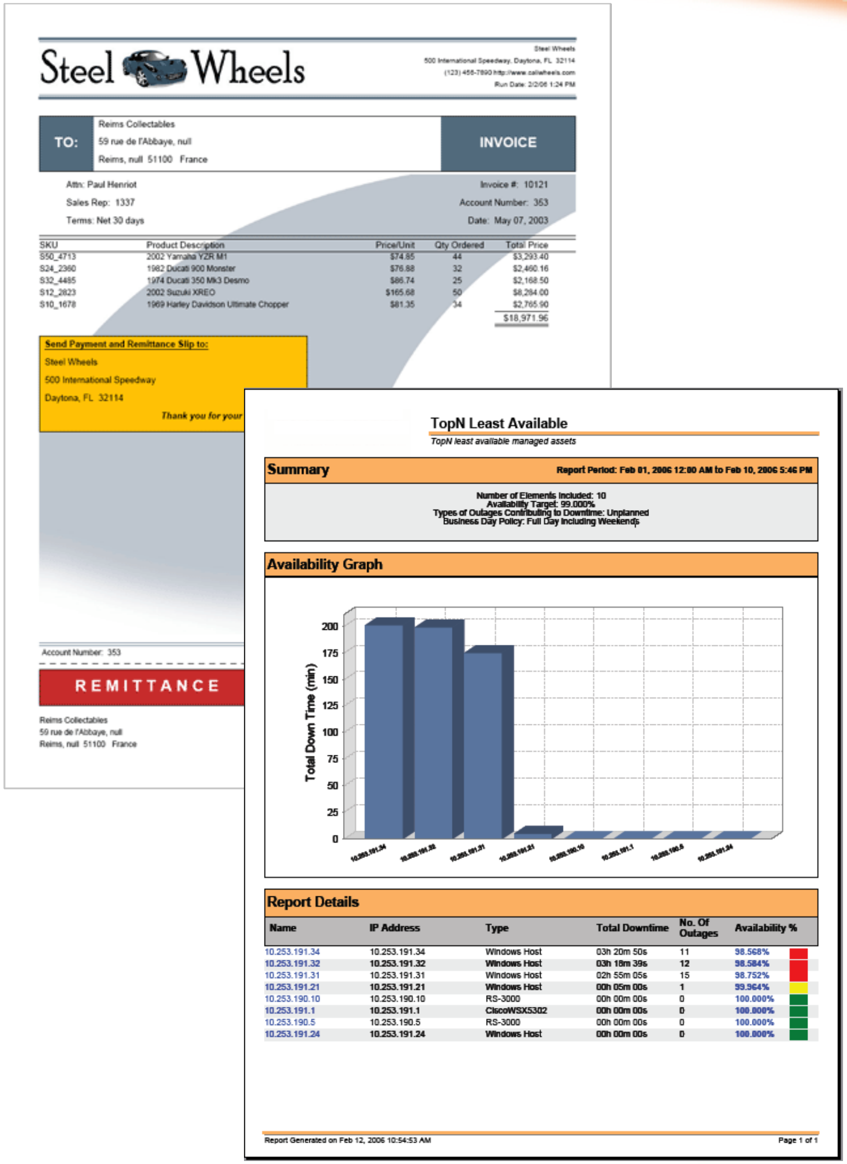
Presentation

- Perspective: I do this day in / day out
  - select question from uw_students where q_elapsed_seconds < 2;
- Business Reporting Basics (10 min)
- Dimensional Modeling Basics (20 min)
- Data Transformation (10 min)
- Oracle Specifics (10 min)
- Discuss / Questions (10 min)

Basics: Reporting

- Access and format data from disparate sources
  - Oracle but then…
  - DB2, CSV, XML, Salesforce.com
- Holistic view of business
  - A customer Order touches:
    - Billing
    - Website
    - Fulfillment
    - Warehousing
    - Call center
    - Etc
- Inherently Semantic
  - Customers, Lifetime Value, Marketing Categories, Products



Steel Wheels

Steel Wheels
500 International Speedway, Daytona, FL 32114
(123) 456-7890 http://www.caliwheels.com
Run Date: 2/2/06 1:24 PM

TO:
Reims Collectables
59 rue de l'Abbaye, null
Reims, null 51100 France

INVOICE

Attn: Paul Henriot
Sales Rep: 1337
Terms: Net 30 days

Invoice #: 10121
Account Number: 353
Date: May 07, 2003

SKU	Product Description	Price/Unit	Qty Ordered	Total Price
S50_4713	2002 Yamaha YZR M1	$74.85	44	$3,293.40
S24_2360	1982 Ducati 900 Monster	$76.88	32	$2,460.16
S32_4485	1974 Ducati 350 Mk3 Desmo	$86.74	25	$2,168.50
S12_2823	2002 Suzuki XREO	$165.68	50	$8,284.00
S10_1678	1969 Harley Davidson Ultimate Chopper	$81.35	34	$2,765.90
				$18,971.96

Send Payment and Remittance Slip to:
Steel Wheels
500 International Speedway
Daytona, FL 32114

Thank you for your

Account Number: 353

REMITTANCE

Reims Collectables
59 rue de l'Abbaye, null
Reims, null 51100 France

TopN Least Available

TopN least available managed assets

Summary Report Period: Feb 01, 2006 12:00 AM to Feb 10, 2006 5:46 PM

Number of Elements Included: 10
Availability Target: 99.000%
Types of Outages Contributing to Downtime: Unplanned
Business Day Policy: Full Day Including Weekends

Availability Graph

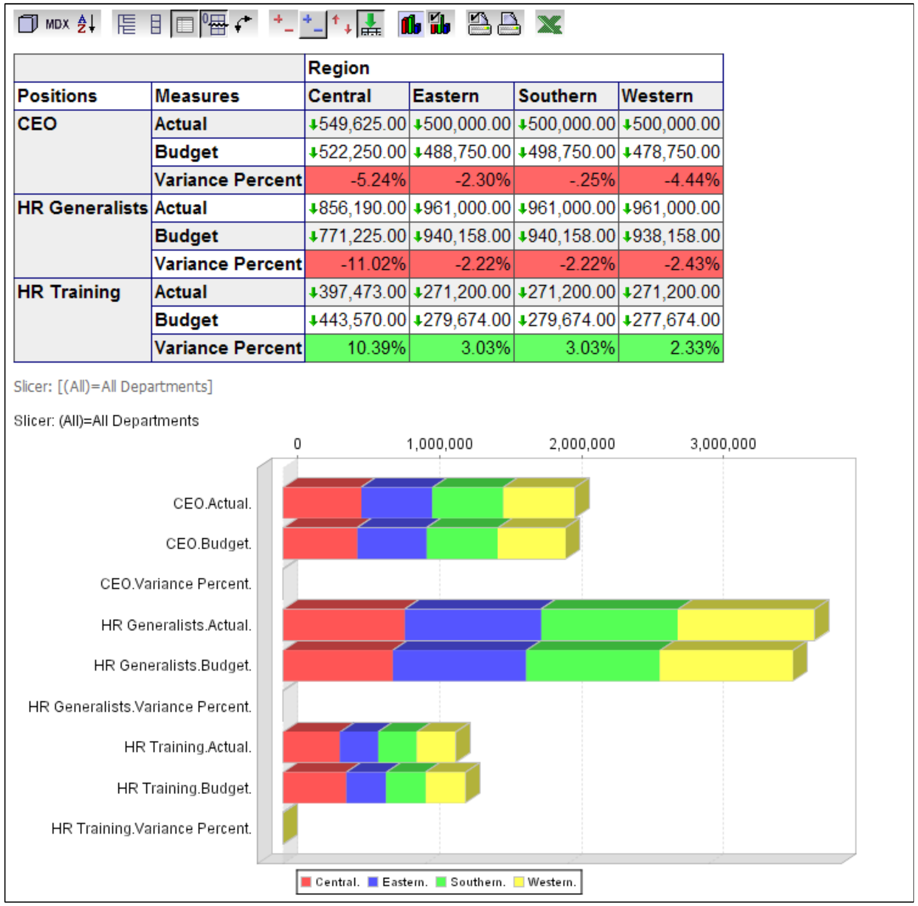
Report Details

Name	IP Address	Type	Total Downtime	No. Of Outages	Availability %	
10.253.191.34	10.253.191.34	Windows Host	03h 20m 50s	11	98.568%	🟥
10.253.191.32	10.253.191.32	Windows Host	03h 18m 39s	12	98.584%	🟥
10.253.191.31	10.253.191.31	Windows Host	02h 55m 05s	15	98.752%	🟥
10.253.191.21	10.253.191.21	Windows Host	00h 05m 00s	1	99.964%	🟨
10.253.190.10	10.253.190.10	RS-3000	00h 00m 00s	0	100.000%	🟩
10.253.191.1	10.253.191.1	CiscoWSX5302	00h 00m 00s	0	100.000%	🟩
10.253.190.5	10.253.190.5	RS-3000	00h 00m 00s	0	100.000%	🟩
10.253.191.24	10.253.191.24	Windows Host	00h 00m 00s	0	100.000%	🟩

