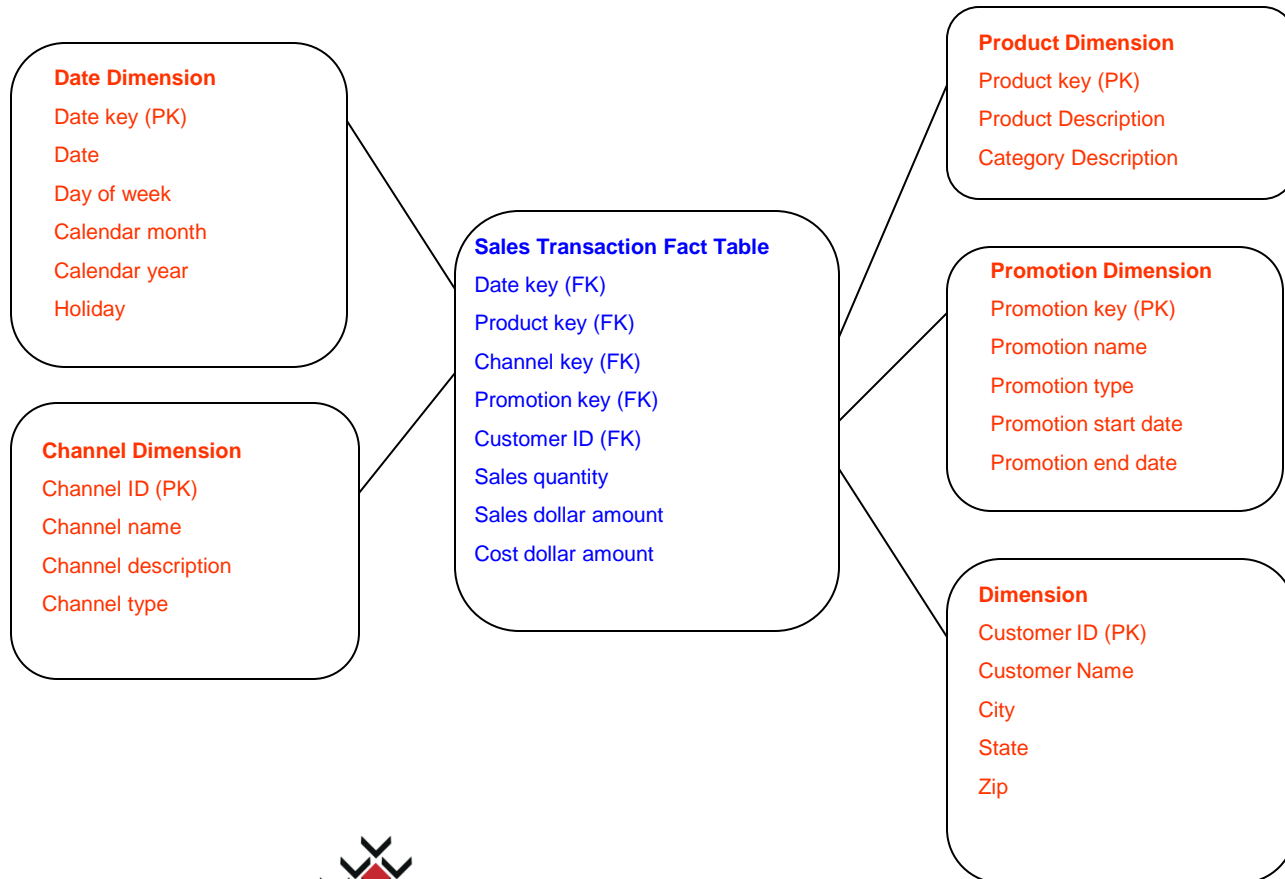




# Data Strategies for Efficiency and Growth



**SYSTEMS SEMINAR CONSULTANTS, INC.**

2997 Yarmouth Greenway Drive Madison, WI 53711

(608) 278-9964 [www.sys-seminar.com](http://www.sys-seminar.com)

# Efficiency and Growth are Two sides of the Same Coin



- Scalability

What happens when data volume increase 10x?

- Consistency

Does each new system require redesign and relearning for users?

- Flexibility

Can new data items be integrated?

# Issues

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- Lack of consistency among systems
- Change is painful
- Backup and rollback (or not)
- Audit and compliance (or not)
- Disaster recovery (or not)
- Steep learning curves for each new system
- The database system is Excel!

