Designing a Dimensional Model

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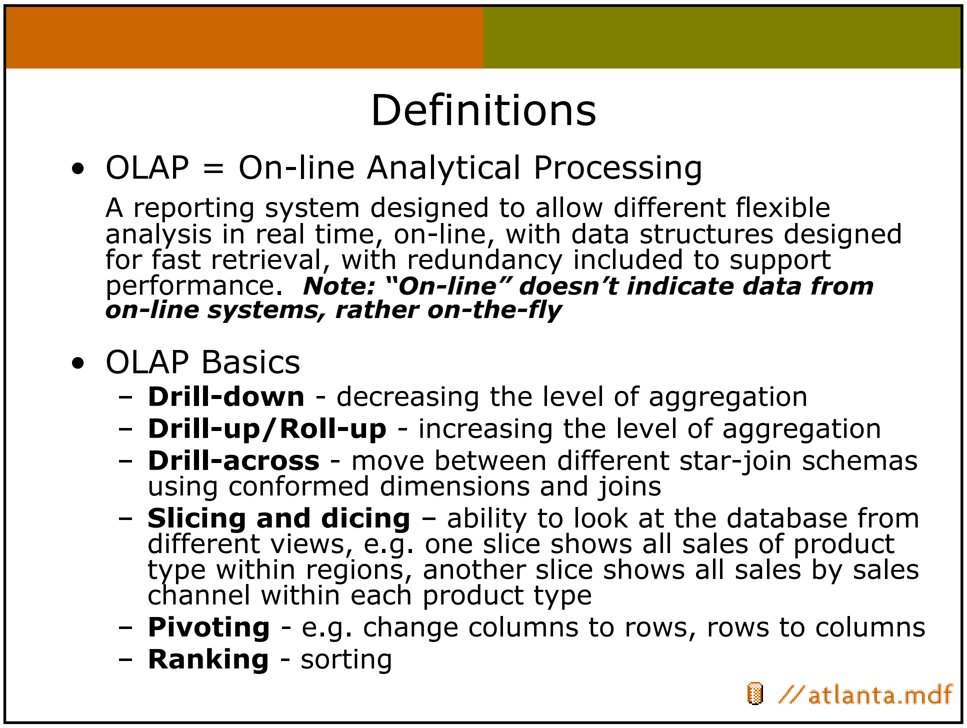
Definitions

- Data Warehousing

  A subject-oriented, integrated, time-variant, and nonvolatile collection of data in support of decision-making process.

- Data Marts
- **R. Kimball -** "a data mart is a flexible set of data, ideally based on the most atomic (granular) data possible to extract from operational source, and presented in a symmetric (dimensional) model that is resilient when faced with unexpected user queries"
- "in its most simplistic form a data mart represent data from a single business process"
  Business process = purchase order, store inventory, etc

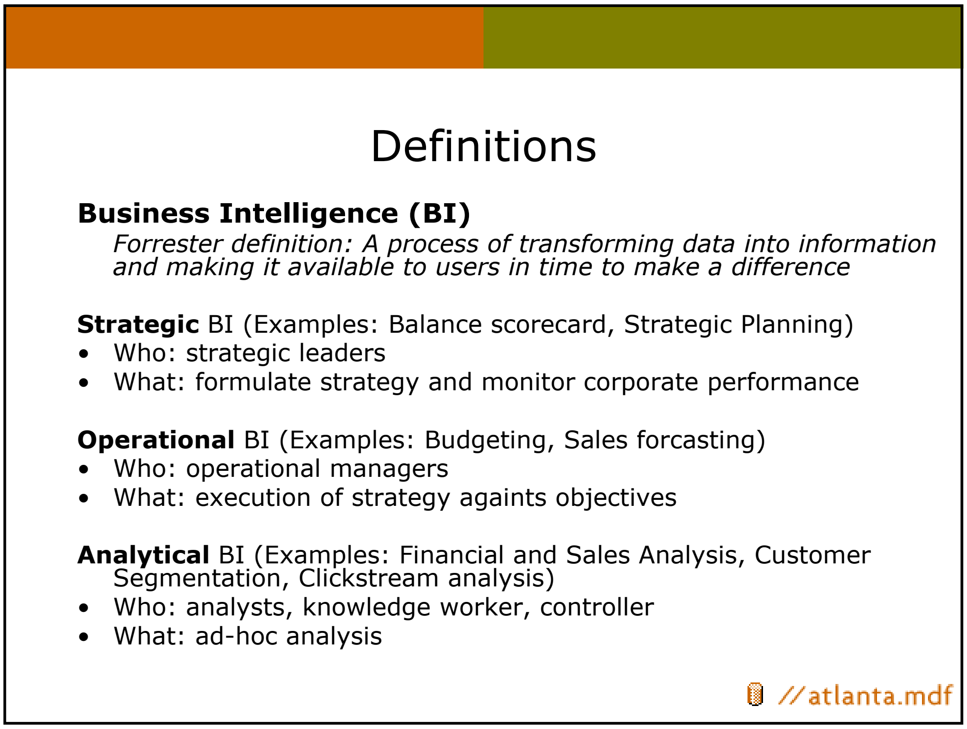


Definitions

- OLAP = On-line Analytical Processing

  A reporting system designed to allow different flexible analysis in real time, on-line, with data structures designed for fast retrieval, with redundancy included to support performance. ***Note: "On-line" doesn't indicate data from on-line systems, rather on-the-fly***

- OLAP Basics
  - **Drill-down** - decreasing the level of aggregation
  - **Drill-up/Roll-up** - increasing the level of aggregation
  - **Drill-across** - move between different star-join schemas using conformed dimensions and joins
  - **Slicing and dicing** – ability to look at the database from different views, e.g. one slice shows all sales of product type within regions, another slice shows all sales by sales channel within each product type
  - **Pivoting** - e.g. change columns to rows, rows to columns
  - **Ranking** - sorting



Definitions

Business Intelligence (BI)

Forrester definition: A process of transforming data into information and making it available to users in time to make a difference

Strategic BI (Examples: Balance scorecard, Strategic Planning)
- Who: strategic leaders
- What: formulate strategy and monitor corporate performance

Operational BI (Examples: Budgeting, Sales forcasting)
- Who: operational managers
- What: execution of strategy againts objectives

Analytical BI (Examples: Financial and Sales Analysis, Customer Segmentation, Clickstream analysis)
- Who: analysts, knowledge worker, controller
- What: ad-hoc analysis