Report Generated on Feb 12, 2006 10:54:53 AM Page 1 of 1

Basics: Analysis

- View data "dimensionally"
  - i.e. Sales by region, by channel, by time period
- Navigate and explore
  - Ad Hoc analysis
  - "Drill-down" from year to quarter
  - Pivot
  - Select specific members for analysis
- Interact with high performance
  - Technology optimized for rapid interactive response



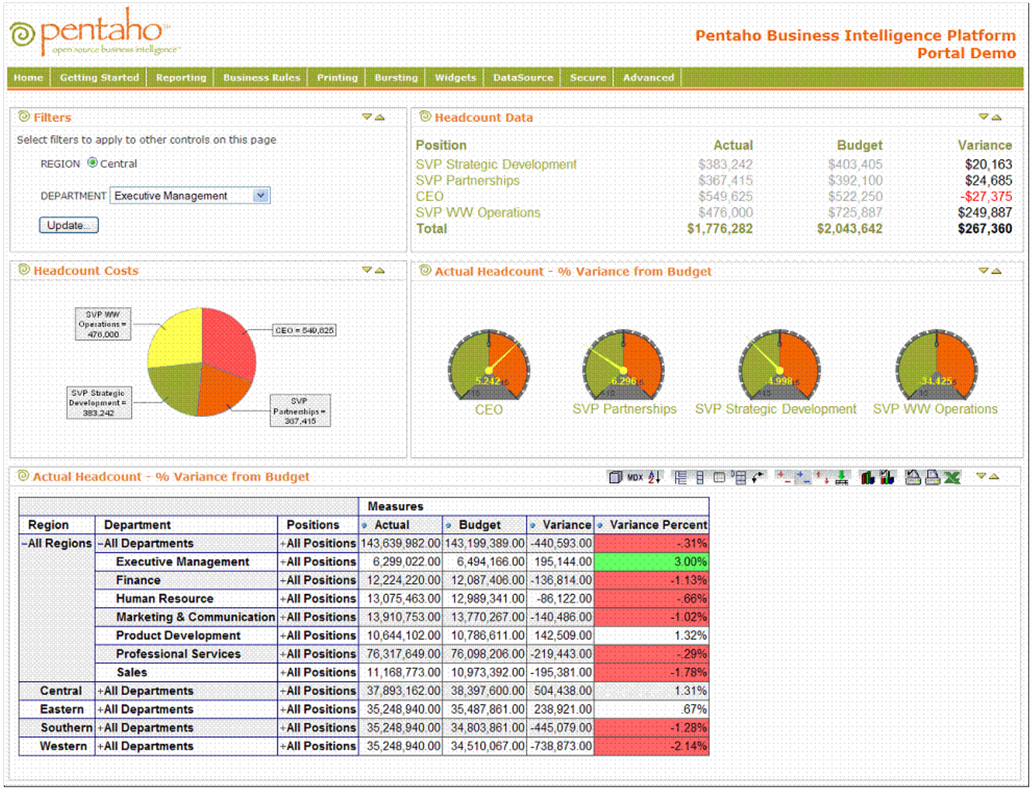
		Region			
Positions	Measures	Central	Eastern	Southern	Western
CEO	Actual	↓549,625.00	↓500,000.00	↓500,000.00	↓500,000.00
	Budget	↓522,250.00	↓488,750.00	↓498,750.00	↓478,750.00
	Variance Percent	-5.24%	-2.30%	-.25%	-4.44%
HR Generalists	Actual	↓856,190.00	↓961,000.00	↓961,000.00	↓961,000.00
	Budget	↓771,225.00	↓940,158.00	↓940,158.00	↓938,158.00
	Variance Percent	-11.02%	-2.22%	-2.22%	-2.43%
HR Training	Actual	↓397,473.00	↓271,200.00	↓271,200.00	↓271,200.00
	Budget	↓443,570.00	↓279,674.00	↓279,674.00	↓277,674.00
	Variance Percent	10.39%	3.03%	3.03%	2.33%

Slicer: [(All)=All Departments]

Slicer: (All)=All Departments

Basics: Dashboards

- Monitor Key Performance Indicators (KPIs) / metrics
- Investigate underlying details
  - Drill to supporting reports
- Track exceptions
  - Alert users based on business rules



Pentaho Business Intelligence Platform
Portal Demo

Filters

Select filters to apply to other controls on this page

REGION ● Central

DEPARTMENT Executive Management

Update...

Headcount Data

Position	Actual	Budget	Variance
SVP Strategic Development	$383,242	$403,405	$20,163
SVP Partnerships	$367,415	$392,100	$24,685
CEO	$549,625	$522,250	-$27,375
SVP WW Operations	$476,000	$725,887	$249,887
Total	$1,776,282	$2,043,642	$267,360

Headcount Costs

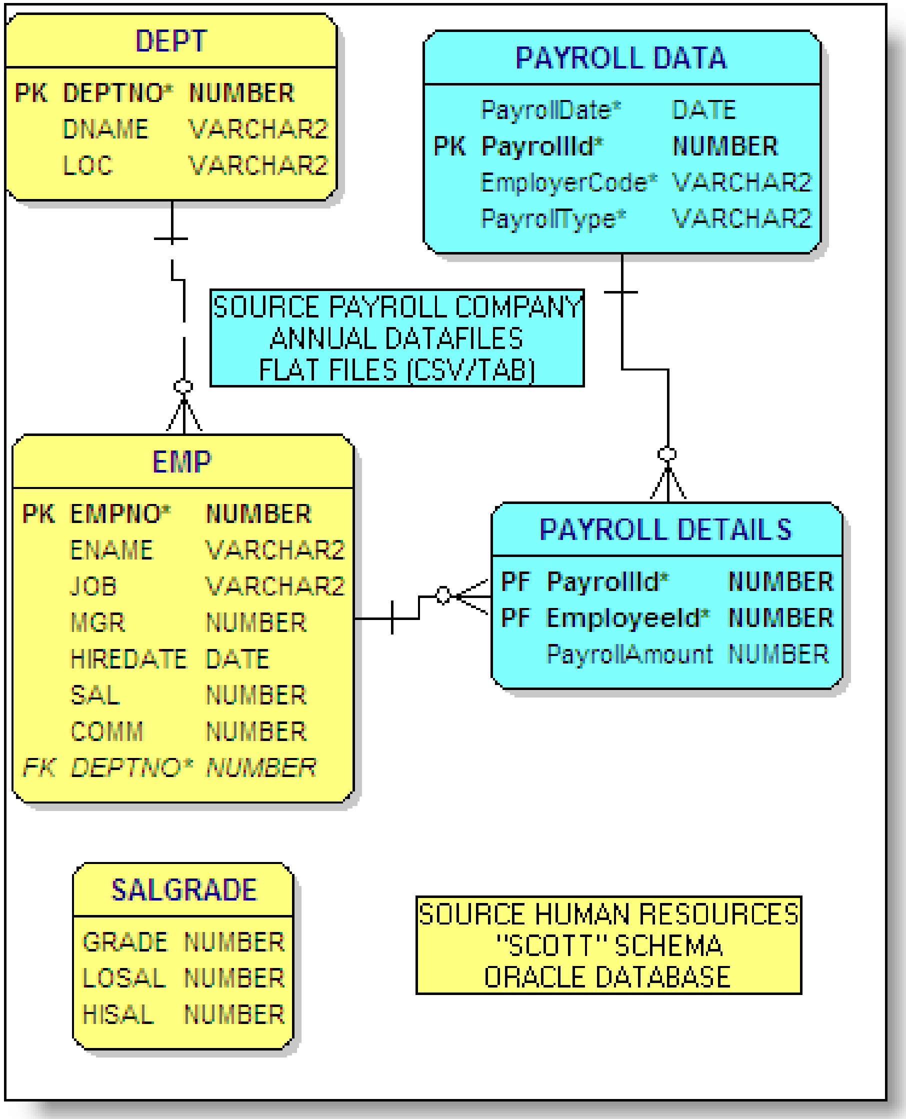
Actual Headcount - % Variance from Budget