# What is data modeling?

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- The generalized logical relationship among tables
- Usually reflected in the physical structure of the tables
- Not tied to any particular product or DBMS
- A critical design consideration

# Why is data modeling important?

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- Allows you to optimize performance
- Allows you to minimize costs
- Facilitates system documentation and maintenance
  
- *The dimensional data model should be the basis for the query side of your business processes.*
- The dimensional data model is the foundation of a well designed data mart or data warehouse

# Common data models

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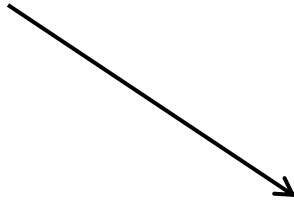
- Denormalized or non-normalized
  - Minimize multiple instances of data...not!
  - Often evolve from informal systems, e.g., spreadsheets
- Normalized
  - Usually the result of a formal data design process
  - Often implement on a RDBS supporting constraints
  - Goal: Transaction efficiency
- Dimensional
  - “Semi normalized”
  - Goal: Query efficiency

# De-normalized Data



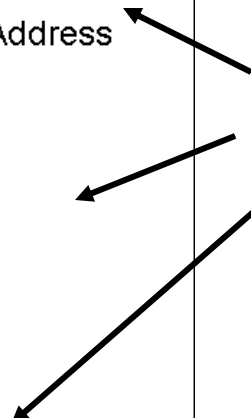
## Sales Transaction Table

Each row represents a sale transaction line.



Transaction line table	
Transaction number	
Customer Name	
Customer Street Address	
Customer City	
Customer State	
Customer Zip	
Multi-state region	
Product Category	
Product Number	
Product Name	
Calendar day	
Day of week	
Month	
Year	
Season	
Annual product cycle number	
Sale quantity	
Sale dollar amount	

Attributes of the sale:  
customer and product info,  
date, etc.



Sale facts: number  
of items and dollars



*All attributes of the sale  
are included with each  
transaction line row.*

# De-Normalized Data

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*A single row contains:*

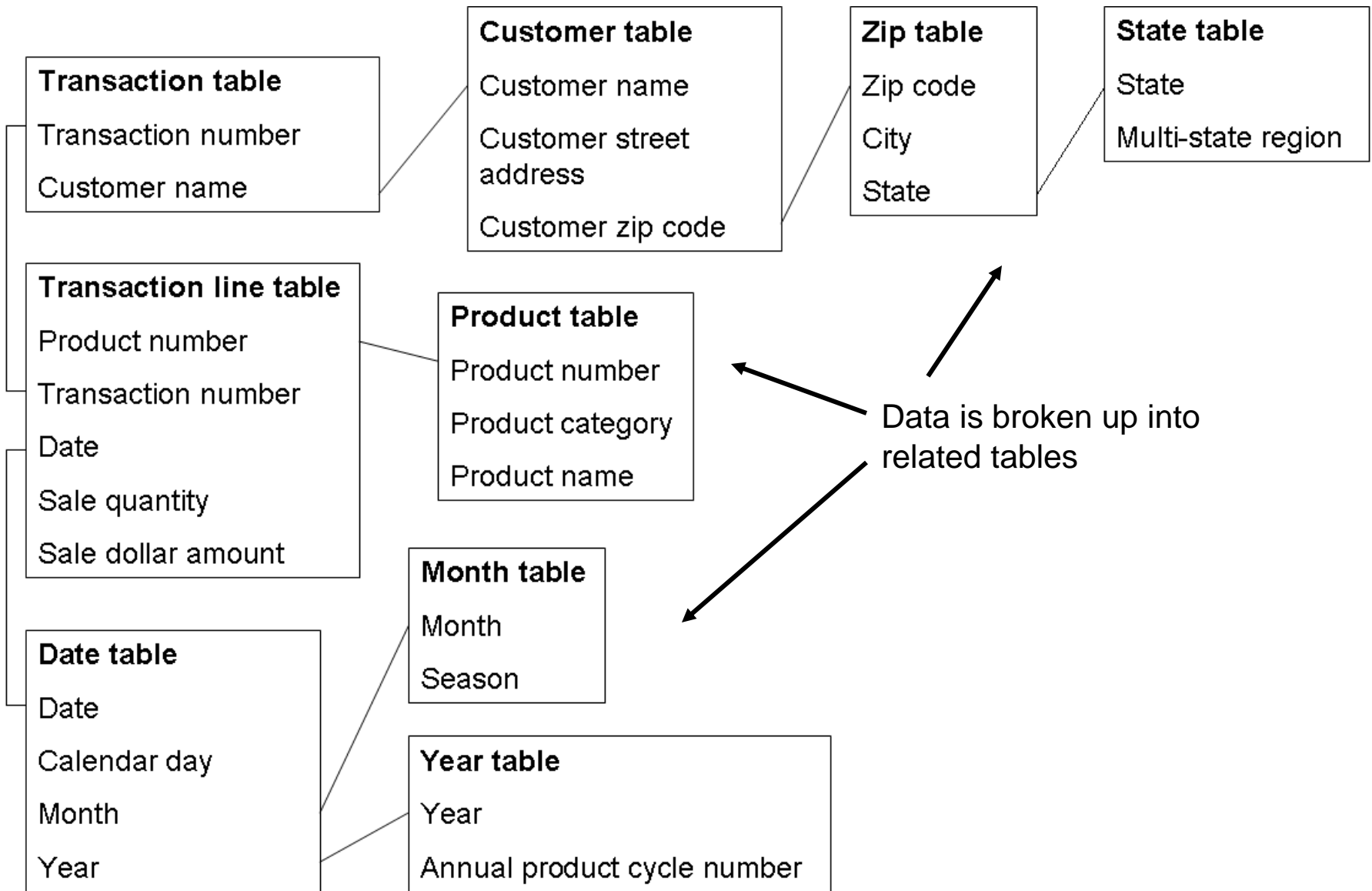
- Numeric measurements and...
- All attributes related to that measurement
- All data is in a single table.