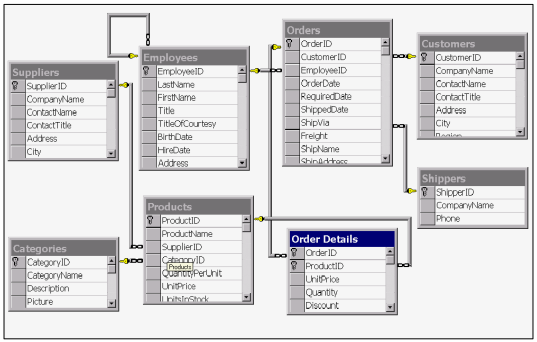
THE Definition

- Dimensional Modeling

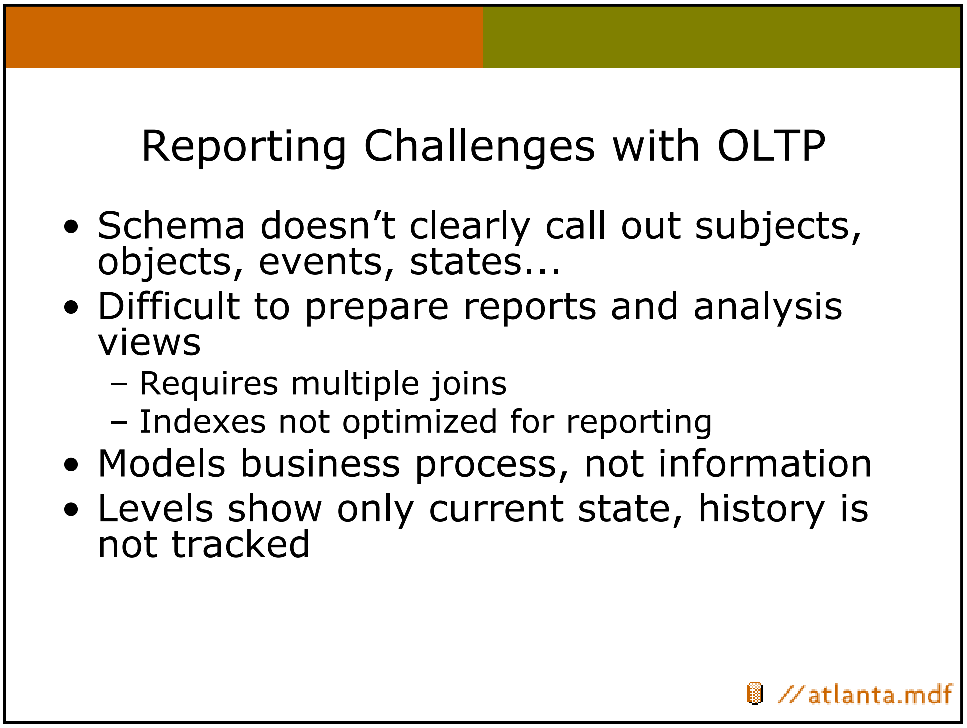
  The process and outcome of designing logical database schemas created to support OLAP and Data Warehousing solutions

Transactional System Emphasis

- OLTP = On Line Transactional Processing
  - Each transaction must be written to the database in real time, i.e. “on line”

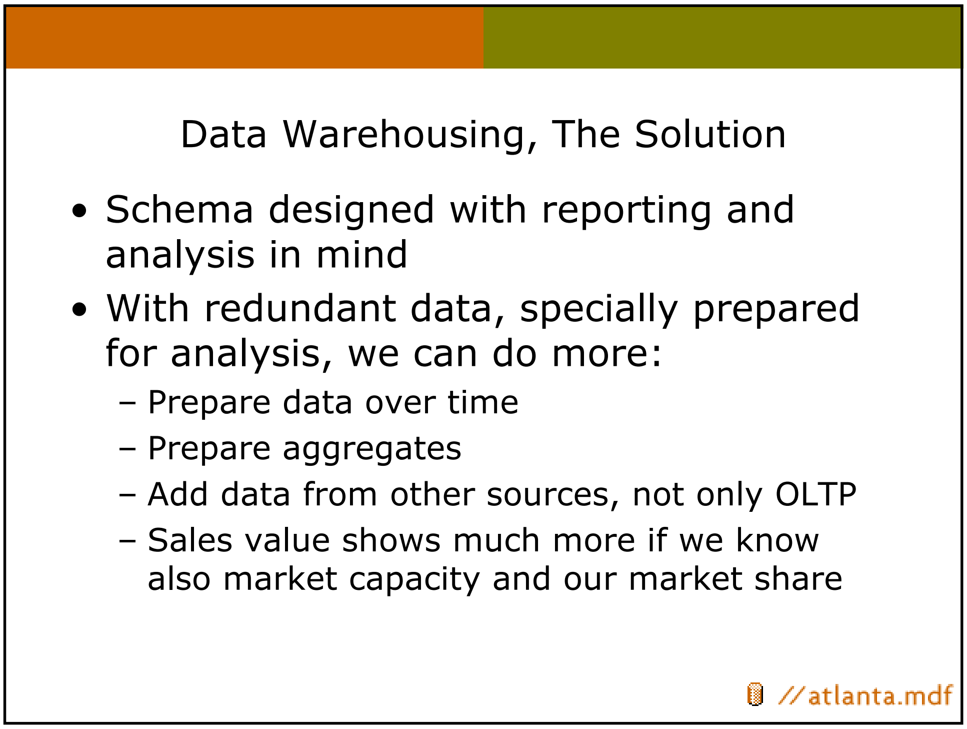


- Data structures must enable consistent and fast writing
  - The best consistency and speed can be achieved if each piece of data is written only once
  - Normalized (netlike) relational schema suits these requests



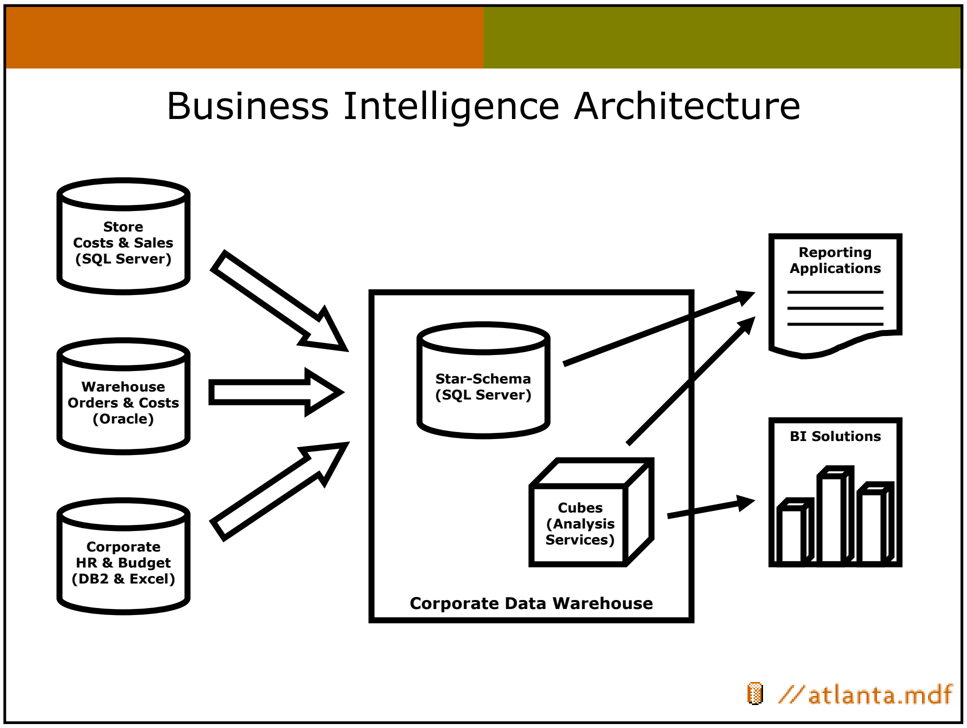
Reporting Challenges with OLTP

- Schema doesn’t clearly call out subjects, objects, events, states...
- Difficult to prepare reports and analysis views
  - Requires multiple joins
  - Indexes not optimized for reporting
- Models business process, not information
- Levels show only current state, history is not tracked



Data Warehousing, The Solution

- Schema designed with reporting and analysis in mind
- With redundant data, specially prepared for analysis, we can do more:
  - Prepare data over time
  - Prepare aggregates
  - Add data from other sources, not only OLTP
  - Sales value shows much more if we know also market capacity and our market share



Business Intelligence Architecture

Store Costs & Sales (SQL Server)

Warehouse Orders & Costs (Oracle)

Corporate HR & Budget (DB2 & Excel)