Actual Headcount - % Variance from Budget

			Measures			
Region	Department	Positions	Actual	Budget	Variance	Variance Percent
-All Regions	-All Departments	+All Positions	143,639,982.00	143,199,389.00	-440,593.00	-.31%
	Executive Management	+All Positions	6,299,022.00	6,494,166.00	195,144.00	3.00%
	Finance	+All Positions	12,224,220.00	12,087,406.00	-136,814.00	-1.13%
	Human Resource	+All Positions	13,075,463.00	12,989,341.00	-86,122.00	-.66%
	Marketing & Communication	+All Positions	13,910,753.00	13,770,267.00	-140,486.00	-1.02%
	Product Development	+All Positions	10,644,102.00	10,786,611.00	142,509.00	1.32%
	Professional Services	+All Positions	76,317,649.00	76,098,206.00	-219,443.00	-.29%
	Sales	+All Positions	11,168,773.00	10,973,392.00	-195,381.00	-1.78%
Central	+All Departments	+All Positions	37,893,162.00	38,397,600.00	504,438.00	1.31%
Eastern	+All Departments	+All Positions	35,248,940.00	35,487,861.00	238,921.00	.67%
Southern	+All Departments	+All Positions	35,248,940.00	34,803,861.00	-445,079.00	-1.28%
Western	+All Departments	+All Positions	35,248,940.00	34,510,067.00	-738,873.00	-2.14%

Basics: Relational Rules, right?

- Most DATABASE Training:
  - Relational Databases
  - 3NF = IDEAL
  - Keys, Joins, Roles, Flexibility
- OLTP
  - **O**n**L**ine **T**ransaction **P**rocessing
  - Database to support your applications
  - IDEAL MODEL FOR:
    - Lots of Users, Small slices of Data
    - Ie, Debit account # 1002 $40.00 from withdrawal at ATM #6551
  - BAD MODEL FOR:
    - Few Users, Large Slices of Data
    - Sums, Aggregations, Calculations



DEPT

PK	DEPTNO*	NUMBER
	DNAME	VARCHAR2
	LOC	VARCHAR2

PAYROLL DATA

	PayrollDate*	DATE
PK	PayrollId*	NUMBER
	EmployerCode*	VARCHAR2
	PayrollType*	VARCHAR2

SOURCE PAYROLL COMPANY
ANNUAL DATAFILES
FLAT FILES (CSV/TAB)

EMP

PK	EMPNO*	NUMBER
	ENAME	VARCHAR2
	JOB	VARCHAR2
	MGR	NUMBER
	HIREDATE	DATE
	SAL	NUMBER
	COMM	NUMBER
FK	DEPTNO*	NUMBER

PAYROLL DETAILS

PF	PayrollId*	NUMBER
PF	EmployeeId*	NUMBER
	PayrollAmount	NUMBER

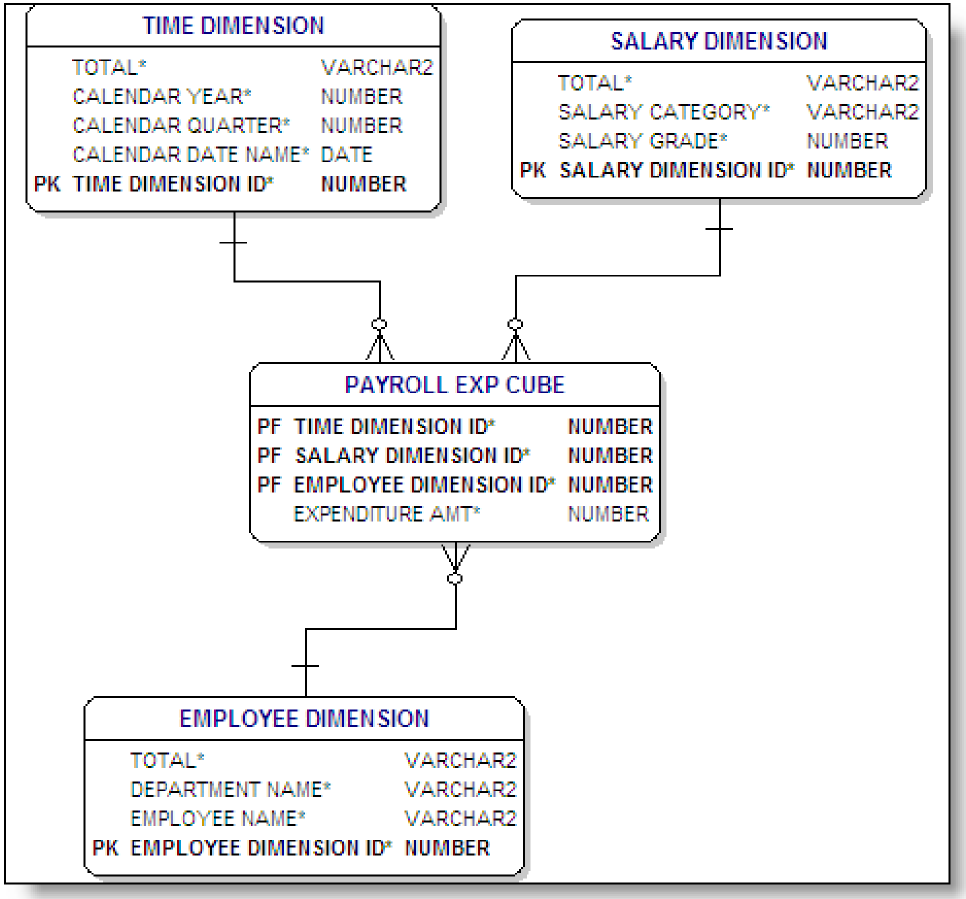
SALGRADE

GRADE	NUMBER
LOSAL	NUMBER
HISAL	NUMBER

SOURCE HUMAN RESOURCES
"SCOTT" SCHEMA
ORACLE DATABASE

Basics: Dimensional Models

- Reporting DATABASE Training:
  - Relational AND Dimensional Databases
  - Relational = ODS or Data Warehouse
  - Dimensional = Reporting Applications
- OLAP
  - **O**n**L**ine **A**nalytical **P**rocessing
  - IDEAL MODEL FOR:
    - Few Users, Huge Amounts of Data
    - Aggregates, slice and dice (sales by about 100 different qualifiers)
    - Ie, What is the proportion of ATM withdrawals that occur within 1 mile of the persons primary address?
  - BAD MODEL FOR:
    - Running your applications