*Data redundancy:*

Directly correlated attributes, such as product number and product category, are repeated in each row

<u>Sale Number</u>	<u>Product Number</u>	<u>Product Category</u>
1	S3200	Software
2	S3223	Software
3	H7005	Hardware

# Normalized Data



# Normalized Data

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- ***Insert Optimized***

A new transaction line involves gathering only the five data items in the Transaction Line table. No other attribute look up is required.

- ***Redundancy is reduced:***

For example, Product Category is not repeated for each transaction

- ***Changes have less impact on the database:***

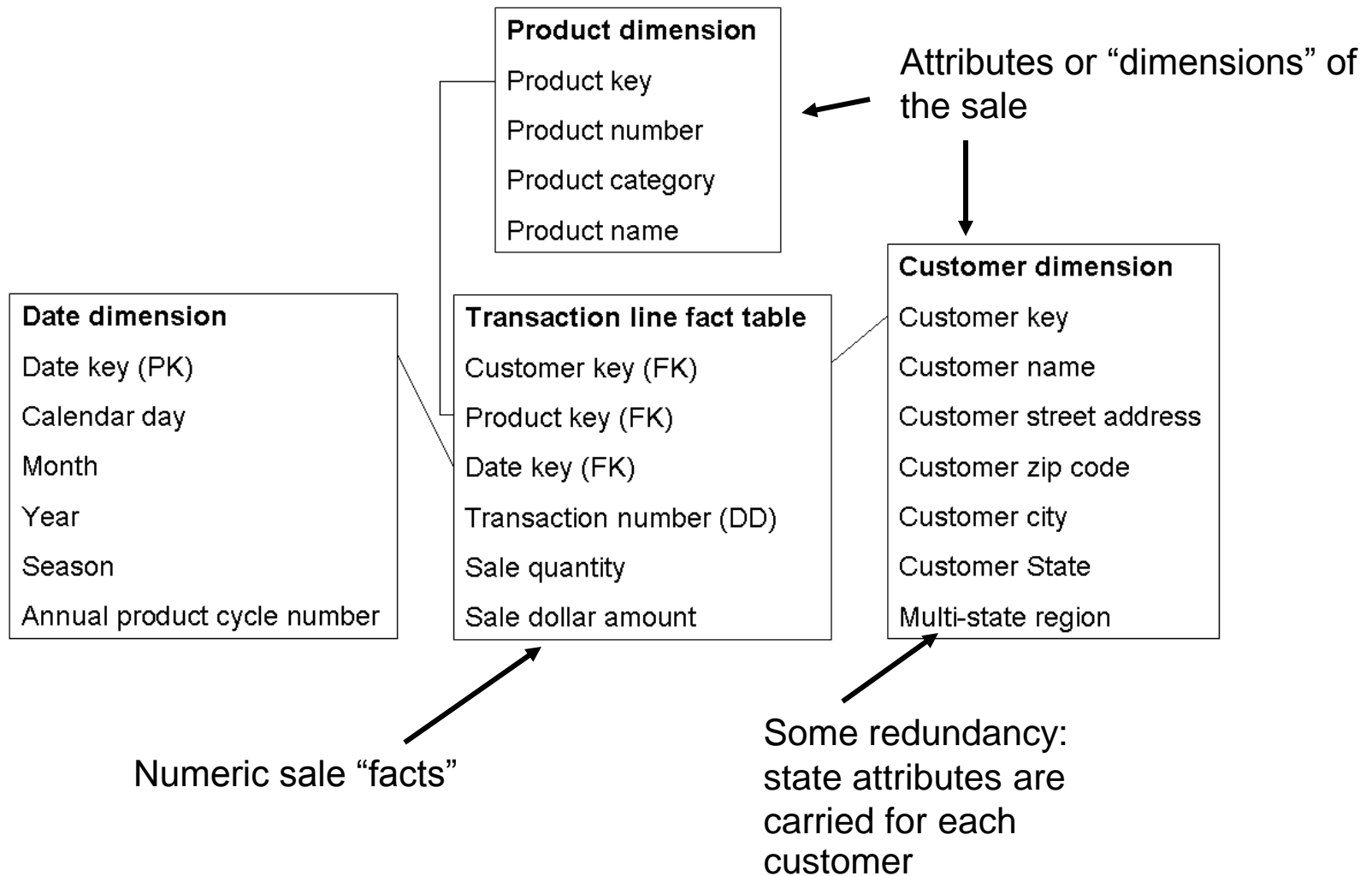
If a product category changes, only the Product table needs to be changed

- ***Query complexity is increased:***

Several tables must be related to each other in order to answer simple questions.