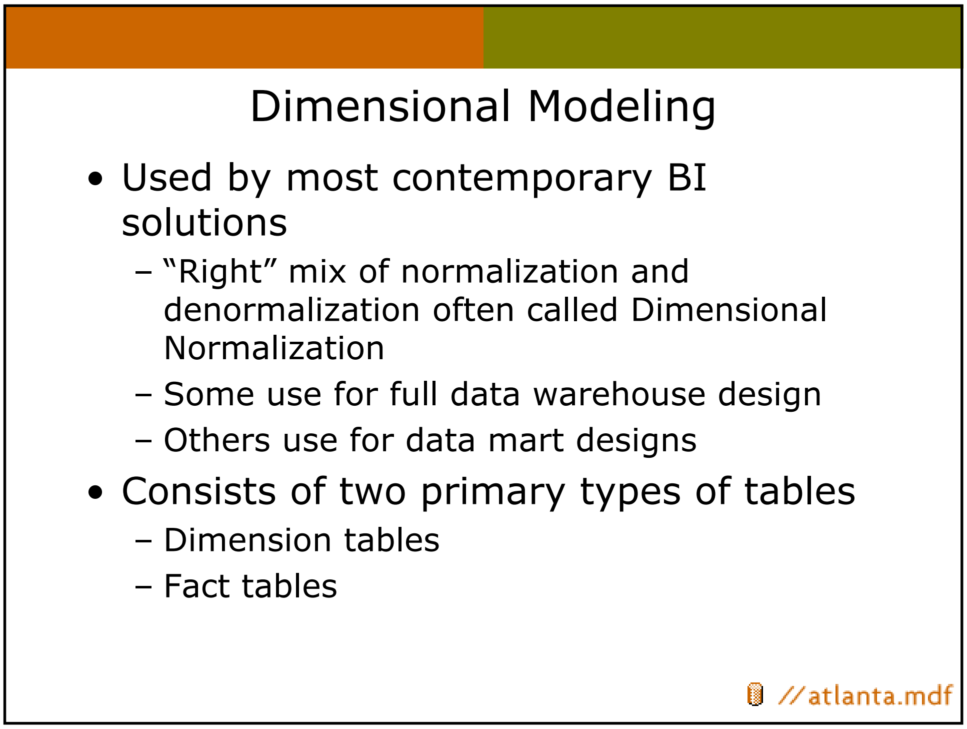
Star-Schema (SQL Server)

Cubes (Analysis Services)

Corporate Data Warehouse

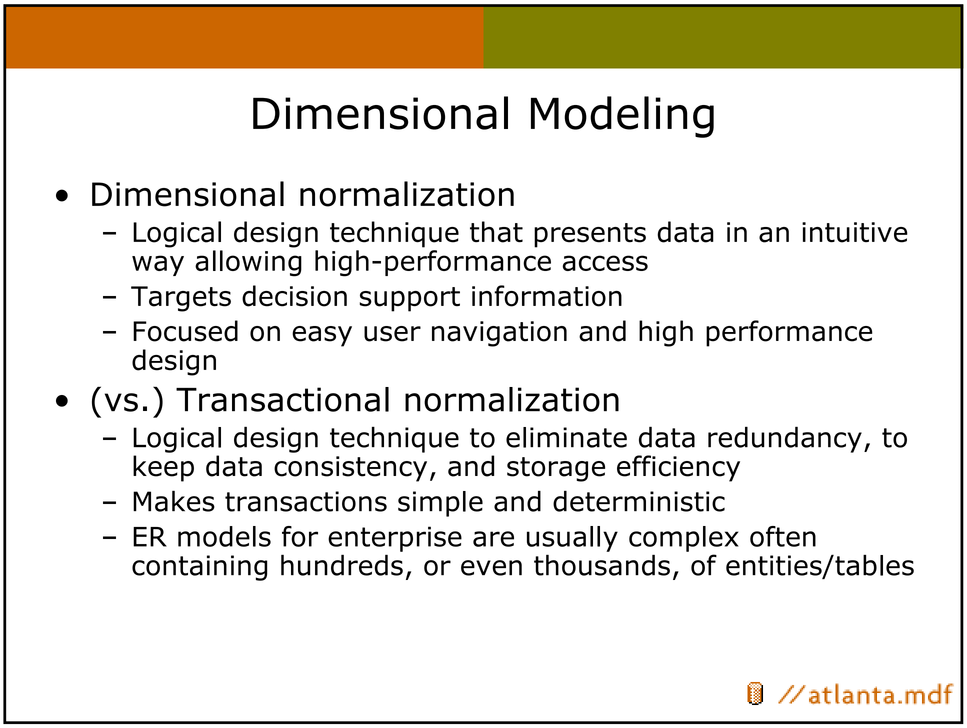
Reporting Applications

BI Solutions



Dimensional Modeling

- Used by most contemporary BI solutions
  - “Right” mix of normalization and denormalization often called Dimensional Normalization
  - Some use for full data warehouse design
  - Others use for data mart designs
- Consists of two primary types of tables
  - Dimension tables
  - Fact tables



Dimensional Modeling

- Dimensional normalization
  - Logical design technique that presents data in an intuitive way allowing high-performance access
  - Targets decision support information
  - Focused on easy user navigation and high performance design
- (vs.) Transactional normalization
  - Logical design technique to eliminate data redundancy, to keep data consistency, and storage efficiency
  - Makes transactions simple and deterministic
  - ER models for enterprise are usually complex often containing hundreds, or even thousands, of entities/tables

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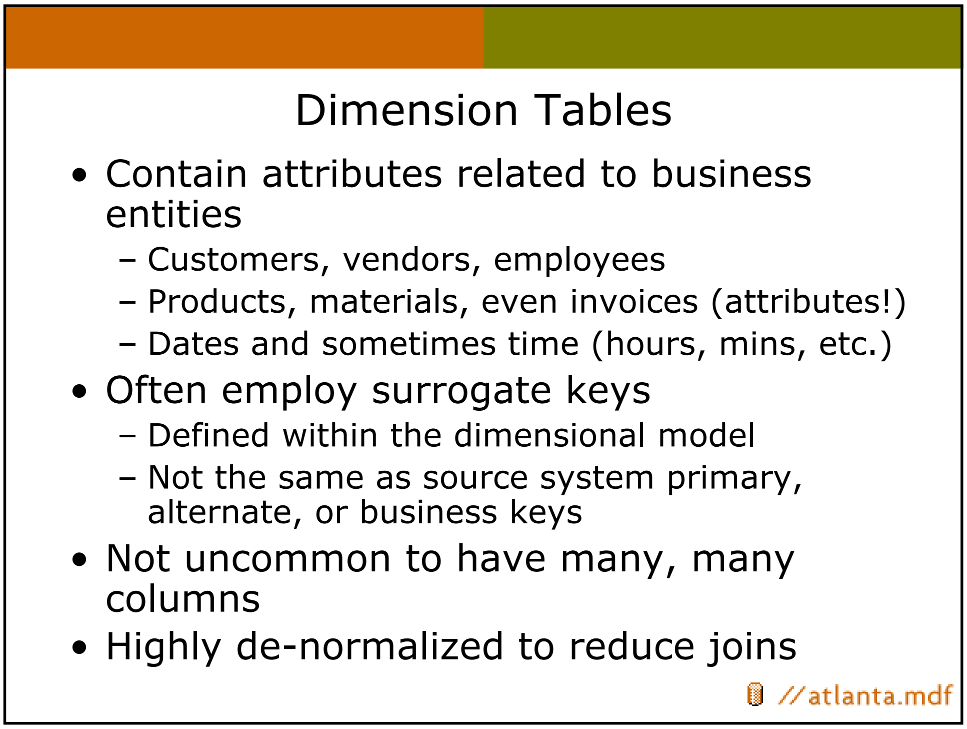

Dimension Tables

- Contain attributes related to business entities
  - Customers, vendors, employees
  - Products, materials, even invoices (attributes!)
  - Dates and sometimes time (hours, mins, etc.)
- Often employ surrogate keys
  - Defined within the dimensional model
  - Not the same as source system primary, alternate, or business keys
- Not uncommon to have many, many columns
- Highly de-normalized to reduce joins