TIME DIMENSION

	TOTAL*	VARCHAR2
	CALENDAR YEAR*	NUMBER
	CALENDAR QUARTER*	NUMBER
	CALENDAR DATE NAME*	DATE
PK	TIME DIMENSION ID*	NUMBER

SALARY DIMENSION

	TOTAL*	VARCHAR2
	SALARY CATEGORY*	VARCHAR2
	SALARY GRADE*	NUMBER
PK	SALARY DIMENSION ID*	NUMBER

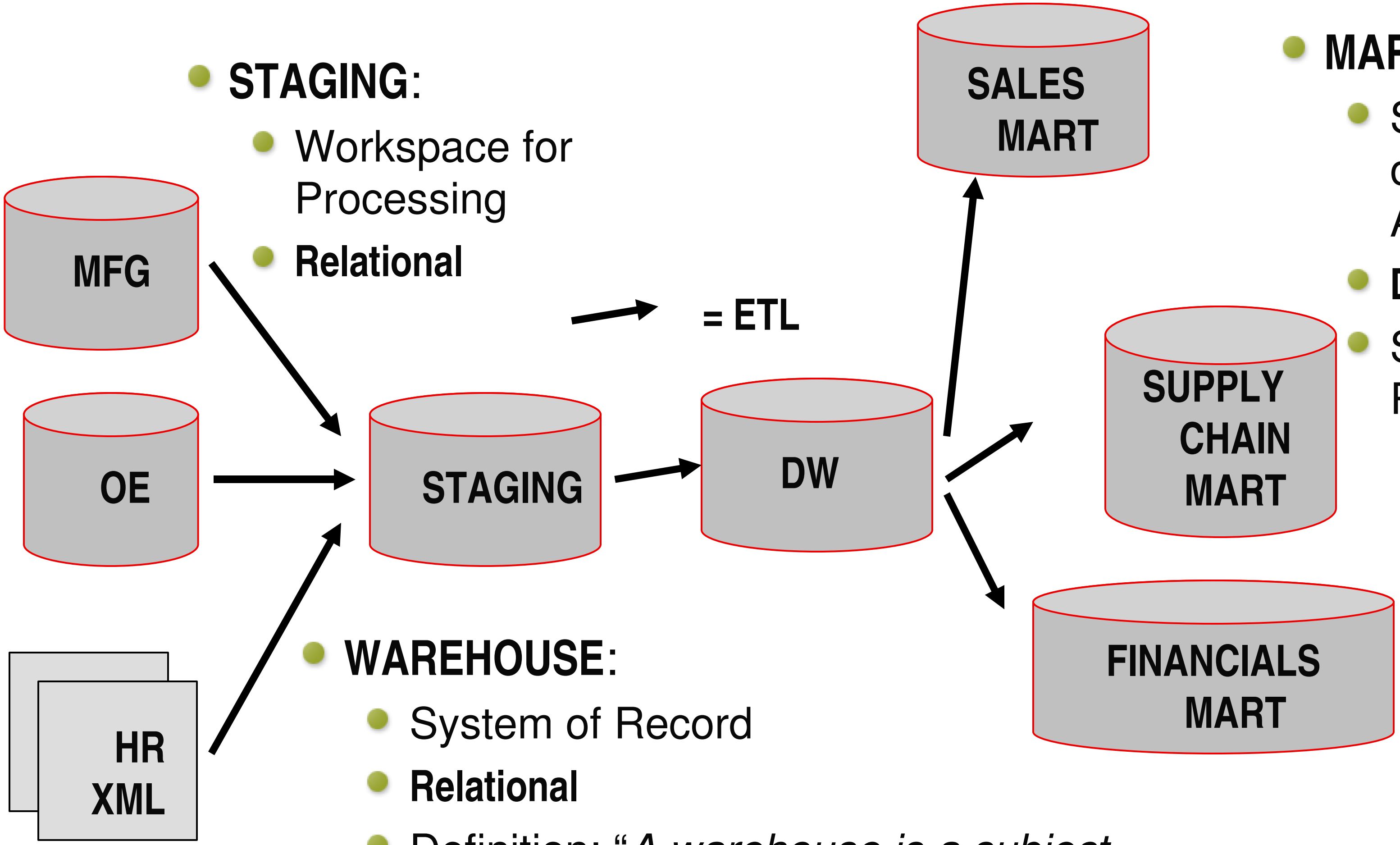
PAYROLL EXP CUBE

PF	TIME DIMENSION ID*	NUMBER
PF	SALARY DIMENSION ID*	NUMBER
PF	EMPLOYEE DIMENSION ID*	NUMBER
	EXPENDITURE AMT*	NUMBER

EMPLOYEE DIMENSION

	TOTAL*	VARCHAR2
	DEPARTMENT NAME*	VARCHAR2
	EMPLOYEE NAME*	VARCHAR2
PK	EMPLOYEE DIMENSION ID*	NUMBER

Basics: Corporate Information Factory



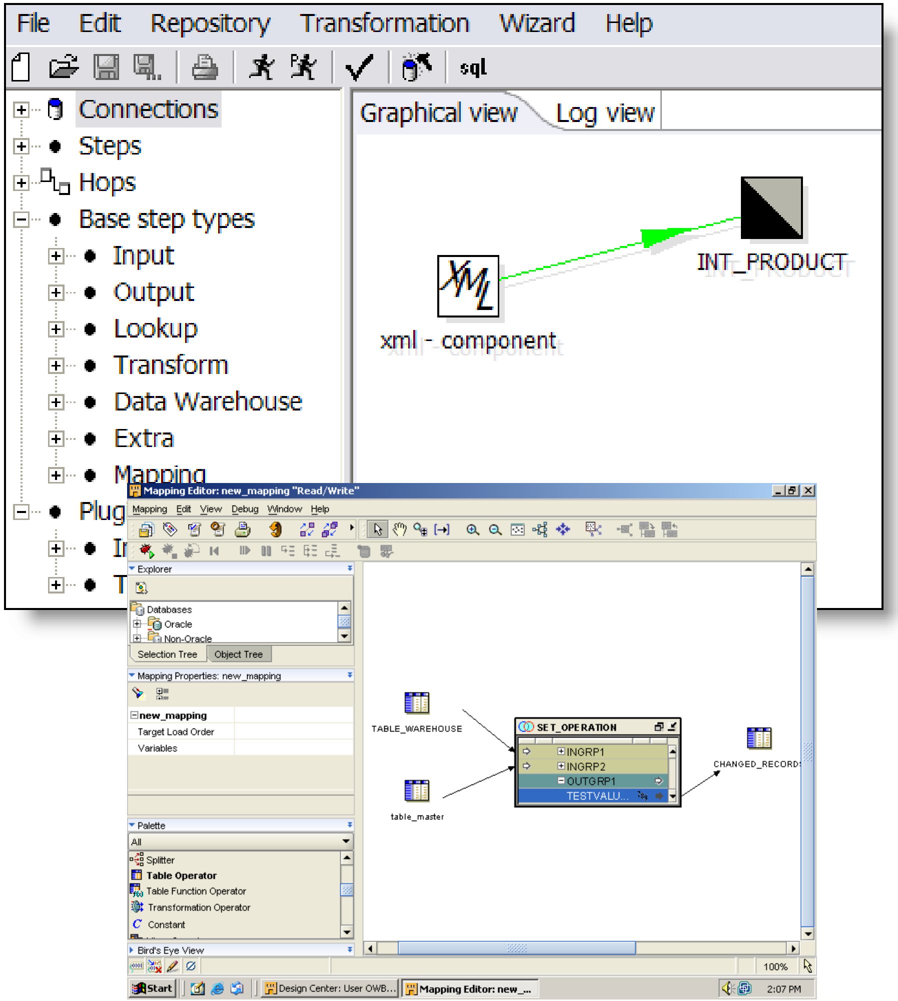
- **STAGING**:
  - Workspace for Processing
  - **Relational**

- **WAREHOUSE**:
  - System of Record
  - **Relational**
  - Definition: "*A warehouse is a subject-oriented, integrated, time-variant and non-volatile collection of data in support of management's decision making process.*" -- Bill Inmon

- **MARTS**:
  - Structures optimized for Analysis
  - **Dimensional**
  - Sometimes Relational