*What is the sum of sale amount for each state?*

# Dimensional Data





- *The central fact table is surrounded by dimension tables*

“Star schema”

- *Table relationships are only one level deep*
- **No more than two tables need to be joined together for common business questions and aggregations**

*What is the sum of sale amount for each state?*

# Facts and Dimensions

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- Key terms: Fact and Dimension

- Fact:*

High cardinality, numeric measure of some event such dollars for a sale.

Typically many rows, one per business event.

- Dimension:*

Low cardinality, typically non-numeric, attribute of a fact.

Typically many columns, one per attribute of interest.

*The dimensional model is made up of facts and dimensions*

# Why dimensional modeling?

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- Bring together data from many different sources and create a single, consistent user view.
- Support the ad hoc queries that arise from novel business questions and situations.
- Maximize flexibility and scalability.
- Improve the end-user experience because...
  - Query performance is optimized
  - Learning curve is flattened

# Fact and Dimensions

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Dimensional modeling implies two distinct types of data:

1. Facts
2. Dimensions

These data are stored two types of tables:

1. Fact tables
2. Dimension tables

# Facts and Dimensions

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A fact is...

- A business measurement, amount, or event
- Typically numeric, continuously valued, and additive
- Something we analyze: “What were total sales by state?”

Some facts:

a sale dollar amount, an order quantity, banner ad click

A dimension is...

- Context surrounding a fact: who the fact applies to; when, where, and under what conditions the fact was measured
- Usually a discrete character or numeric value
- Static or slowly changing
- Something we use to identify or group data: “What were total sales by state?”

Some dimensions:

*customer, date, time, location*



Elements of a fact table:

- **Fact:** the measure(s) of interest
- **Dimension foreign key:** Key to a row in a dimension table

## Sales Transaction Fact Table

Date key (FK)

Product key (FK)

Channel key (FK)

Promotion key (FK)

Customer ID (FK)

Sales quantity

Sales dollar amount

Cost dollar amount

# Dimension Table

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The dimension table represents an entity of interest to the business: Customer, product, vendor, promotion, location, etc.

Elements:

- **Primary key (PK)**: Unique for each row in the table. It should be a surrogate key, i.e., have no inherent meaning. The value of the dimension key is what's stored in the fact table.
- **Dimension attributes**: A set of variables that encompass what is known about the business entity.

## Customer Dimension

Customer ID (PK)