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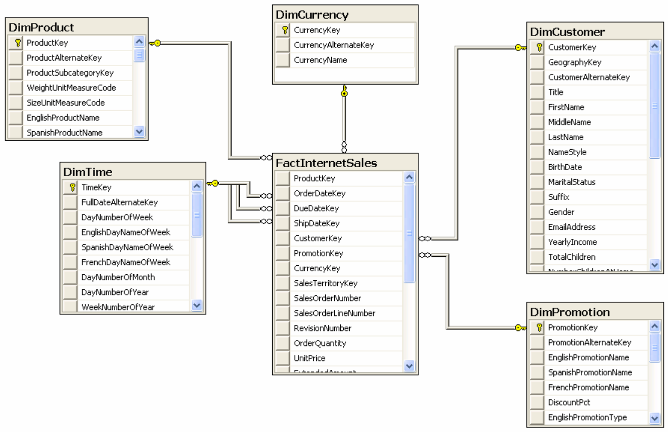
Fact Tables

- Contain numbers and other business metrics
  - Define the basic measures users want to analyze
  - Numbers are then aggregated according to related dimensions
- Fact tables contain dimension keys
  - Defines relationship between measures and dimensions using surrogate keys
- Typically narrow tables, but often very large
- Highly normalized structure

Dimensional Model Example



DimProduct
- ProductKey
- ProductAlternateKey
- ProductSubcategoryKey
- WeightUnitMeasureCode
- SizeUnitMeasureCode
- EnglishProductName
- SpanishProductName

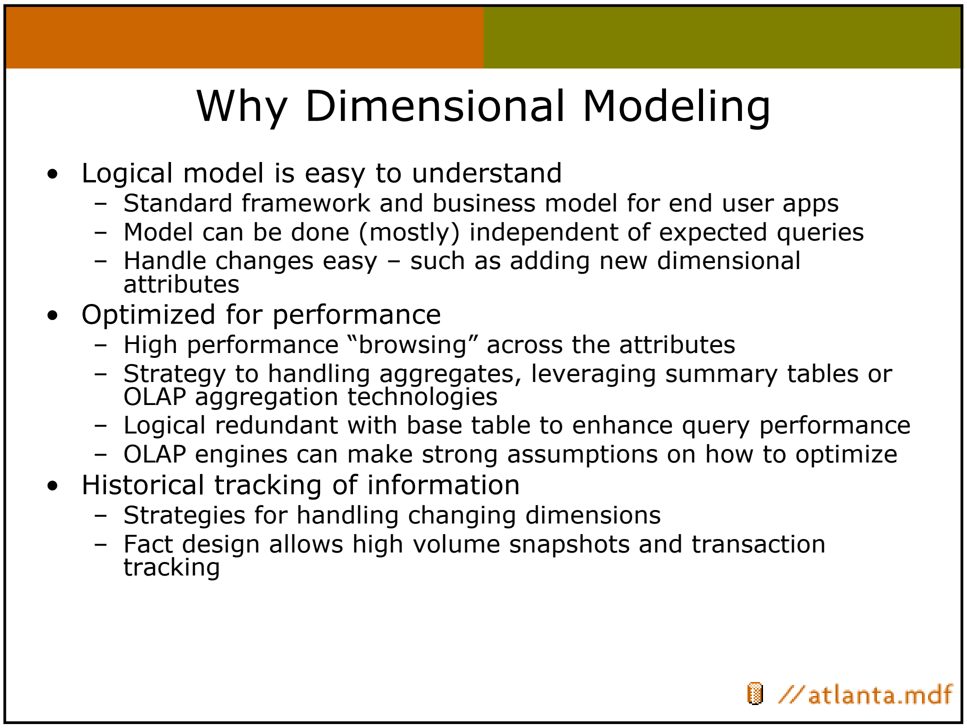
DimCurrency
- CurrencyKey
- CurrencyAlternateKey
- CurrencyName

DimCustomer
- CustomerKey
- GeographyKey
- CustomerAlternateKey
- Title
- FirstName
- MiddleName
- LastName
- NameStyle
- BirthDate
- MaritalStatus
- Suffix
- Gender
- EmailAddress
- YearlyIncome
- TotalChildren

DimTime
- TimeKey
- FullDateAlternateKey
- DayNumberOfWeek
- EnglishDayNameOfWeek
- SpanishDayNameOfWeek
- FrenchDayNameOfWeek
- DayNumberOfMonth
- DayNumberOfYear
- WeekNumberOfYear

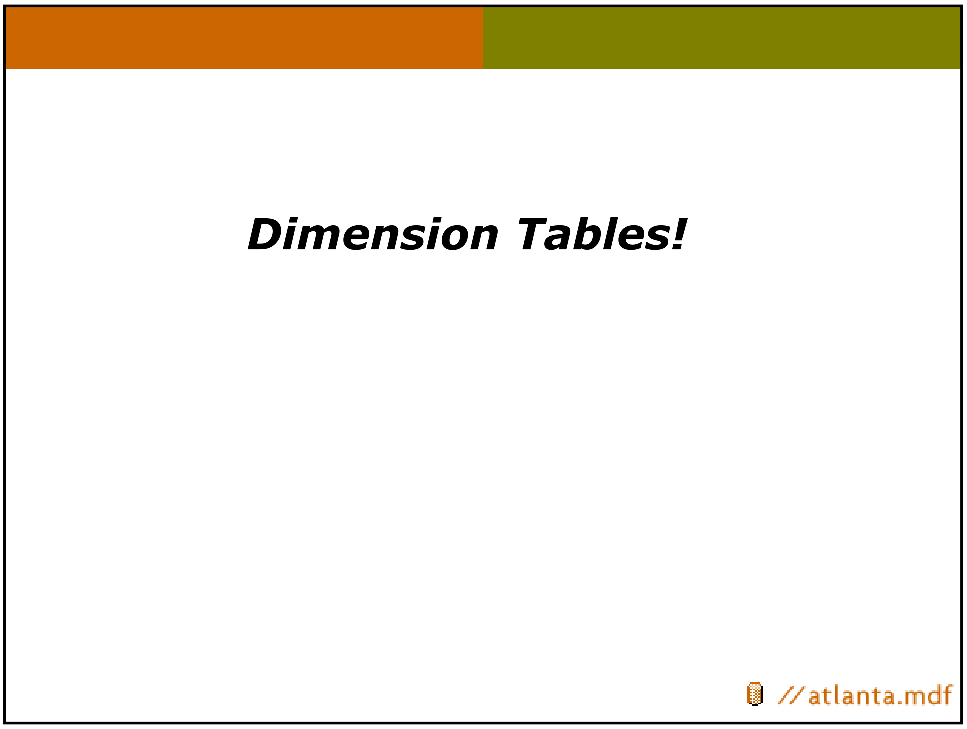
FactInternetSales
- ProductKey
- OrderDateKey
- DueDateKey
- ShipDateKey
- CustomerKey
- PromotionKey
- CurrencyKey
- SalesTerritoryKey
- SalesOrderNumber
- SalesOrderLineNumber
- RevisionNumber
- OrderQuantity
- UnitPrice

DimPromotion
- PromotionKey
- PromotionAlternateKey
- EnglishPromotionName
- SpanishPromotionName
- FrenchPromotionName
- DiscountPct
- EnglishPromotionType



Why Dimensional Modeling

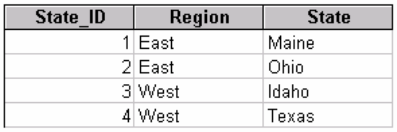
- Logical model is easy to understand
  - Standard framework and business model for end user apps
  - Model can be done (mostly) independent of expected queries
  - Handle changes easy – such as adding new dimensional attributes
- Optimized for performance
  - High performance “browsing” across the attributes
  - Strategy to handling aggregates, leveraging summary tables or OLAP aggregation technologies
  - Logical redundant with base table to enhance query performance
  - OLAP engines can make strong assumptions on how to optimize
- Historical tracking of information
  - Strategies for handling changing dimensions
  - Fact design allows high volume snapshots and transaction tracking



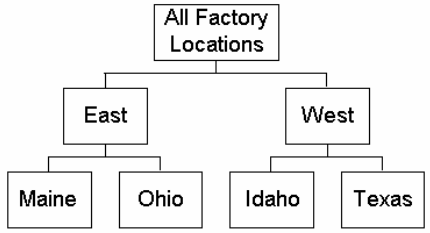
Dimension Tables!