Basics: Extract Transform Load

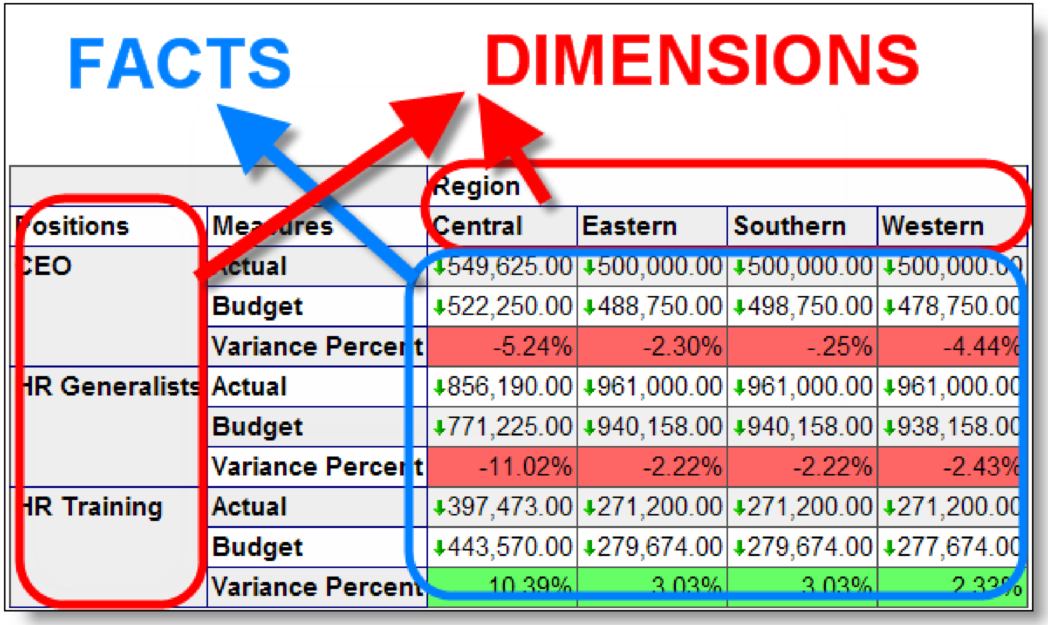
- Data Processing
  - Pull data from X,Y,Z and insert or update in the Warehouse
- Logical Transformations
  - Sum, Join, Outer Join, Bucketize, calculate time variant items
  - *Everything you need to process flat files, XML, Tables into a set of tables that represent your reporting data.*
- Tools
  - Visual and include a Logical and Physical representation
  - Kettle and OWB
- SQL Scripts / Perl / Cron



Dimensional Modeling: Star Schema

- FACTS
  - Has what you are trying to **MEASURE** (Sales, Expenditures)
  - Usually Numeric
  - *Tough to model facts “correctly” when you’re learning*

- DIMENSIONS
  - How you are trying to qualify measures. Products, Time, Department, etc.
  - DENORMALIZED
  - Usually Hierarchical (Year -> Qtr -> Mon -> Day)
  - *Feels “weird” the first few times*



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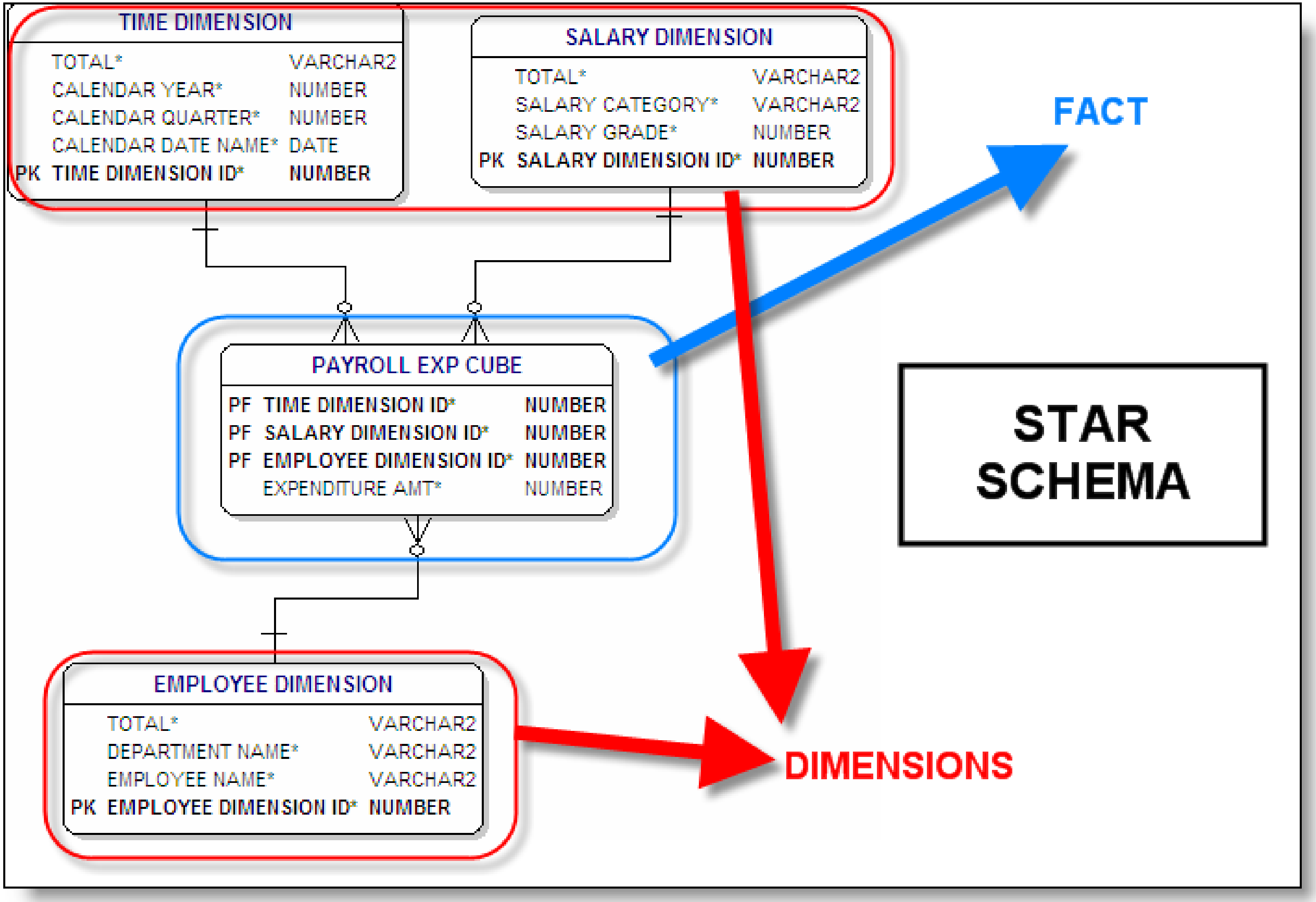
Dimensional Modeling: Star Schema