Customer Name

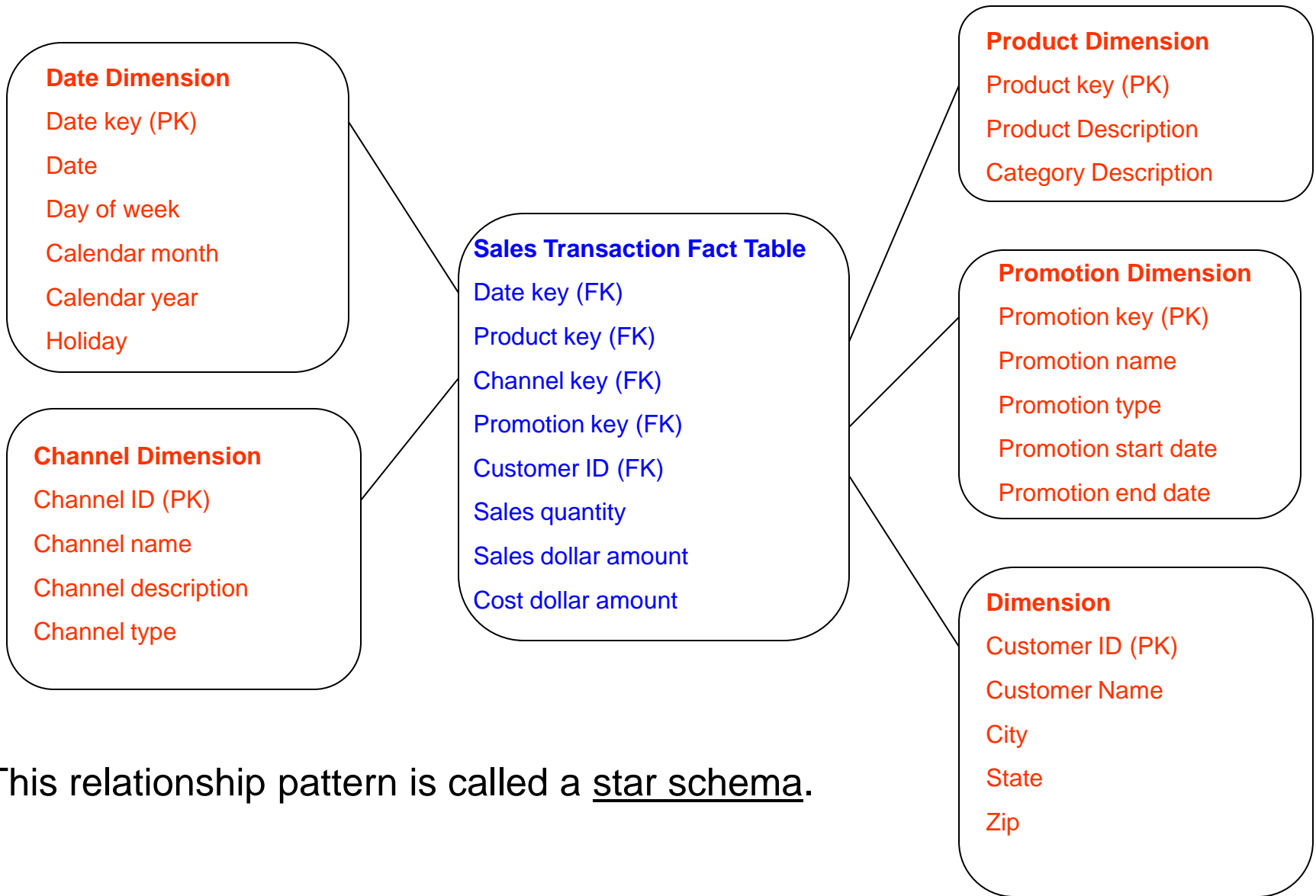
City

State

Zip

Date of first contact

# Fact-Dimension Data Model



This relationship pattern is called a star schema.

# Granularity

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- Granularity is the level of detail in a fact table
- Granularity is the combination of all dimensions. The more dimensions the finer the grain.

The grain of the previous table is:

Date

Product

Channel

Promotion

Customer

- Only facts with the same grain (i.e. described by the same dimensions) can coexist in a fact table.
- Granularity can always be reduced through aggregation, but can never be increased after the table is built. So: *This is a critical design factor!*

# Granularity



- The fact tables represent two different business processes.
- The fact tables each have a unique set of foreign keys, though some foreign keys match (red).

## Sales Transaction Fact Table

Date key (FK)

Product key (FK)

Channel key (FK)

Promotion key (FK)

Customer ID (FK)

Sales quantity

Sales dollar amount

Cost dollar amount

Each line is a sales transaction— one customer buying some quantity of one product.

## Promotion Event Fact Table

Date key (FK)

Promotion key (FK)

Medium key (FK)

Customer ID (FK)

Count variable

Each line is a promotion event— one customer being offered one promotion.

# Surrogate Key



Each row in a dimension table should be identified by a surrogate primary key. A surrogate key has no inherent meaning.

Surrogate key                      Natural key

↙                                      ↙

Channel ID (PK)	Channel Name	Channel Description	Channel Type
<b>1042</b>	<b>Store #0720</b>	<b>St. Louis Retail Store</b>	<b>Retail Store</b>
<b>1043</b>	<b>Store #0721</b>	<b>Albuquerque Street Kiosk</b>	<b>Kiosk</b>
<b>1044</b>	<b>Store #0722</b>	<b>Scranton Retail Store</b>	<b>Retail Store</b>
<b>1045</b>	<b>Store #0720</b>	<b>St. Louis Outlet Store</b>	<b>Outlet Store</b>

- The two records for Store #0720 (natural key) can coexist without conflict because each has a unique surrogate key.

# Surrogate Key

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## Benefits of using a surrogate key:

- Surrogate keys make it possible to integrate data from sources that use different forms of a natural key.
- Allow the use of legitimate unknown and null natural keys, or natural keys with special meanings.
- Natural keys may be reused. For example, transaction numbers may be recycled six months after the transaction. A unique surrogate key value distinguishes between two like-numbered transactions.

# Drill Down and Up

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Drill down means displaying facts at a finer level of granularity.  
When you drill down you add dimensional attributes.

Example:

*I am viewing sales by state and I want to drill down to the zip code level within state.*

Drill up is the reverse. Drill up reduces the number of dimensional attributes.

Drill up is aggregation.

Example:

*I am viewing sales by state but want sales aggregated by multi-state region.*

# Drill Up and Down



June 25, 2008

## Date Dimension

**Date key (PK)**

**Date**

Day of week  
Calendar month  
Calendar year  
Holiday

E-store

## Channel Dimension

**Channel ID (PK)**

**Channel name**

Channel description  
Channel type

## Sales Transaction Fact Table

**Date key (FK)**

**Product key (FK)**

**Channel key (FK)**

**Promotion key (FK)**

**Customer ID (FK)**

Transaction number (DD)

**Sales quantity**

Sales dollar amount

Cost dollar amount

## Product Dimension

**Product key (PK)**

Product Description

**Category Description**

General Merchandise

## Promotion Dimension

**Promotion key (PK)**

**Promotion name**

Promotion type  
Promotion start date  
Promotion end date

Preferred Gold

## Customer Dimension

**Customer ID (PK)**

Customer Name

**City**

State

Zip

**Date of first contact**

Tulsa

June 25, 2008

# Drill Across

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Drill Across means:

*Join two or more facts that share the same dimensions.*

Consider the question...