Dimensions

- Organized hierarchies of categories, levels, and members
- Used to “slice” and query within a cube
- Business perspective from which data is looked upon
- Collection of text attributes that are highly correlated (e.g. Product, Store, Time)
- Shared with multiple fact relationships to provides data correlation



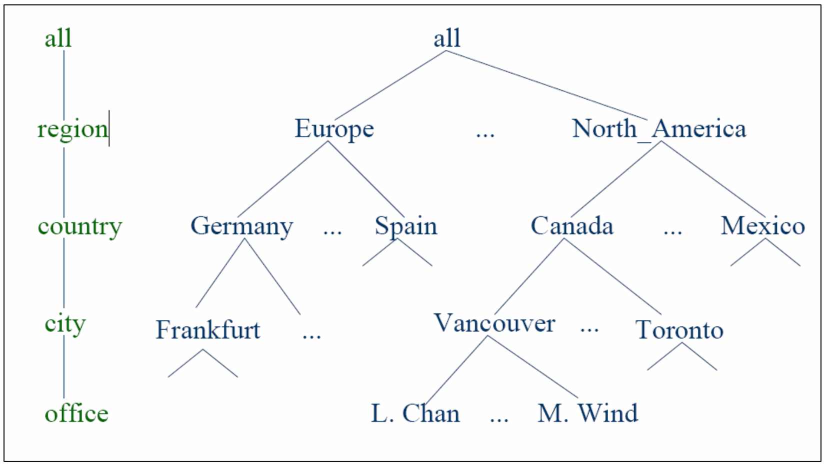
State_ID	Region	State
1	East	Maine
2	East	Ohio
3	West	Idaho
4	West	Texas



Dimension Details

- Attributes
  - Descriptive characteristics of an entity
  - Building blocks of dimensions, describe each instance
  - Usually text fields, with discrete values
  - e.g., the flavor of a product, the size of a product
- Dimension Keys
  - Surrogate Keys
  - Candidate Business Keys
- Dimension Granularity
  - Granularity in general is the level of detail of data contained in an entity
  - A dimensions granularity is the lowest level object which uniquely identifies a member
  - Typically the identifying name of a dimension

Hierarchies



Dimension Keys

- Dimension Business Key
  - Column or columns that identify a unique instance of the business record (not necessarily a unique record in the dimension table)
  - Used in the ETL process to tie fact records with dimension members
- Dimension Record Surrogate Key
  - Defines the dimension’s primary key
  - Relates to the fact table foreign key field
  - Numeric data type, typically integer (2,4,8 byte)

Dimension Surrogate Keys

- Surrogate Key Usage
  - Consolidates multi-value business keys
  - Allows tracking of dimension history
  - Standardizes dimension tables
  - Limits fact table width for optimization
- Surrogate Key Design Practices
  - Avoid smart keys
  - Avoid production keys (may change!)
  - the company may acquire a competitor and thereby change the key building rules changed record, but deliberately not changed key
  - Narrow as possible

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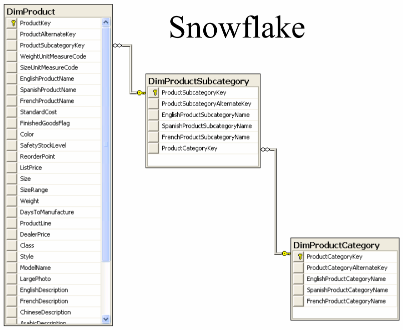
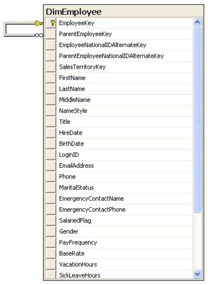
Dimensions Types

- Basic Dimension Types
  - Standard Star dimension
  - Snowflake dimension
  - Parent-Child dimensions
- Advanced Types
  - Degenerate
  - Profile or Junk dimensions
  - Role-playing and Outriggers


Snowflake



Parent-Child

Employee	Manager
The Board	<None>
SteveB	The Board
BillG	The Board
JimAll	SteveB
PaulMa	SteveB
BobMu	SteveB
TodN	PaulMa
DavidV	PaulMa
PaulFle	DavidV

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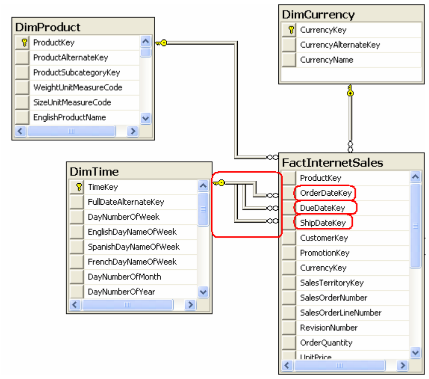
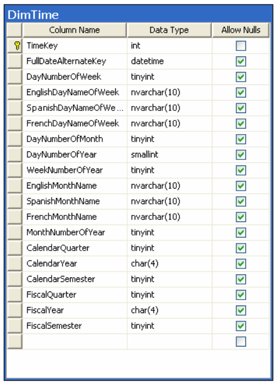
Role-Playing and Time Dimensions





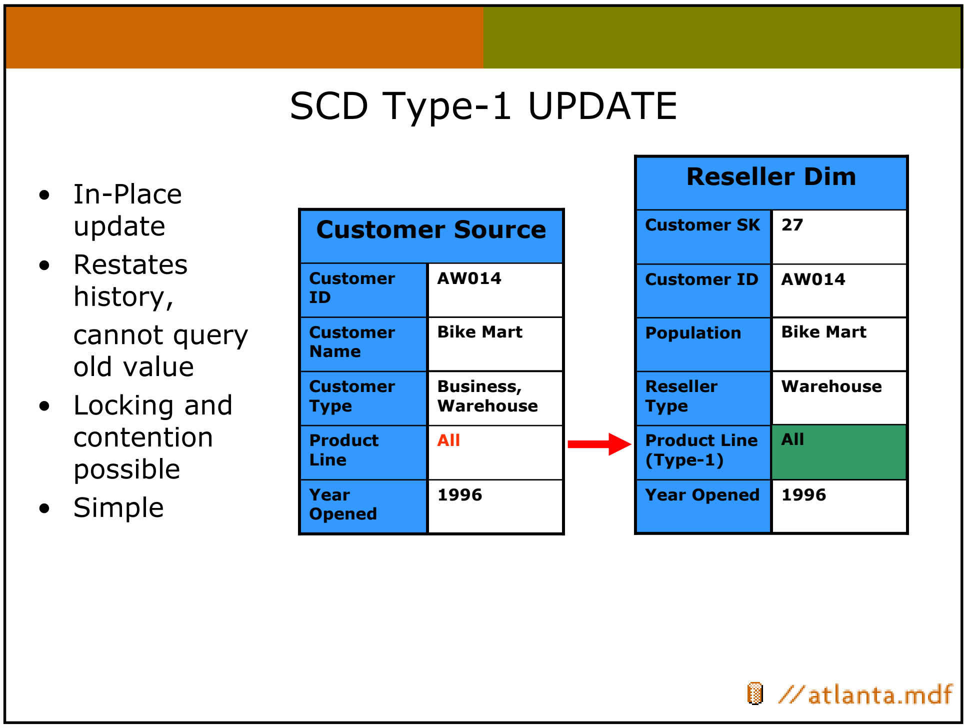
DimTime

Column Name	Data Type	Allow Nulls
TimeKey	int	□
FullDateAlternateKey	datetime	☑
DayNumberOfWeek	tinyint	☑
EnglishDayNameOfWeek	nvarchar(10)	☑
SpanishDayNameOfWe...	nvarchar(10)	☑
FrenchDayNameOfWeek	nvarchar(10)	☑
DayNumberOfMonth	tinyint	☑
DayNumberOfYear	smallint	☑
WeekNumberOfYear	tinyint	☑
EnglishMonthName	nvarchar(10)	☑
SpanishMonthName	nvarchar(10)	☑
FrenchMonthName	nvarchar(10)	☑
MonthNumberOfYear	tinyint	☑
CalendarQuarter	tinyint	☑
CalendarYear	char(4)	☑
CalendarSemester	tinyint	☑
FiscalQuarter	tinyint	☑
FiscalYear	char(4)	☑
FiscalSemester	tinyint	☑
		□