TIME DIMENSION

	TOTAL*	VARCHAR2
	CALENDAR YEAR*	NUMBER
	CALENDAR QUARTER*	NUMBER
	CALENDAR DATE NAME*	DATE
PK	TIME DIMENSION ID*	NUMBER

SALARY DIMENSION

	TOTAL*	VARCHAR2
	SALARY CATEGORY*	VARCHAR2
	SALARY GRADE*	NUMBER
PK	SALARY DIMENSION ID*	NUMBER

PAYROLL EXP CUBE

PF	TIME DIMENSION ID*	NUMBER
PF	SALARY DIMENSION ID*	NUMBER
PF	EMPLOYEE DIMENSION ID*	NUMBER
	EXPENDITURE AMT*	NUMBER

EMPLOYEE DIMENSION

	TOTAL*	VARCHAR2
	DEPARTMENT NAME*	VARCHAR2
	EMPLOYEE NAME*	VARCHAR2
PK	EMPLOYEE DIMENSION ID*	NUMBER

FACT

STAR SCHEMA

DIMENSIONS

Dimensional Modeling: Step 1

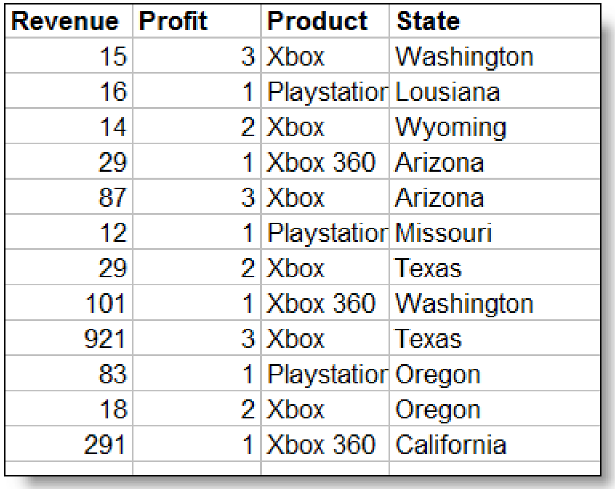
- REQUIREMENTS REQUIREMENTS REQUIREMENTS
  - **Business Users Drive Process**
    - Do NOT ask precisely what numbers do you want!
      - They ask for everything as a flat file or report so they can do their own analysis.
      - What they WANT and what they NEED are usually different.
    - Have them express real English analytical ‘wish list.’
    - Examples:
      - I would like to know what is the proportion of Sales by my different product groups and customer types.
      - What is the proportion of revenue that comes from repeat versus first time customers.
      - What is the profile of customers (profile = Location, Income, and Gender) that make up 80% of my actual Profit as opposed to 80% of revenue.
    - Have them show you their clandestine MS Access or Excel spreadsheet
      - Every numbers business group has “a guy” with “a spreadsheet” that consolidates, processes, and prepares the data like the business users desire.
      - Find this GUY and make him your best friend.

Dimensional Modeling: Step 2

- FIND PATTERNS
  - Begin to identify the WHAT's and the BY's
  - WHAT = FACT (measures)
  - BY = DIMENSION
    - Examples:
      - **I would like to know what is the proportion of Sales by my different product groups and customer types.**
      - **What is the proportion of revenue that comes from repeat versus first time customers.**
      - **What is the profile of customers (profile = Location, Income, and Gender) that make up 80% of my actual Profit as opposed to 80% of revenue.**
  - Develop a rough dimensional model
    - Meant to help PROTOTYPE reports

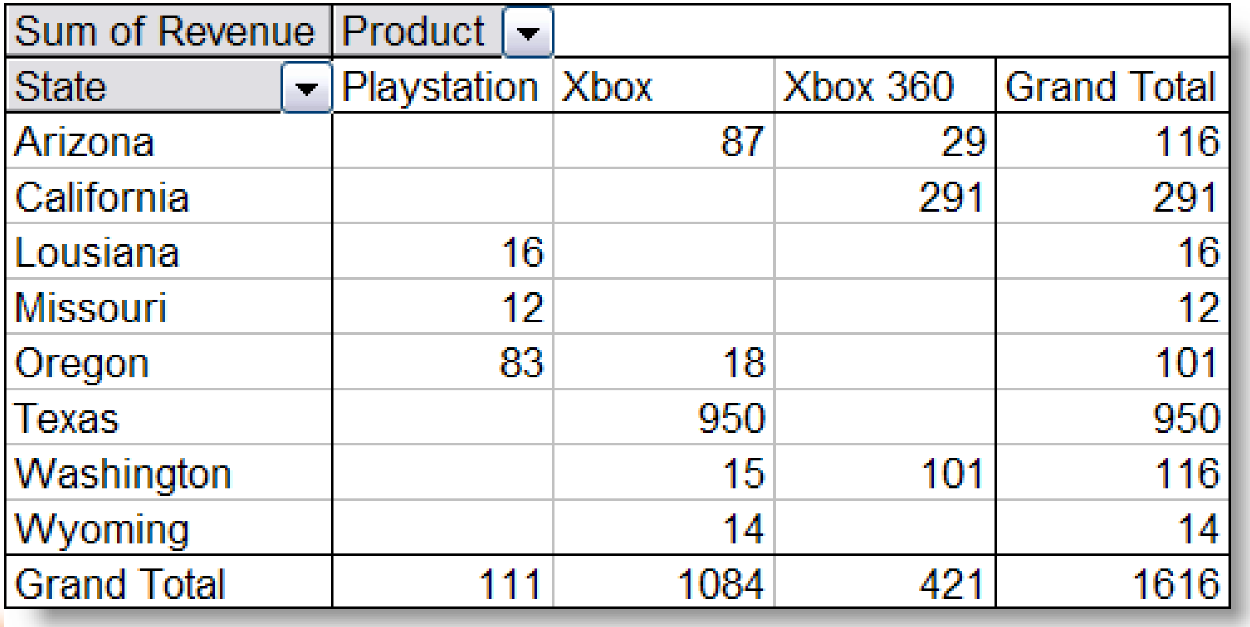
Dimensional Modeling: Step 3

- **PROTOTYPE A FEW “CROSS TAB” REPORTS**
  - Use Excel because it’s wicked easy
  - Helps them “SEE” the dimensional model without abstract terms like “Dimensions” and “Facts”
  - *Try before you buy*



Revenue	Profit	Product	State
15	3	Xbox	Washington
16	1	Playstatior	Lousiana
14	2	Xbox	Wyoming
29	1	Xbox 360	Arizona
87	3	Xbox	Arizona
12	1	Playstatior	Missouri
29	2	Xbox	Texas
101	1	Xbox 360	Washington
921	3	Xbox	Texas
83	1	Playstatior	Oregon
18	2	Xbox	Oregon
291	1	Xbox 360	California

PROTOTYPE SOURCE



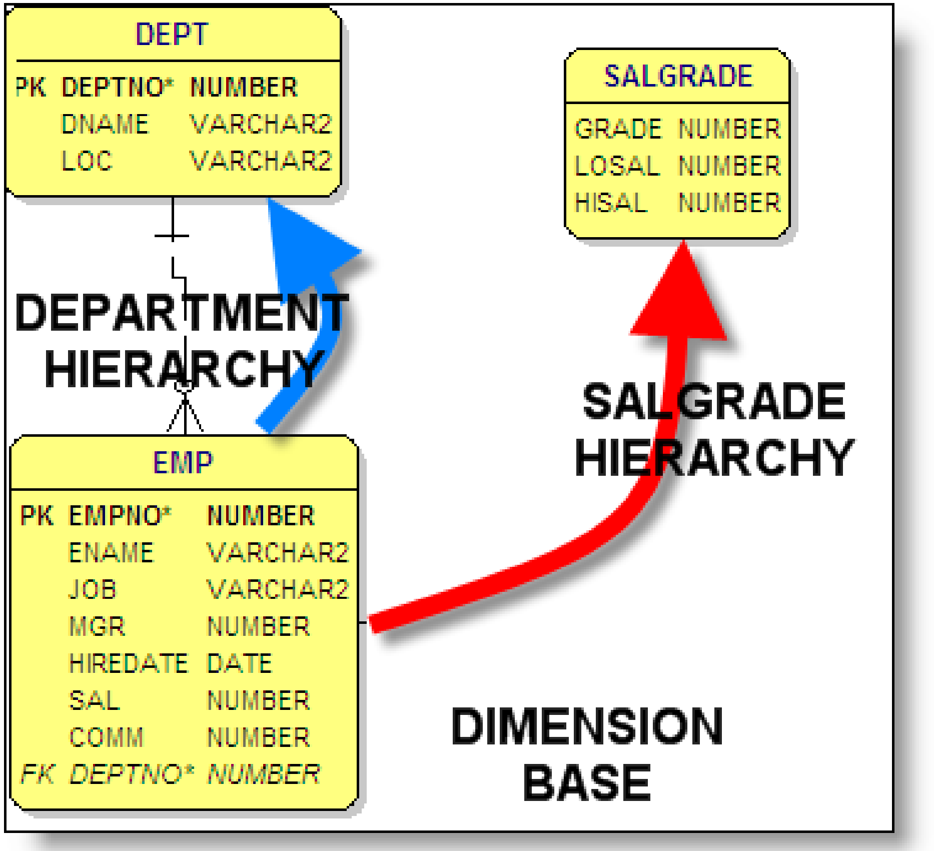
Sum of Revenue	Product ▾			
State ▾	Playstation	Xbox	Xbox 360	Grand Total
Arizona		87	29	116
California			291	291
Lousiana	16			16
Missouri	12			12
Oregon	83	18		101
Texas		950		950
Washington		15	101	116
Wyoming		14		14
Grand Total	111	1084	421	1616