*“How many customers who purchased products this December were notified of the Year End Clearance promotion by e-mail?”*

The answer involves two different facts:

1. Sale events
2. Promotion events

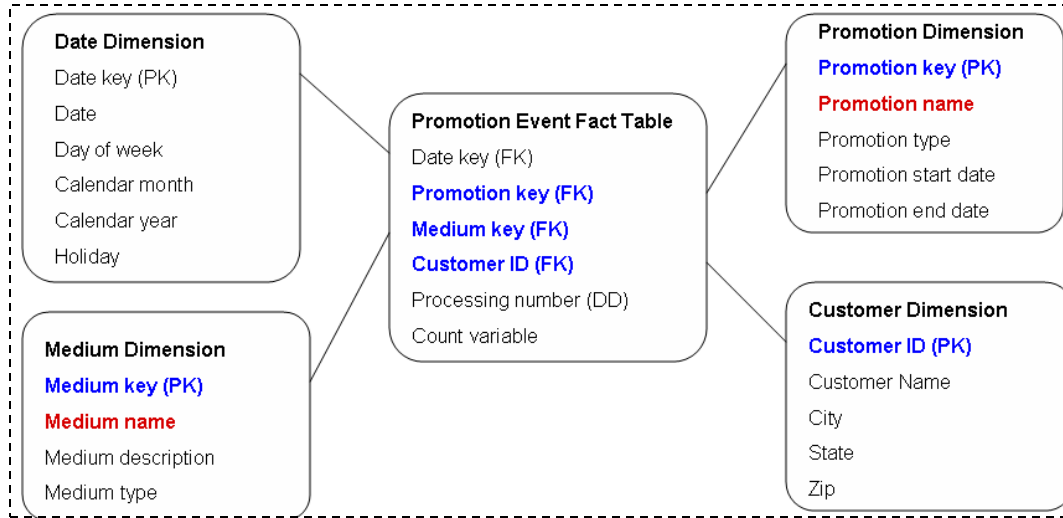
Sales facts and promotion facts can be joined on their common dimension: customer

# Drill Across Query



## Promotion Event Schema

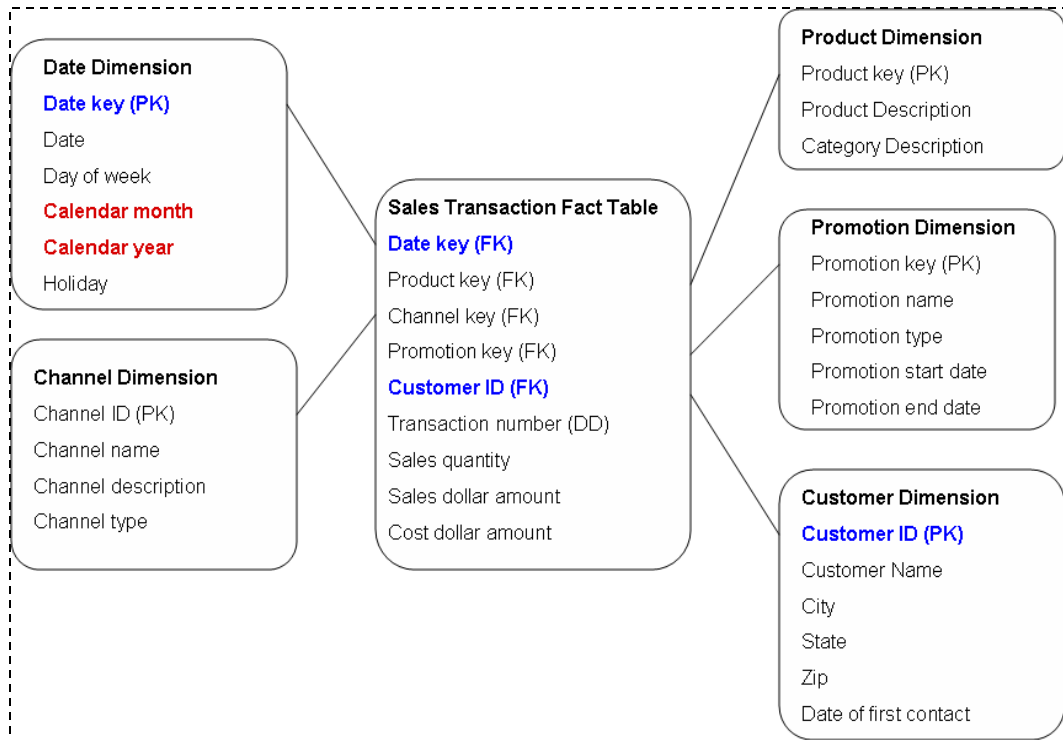
E-mail



Year-end Clearance

## Sales Transaction Schema

December 2007



The shared customer dimension allows for a join on Customer ID

# Conformed Dimensions



## Criteria for conformed dimensions:

- Like-entities represented in different tables have the same primary key
- Like-named attributes are equivalent– they have the same meaning and the same range of values.