Changing Dimensions

- Problem known as “Slowly Changing Dimensions” (Ralph Kimball)

- Common changing types:
  0: No change.
  1: Not interested in the previous state. Overwrites value.
  2: Slow changes. Adds new row.
  3: Fast changes. Adds new column



SCD Type-1 UPDATE

- In-Place update
- Restates history, cannot query old value
- Locking and contention possible
- Simple

Customer Source	
Customer ID	AW014
Customer Name	Bike Mart
Customer Type	Business, Warehouse
Product Line	All
Year Opened	1996

→

Reseller Dim	
Customer SK	27
Customer ID	AW014
Population	Bike Mart
Reseller Type	Warehouse
Product Line (Type-1)	All
Year Opened	1996

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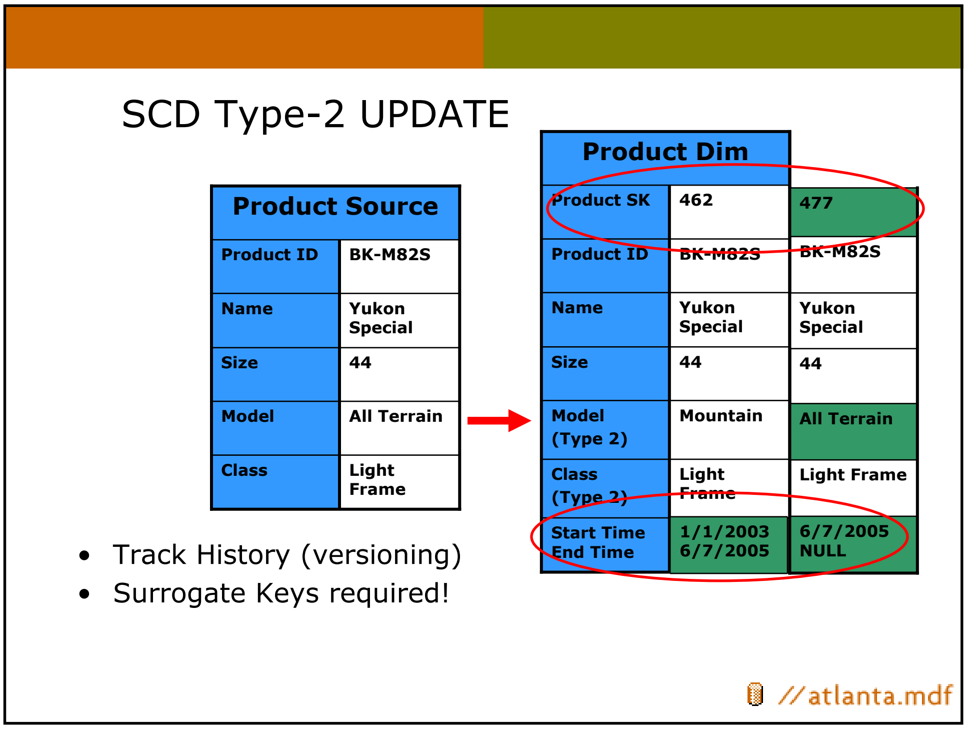

SCD Type-2 UPDATE

Product Source	
Product ID	BK-M82S
Name	Yukon Special
Size	44
Model	All Terrain
Class	Light Frame

→

Product Dim		
Product SK	462	477
Product ID	BK-M82S	BK-M82S
Name	Yukon Special	Yukon Special
Size	44	44
Model (Type 2)	Mountain	All Terrain
Class (Type 2)	Light Frame	Light Frame
Start Time End Time	1/1/2003 6/7/2005	6/7/2005 NULL

- Track History (versioning)
- Surrogate Keys required!

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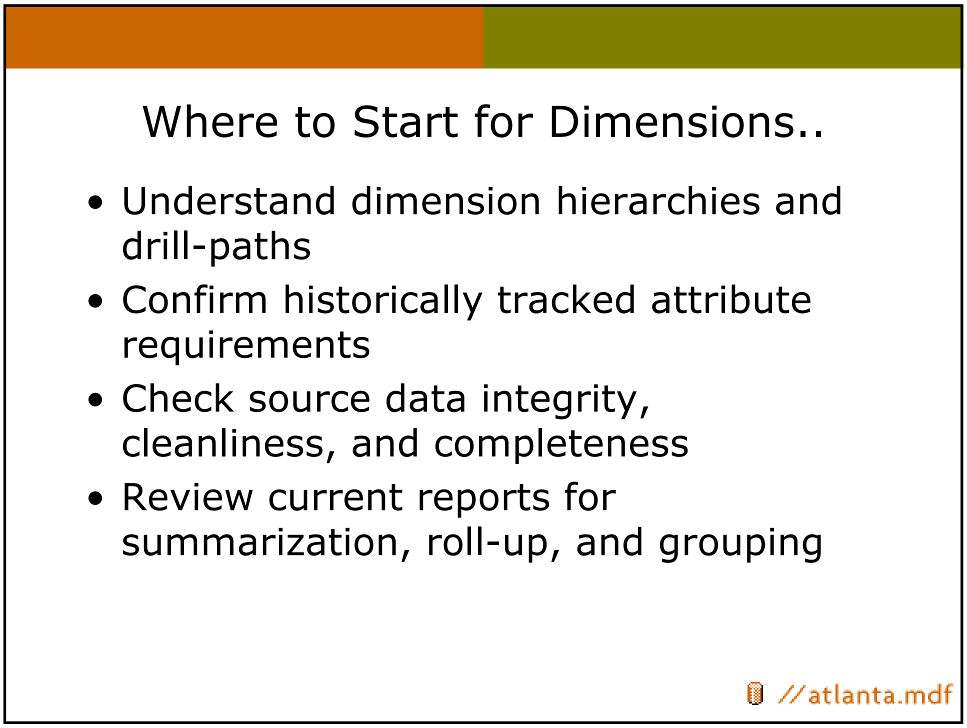

Where to Start for Dimensions..

- Understand dimension hierarchies and drill-paths
- Confirm historically tracked attribute requirements
- Check source data integrity, cleanliness, and completeness
- Review current reports for summarization, roll-up, and grouping

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Fact Tables!