CROSSTAB

Dimensional Modeling: Step 4

- **REFINE MODEL**

  AND IDENTIFIY HIERARCHIES
  - Use feedback from the business users to further refine additional FACT measures (Revenue, Profit, Cost of Goods, etc).
  - Grab other attributes close
    - Product Short Name → Product Long Name.
    - Country Name → Country ISO code.
  - FIND HIERARCHIES
    - Requirements are good place to find them.
    - **SOURCE SYSTEM MASTER/DETAIL is a good indicator of hierarchical data.**



DEPT

PK	DEPTNO*	NUMBER
	DNAME	VARCHAR2
	LOC	VARCHAR2

SALGRADE

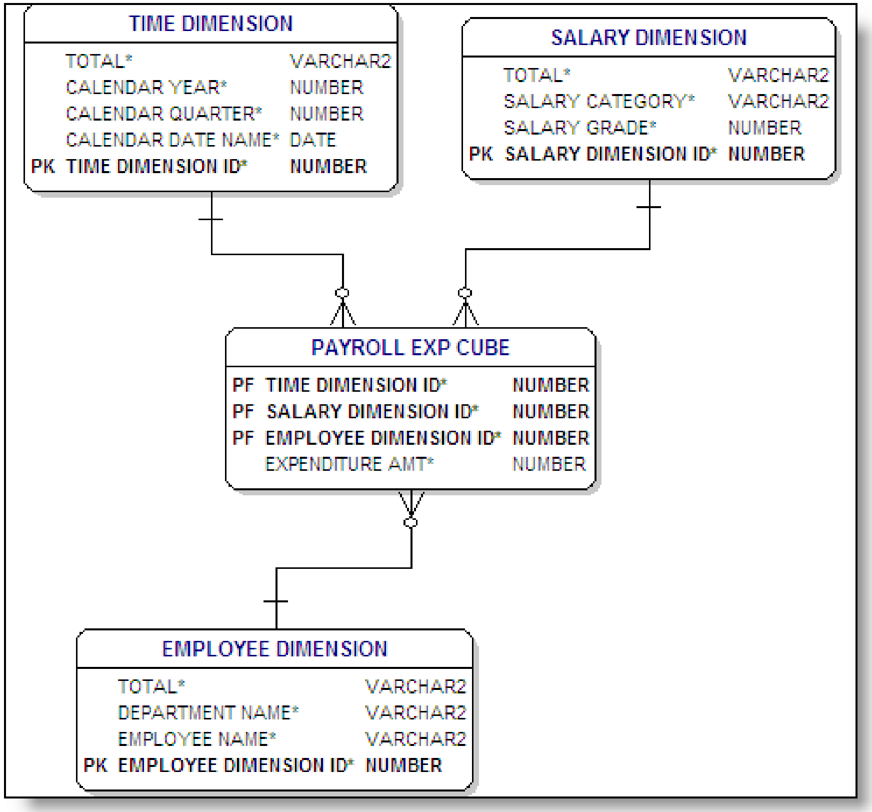
GRADE	NUMBER
LOSAL	NUMBER
HISAL	NUMBER

EMP

PK	EMPNO*	NUMBER
	ENAME	VARCHAR2
	JOB	VARCHAR2
	MGR	NUMBER
	HIREDATE	DATE
	SAL	NUMBER
	COMM	NUMBER
FK	*DEPTNO**	*NUMBER*

Dimensional Modeling: Step 5

- **FINISH MODEL AND SANITY CHECK**
  - Finish the STAR SCHEMA and build the DIMENSIONAL MODEL
  - SANITY CHECK 1: Source Data?
    - Document the PSEUDO-ETL, a simple logical description of how you take your data in your source system and turn it into the dimension or fact.
    - Verifies that there’s not a “missing” piece of data that makes the model useful.
  - SANITY CHECK 2: Can you write SQL/MDX against your model?
    - Run through your mock up reports, and free text questions.
    - Mentally walk through your reports, and ensure you can answer your reports from this model



TIME DIMENSION

	TOTAL*	VARCHAR2
	CALENDAR YEAR*	NUMBER
	CALENDAR QUARTER*	NUMBER
	CALENDAR DATE NAME*	DATE
PK	TIME DIMENSION ID*	NUMBER

SALARY DIMENSION

	TOTAL*	VARCHAR2
	SALARY CATEGORY*	VARCHAR2
	SALARY GRADE*	NUMBER
PK	SALARY DIMENSION ID*	NUMBER

PAYROLL EXP CUBE

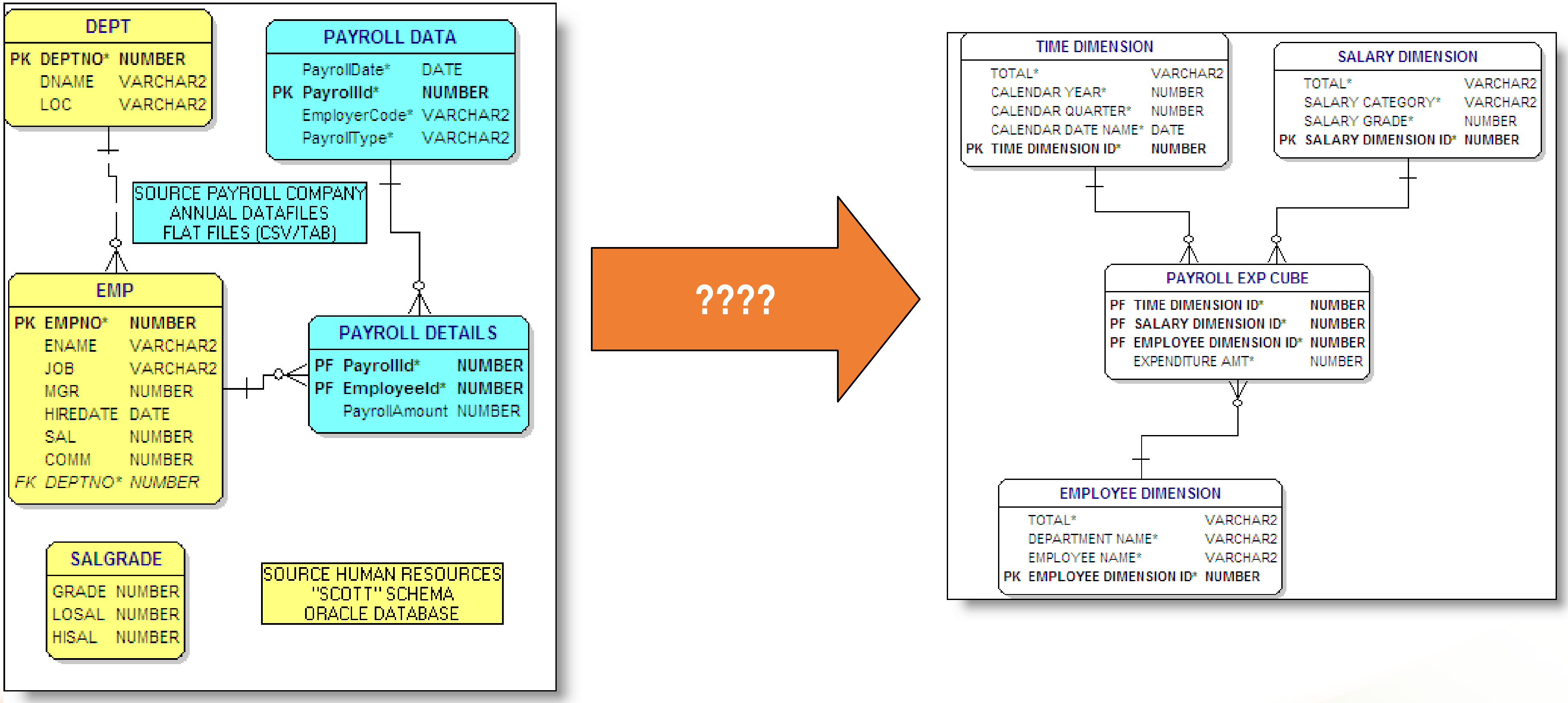
PF	TIME DIMENSION ID*	NUMBER
PF	SALARY DIMENSION ID*	NUMBER
PF	EMPLOYEE DIMENSION ID*	NUMBER
	EXPENDITURE AMT*	NUMBER