### Customer Dimension

Customer ID (PK)

Customer Name

City

State

Zip

Date of first contact

### Customer Dimension

Customer ID (PK)

Customer Name

City

State

Zip

Customer dimension  
from the Sales  
Transaction schema

Customer dimension  
from the Promotion  
Event schema.

*A subset of  
transaction customer*

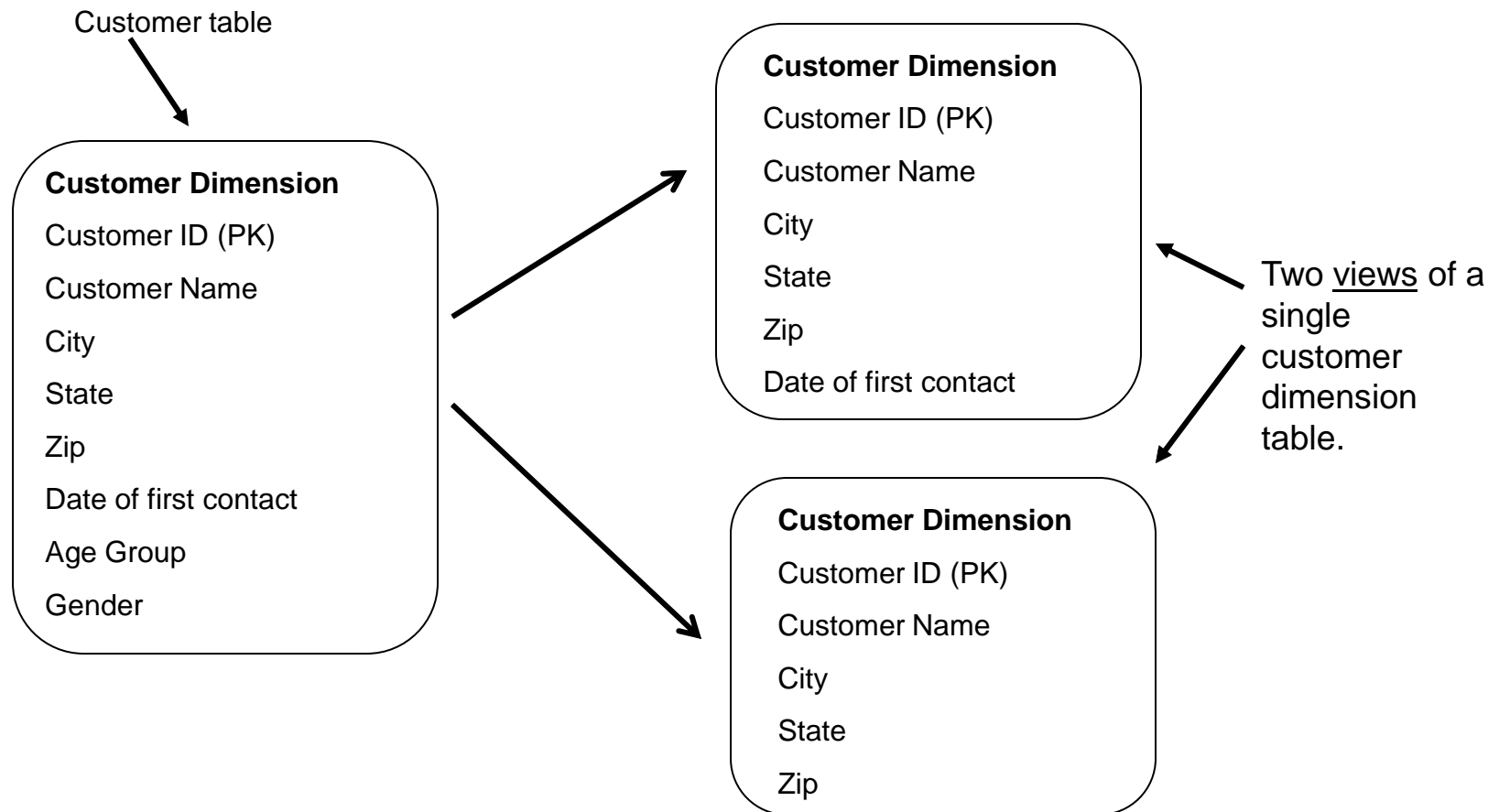
***One set of dimension attributes (table) may be a subset of the another***

# Conformed Dimensions



“Conformed dimension” is a logical concept.