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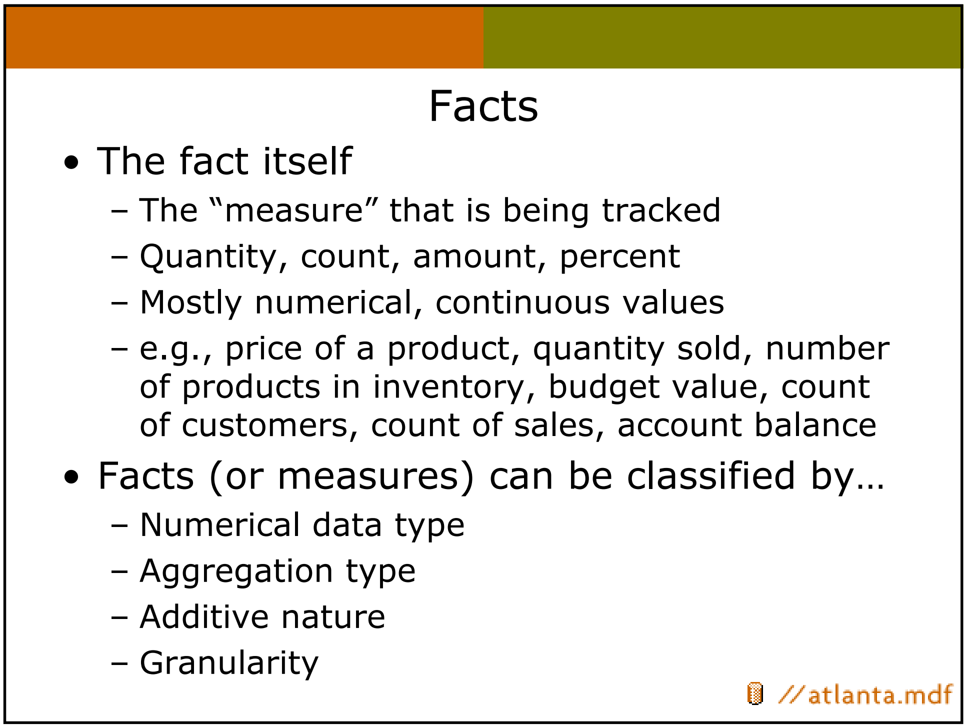

Facts

- The fact itself
  - The "measure" that is being tracked
  - Quantity, count, amount, percent
  - Mostly numerical, continuous values
  - e.g., price of a product, quantity sold, number of products in inventory, budget value, count of customers, count of sales, account balance
- Facts (or measures) can be classified by…
  - Numerical data type
  - Aggregation type
  - Additive nature
  - Granularity

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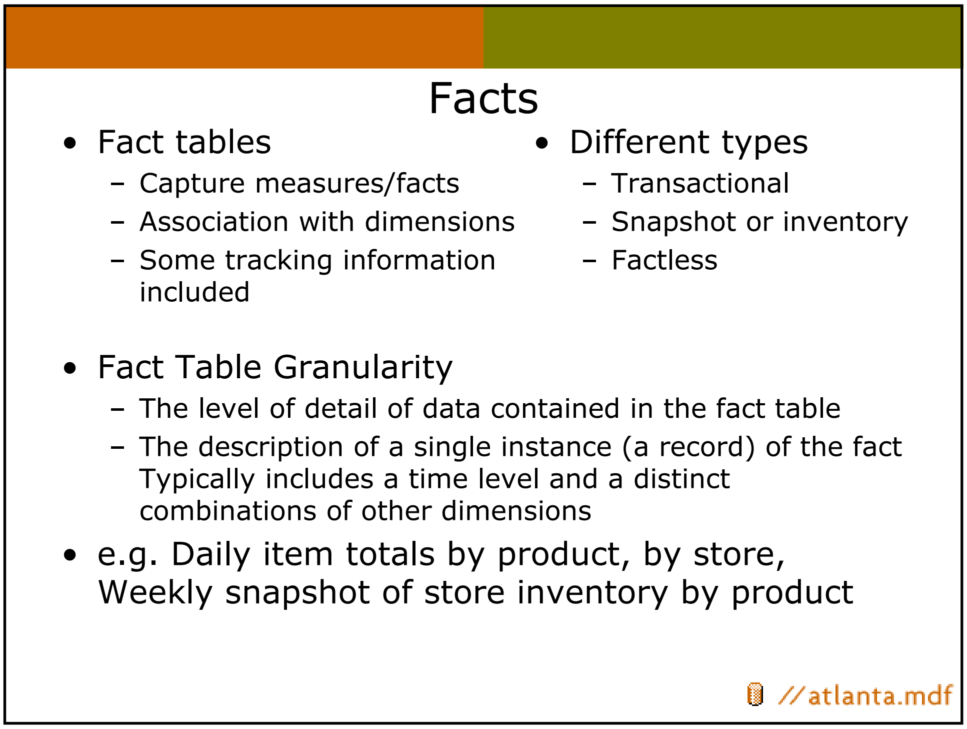

Facts

- Fact tables
  - Capture measures/facts
  - Association with dimensions
  - Some tracking information included
- Different types
  - Transactional
  - Snapshot or inventory
  - Factless
- Fact Table Granularity
  - The level of detail of data contained in the fact table
  - The description of a single instance (a record) of the fact Typically includes a time level and a distinct combinations of other dimensions
- e.g. Daily item totals by product, by store, Weekly snapshot of store inventory by product

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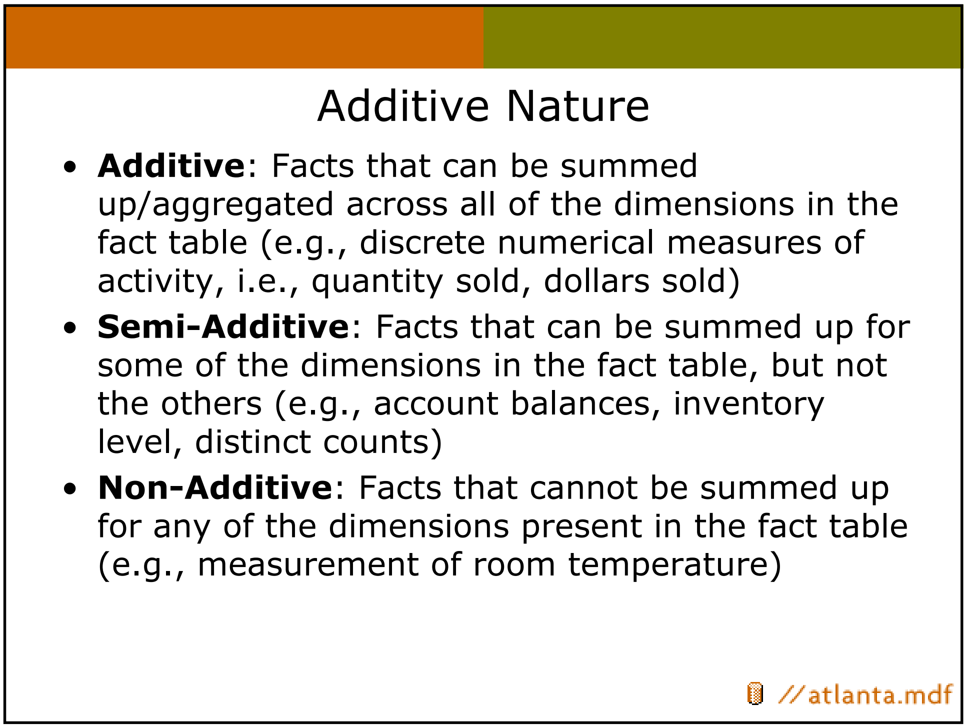
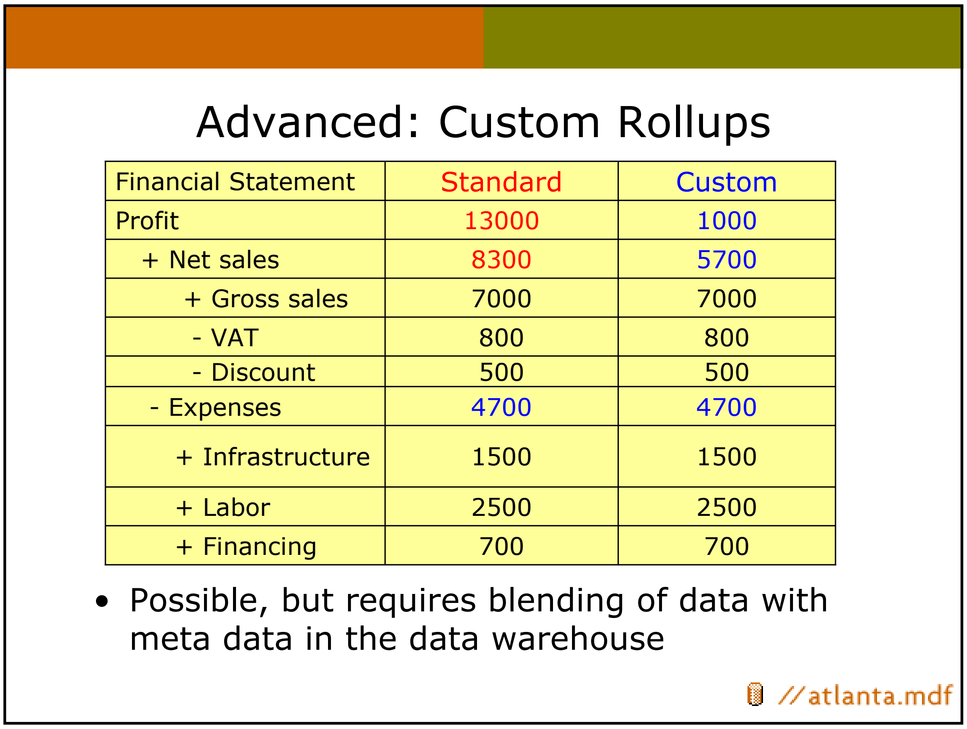