EMPLOYEE DIMENSION

	TOTAL*	VARCHAR2
	DEPARTMENT NAME*	VARCHAR2
	EMPLOYEE NAME*	VARCHAR2
PK	EMPLOYEE DIMENSION ID*	NUMBER

Data Transformation: Problem to Solve

- Turn the OLTP data (source data) into our OLAP data (star schema)
- Known as Extract Transform and Load (ETL)



DEPT

PK	DEPTNO*	NUMBER
	DNAME	VARCHAR2
	LOC	VARCHAR2

PAYROLL DATA

	PayrollDate*	DATE
PK	PayrollId*	NUMBER
	EmployerCode*	VARCHAR2
	PayrollType*	VARCHAR2

SOURCE PAYROLL COMPANY
ANNUAL DATAFILES
FLAT FILES (CSV/TAB)

EMP

PK	EMPNO*	NUMBER
	ENAME	VARCHAR2
	JOB	VARCHAR2
	MGR	NUMBER
	HIREDATE	DATE
	SAL	NUMBER
	COMM	NUMBER
FK	DEPTNO*	NUMBER

PAYROLL DETAILS

PF	PayrollId*	NUMBER
PF	EmployeeId*	NUMBER
	PayrollAmount	NUMBER

SALGRADE

GRADE	NUMBER
LOSAL	NUMBER
HISAL	NUMBER

SOURCE HUMAN RESOURCES
"SCOTT" SCHEMA
ORACLE DATABASE

TIME DIMENSION

	TOTAL*	VARCHAR2
	CALENDAR YEAR*	NUMBER
	CALENDAR QUARTER*	NUMBER
	CALENDAR DATE NAME*	DATE
PK	TIME DIMENSION ID*	NUMBER

SALARY DIMENSION

	TOTAL*	VARCHAR2
	SALARY CATEGORY*	VARCHAR2
	SALARY GRADE*	NUMBER
PK	SALARY DIMENSION ID*	NUMBER

PAYROLL EXP CUBE

PF	TIME DIMENSION ID*	NUMBER
PF	SALARY DIMENSION ID*	NUMBER
PF	EMPLOYEE DIMENSION ID*	NUMBER
	EXPENDITURE AMT*	NUMBER

EMPLOYEE DIMENSION

	TOTAL*	VARCHAR2
	DEPARTMENT NAME*	VARCHAR2
	EMPLOYEE NAME*	VARCHAR2
PK	EMPLOYEE DIMENSION ID*	NUMBER

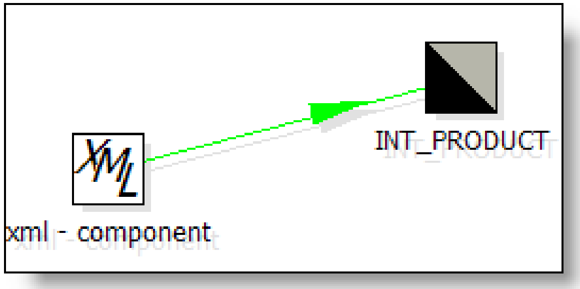
Data Transformation: ETL

- Tools or Technologies that process source data and insert/update data in the warehouse based on the business rules defined.
- Example
  - We need to turn our source data into our warehouse data
  - Source System:
    - **ORDER_LINE_ITEM**: Quantity, Discount Amount, Actual Price
  - Data Warehouse:
    - **SALES_FACT**: REVENUE, DISCOUNT PERCENT, etc.
- Technologies
  - SQL (if it’s in the same database you can use SQL to do this)
  - Perl (original data warehouse toolkit, still in common use)
  - Commercial Tools (Oracle Warehouse Builder, Informatica)
  - Open Source Tools (Kettle, KETL)
- BOTTOM LINE: Get the job done!

Data Transformation: ETL Topics

- Surrogate Keys
  - Protect yourself from source system changes.
  - Needed since Dimensions of TYPE II (see appendix) will have a different natural key.
  - Example:
    - Surrogate Id 1 / Customer Id : 100 / State: WA
    - Surrogate Id 2 / Customer Id : 100 / State: CA
- History
  - EFFECTIVE and EXPIRATION dates
  - Example:
    - Surrogate Id 1 / Customer Id: 100 / Eff 01-Jan-2006 / Exp 31-Mar-2006
    - Surrogate Id 2 / Customer Id: 100 / Eff 31-Mar-2006 / NULL
    - Accurate reports the sale two years ago and last week.

Data Transformation: ETL Topics cont



- UPSERTS
  - INSERT/UPDATE is a common pattern in situations
- Process Everything or Just Changes
  - Deltas = Changes since last processing
  - Detected Deltas
    - Compare Yesterday’s data to right now and build a list of changes
  - Application Managed Deltas
    - Corresponding SOURCE_HISTORY table that has the data history
  - Database Managed Deltas
    - Streams / Triggers

Oracle Specifics: OLAP Performance

- BITMAP Indexes
  - Ensures one pass through dimension tables (small, < 100k rows) and only ONE scan of FACT table (usually large, millions of rows)
- Parallel Query with Partitioned Fact tables
  - Allows for the “ONE scan” of the FACT table to be split across CPUs (nodes in RAC?) and I/O channels. I/O is MORE important than CPUs. Data Warehouse queries are almost ALWAYS waiting on disks.
- Materialized Views
  - Watch your reporting tool (Discoverer, Mondrian) and determine what SQL your “canned” reports are generating. Building a corresponding MView and refreshing after load will make these LIGHTNING quick!
- Oracle Tuning
  - Few Users, Lots of Sort Operations (group by)
  - Dedicated Connections

Oracle Specifics: Misc

- ETL
  - Merge Statements
    - ROCK for doing UPSERTs in the database.
  - Sequences for Surrogate IDs.
- REDO
  - Lots of REDO during batch load.
  - Hardly ANY REDO during data access.
- Oracle Streams
  - Next generation message based Delta communication.
  - Log Miner ++.
  - Allows the warehouse to get a complete view of the Oracle source.
- Availability / Backup
  - Can USUALLY take cold backups (10pm at night).
  - Has less stringent availability then OLTP databases.

Appendix: Where to go for more information

- Business Intelligence Tools
  - Oracle
    - Oracle Warehouse Builder, Oracle Discoverer, Oracle OLAP Option, Oracle Designer, Oracle BI Suite Enterprise Edition (2006)
  - Open Source
    - www.pentaho.org (Reporting, OLAP, Data Integration, etc)
    - Free to use and prototype; use for your learning!
- Modeling and Data Warehousing
  - Ralph Kimball expert in Dimensional Modeling
    - Kimball University http://www.kimballgroup.com/
    - Data Warehouse Toolkit (Book, Kimball)
  - Data Warehousing
    - The Data Warehouse Institute Classes (http://www.tdwi.org/)
    - Corporate Information Factory (Book, Imhoff)

Appendix : Slowly Changing Dimensions

- Type I
  - Corrections / Updates
  - There is no history kept in dimensions, changes in source are updated in warehouse.
- Type II
  - Historical
  - Multiple “versions” of the customer are kept in the warehouse.
  - Example:
    - Customer moves from WA → MA. Need to attribute one fact in WA and the other in MA but both from the same customer.
- Type III
  - Old and New Together
  - Typically used for change of classifications/rollups
  - Example:
    - Reorganization of Sales Organization.
    - New Sales Territory: Pacific, Old Sales Territory: West