The conformed dimension that is shared between two dimensional models may be a single physical table.



# Slowly Changing Dimensions

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The value of a dimension attribute may change.

For example, the Channel Type for Store #0720 may change:

Channel ID (PK)	Channel Name	Channel Description	Channel Type
<b>1042</b>	<b>Store #0720</b>	<b>St. Louis Retail Store</b>	<b>Retail Store</b>

Channel ID (PK)	Channel Name	Channel Description	Channel Type
<b>1042</b>	<b>Store #0720</b>	<b>St. Louis Outlet Store</b>	<b>Outlet Store</b>

# Slowly Changing Dimensions

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There are three generally accepted ways to handle slowly changing dimensions (SCD):

Type 1 – simply replace the value old attribute value with the new.

Type 2 – insert a new dimension row, with a new key, representing the changed attribute. The old version of the dimension, with its original key, remains.

Type 3 – Design the dimension table with columns that hold previous values of the attribute anticipated to change.

# SCD Type 1

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Channel ID (PK)	Channel Name	Channel Description	Channel Type
<b>1042</b>	<b>Store #0720</b>	<b>St. Louis Retail Store</b>	<b>Retail Store</b>

Channel ID (PK)	Channel Name	Channel Description	Channel Type
<b>1042</b>	<b>Store #0720</b>	<b>St. Louis Outlet Store</b>	<b>Outlet Store</b>

Note the same primary key: 1042

# SCD Type 2

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Channel ID (PK)	Channel Name	Channel Description	Channel Type
<b>1042</b>	<b>Store #0720</b>	<b>St. Louis Retail Store</b>	<b>Retail Store</b>

Channel ID (PK)	Channel Name	Channel Description	Channel Type
<b>1042</b>	<b>Store #0720</b>	<b>St. Louis Retail Store</b>	<b>Retail Store</b>
<b>1099</b>	<b>Store #0720</b>	<b>St. Louis Outlet Store</b>	<b>Outlet Store</b>

# SCD Type 3

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Channel ID (PK)	Channel Name	Current Channel Type	Previous Channel Type
1042	Store #0720	Outlet Store	Retail Store

- SCD Type 3 tables often include columns indicating when a change happened.
- SCD Type 3 designers must anticipate the number of change events to store.

# What can dimensional modeling do for you...

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## ❖ Single version of the truth

The dimensional model enforces business rules so the same fact or dimensional attribute always has the same definition.

## ❖ Data integration

The dimensional model is built around data integration. The dimensional modeling process reveals inconsistencies and allows (or forces) them to be reconciled.

Bring together data from many different sources and create a **single, consistent** user view .

# What can dimensional modeling do for you...

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## ❖ Analyze on the fly

The dimensional model facilitates ad hoc queries and unanticipated business questions because it is generic and not tied to any specific report structure or view of the data.

## ❖ Drill up or drill down to any level of detail contained in the data

The dimensional model is a natural for summary reports and drill down applications. Dimensions are added for drill down, removed for summaries. Commonly used summaries may be pre-aggregated for improved performance.

Supports the query side of the business process: both standardized reporting and ad hoc queries.

# What can dimensional modeling do for you...

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## ❖ Enterprise-wide data warehouse or specialized data mart

The dimensional model works equally well with generalized corporate data warehouse schemes or “data marts” focused on specific departments or user groups. Small scale data marts can be expanded and large warehouse structures can be sub-setted to change your project scale in either direction.

## ❖ Tool agnostic

Almost any BI tool supports dimensional models. You can use your favorite query tool while someone in the next department accesses the same data with a modeling application. SQL queries against a dimensional model all have the same general structure.

## ❖ The data warehouse evolves with the organization

Adding new data sources and adapting to changes in current data sources is handled in a consistent, reproducible manner.

Maximize **flexibility** and **scalability**.

# What can dimensional modeling do for you...

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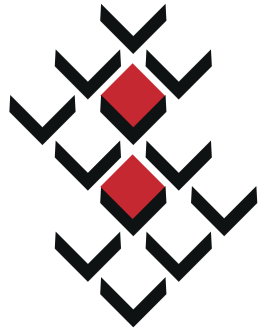
## ❖ The dimensional model is all about queries

The dimensional model is designed to make queries consistent, understandable, and fast. The dimensional model makes business data available to more users because query structure is less of a mystery.

## ❖ Understandable

In the dimensional model, data relationships are consistent and typically no more than one level deep. This makes the data structure more understandable for experts and casual users alike. It also facilitates documentation and meta-data set up.

Optimize the **end-user** experience.



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SAS® Training, Consulting, & Help Desk Services

(608) 278-9964

train@sys-seminar.com

[www.sys-seminar.com](http://www.sys-seminar.com)

2997 Yarmouth Greenway Drive

Madison, WI 53711