Additive Nature

- **Additive**: Facts that can be summed up/aggregated across all of the dimensions in the fact table (e.g., discrete numerical measures of activity, i.e., quantity sold, dollars sold)
- **Semi-Additive**: Facts that can be summed up for some of the dimensions in the fact table, but not the others (e.g., account balances, inventory level, distinct counts)
- **Non-Additive**: Facts that cannot be summed up for any of the dimensions present in the fact table (e.g., measurement of room temperature)



Advanced: Custom Rollups

Financial Statement	Standard	Custom
Profit	13000	1000
+ Net sales	8300	5700
+ Gross sales	7000	7000
- VAT	800	800
- Discount	500	500
- Expenses	4700	4700
+ Infrastructure	1500	1500
+ Labor	2500	2500
+ Financing	700	700

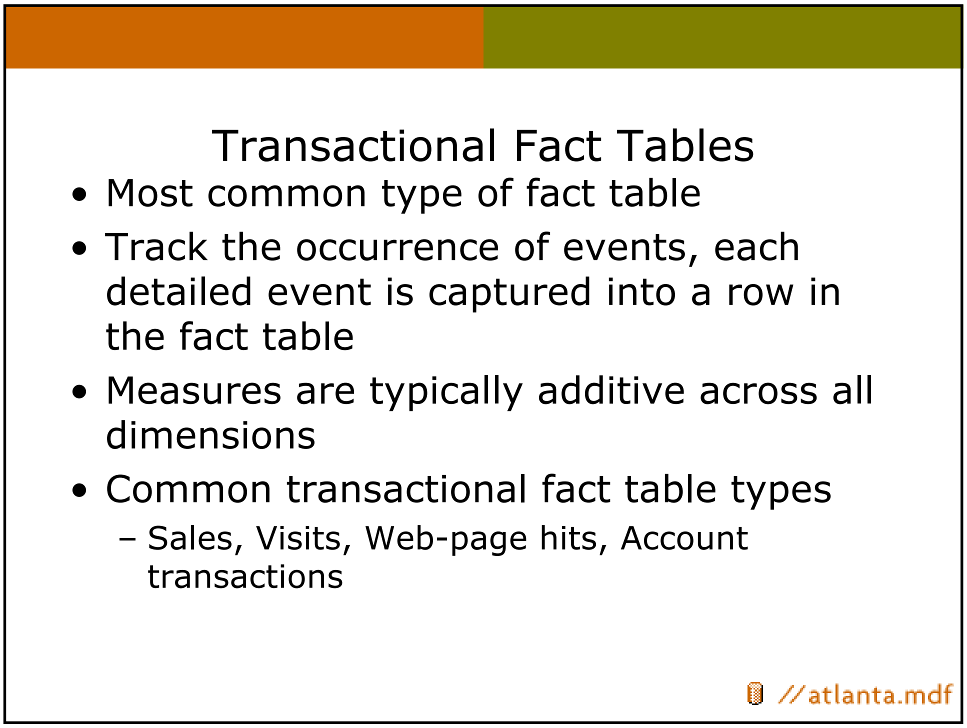
- Possible, but requires blending of data with meta data in the data warehouse

Aggregations (Aggs)

- A summarization of base-level fact table records
- Aggregations need to account for the additive nature of the measures, created on-the-fly or by pre-aggregation
- Common aggregation scenarios
  - Category product aggs by store by day
  - District store aggs by product by day
  - Monthly sales aggs by product by store
  - Category product aggs by store district by day
- Common aggregations = Sum, Count, Distinct Count, Max, Min, Average, Semi-additive (Last Child, Last Non-empty Child)

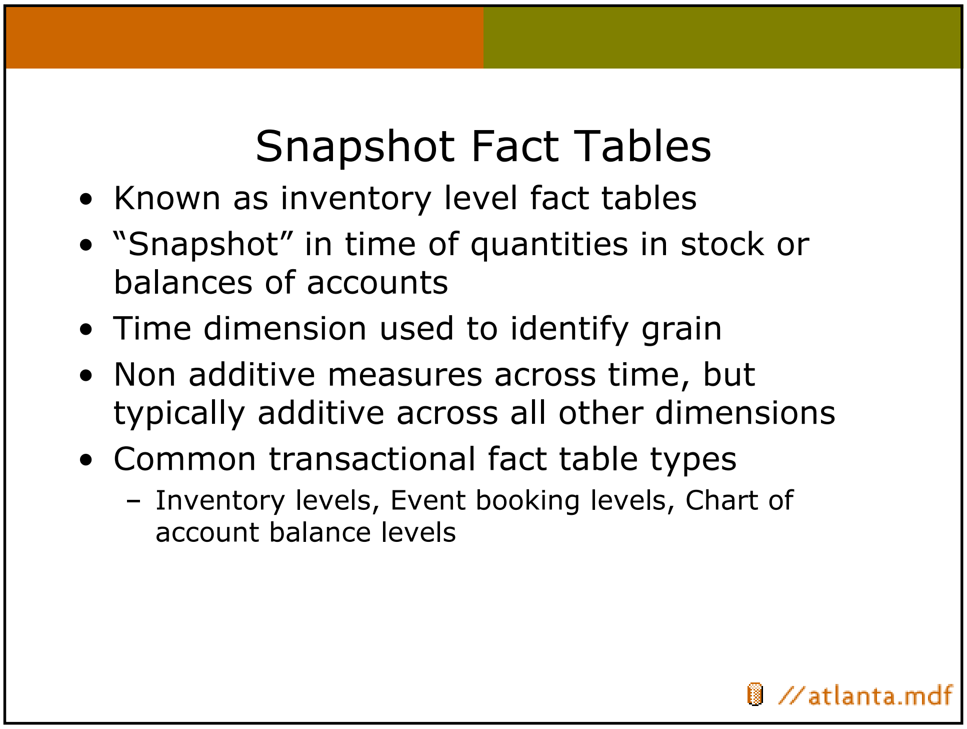
Fact Table Types

- Different types of fact tables
  - **Transactional** – Additive facts tracking events over time
  - **Snapshot or inventory** – Pictures in time of levels or balances
  - **Factless** – Dimensionality relationships
  - **Combinations!**



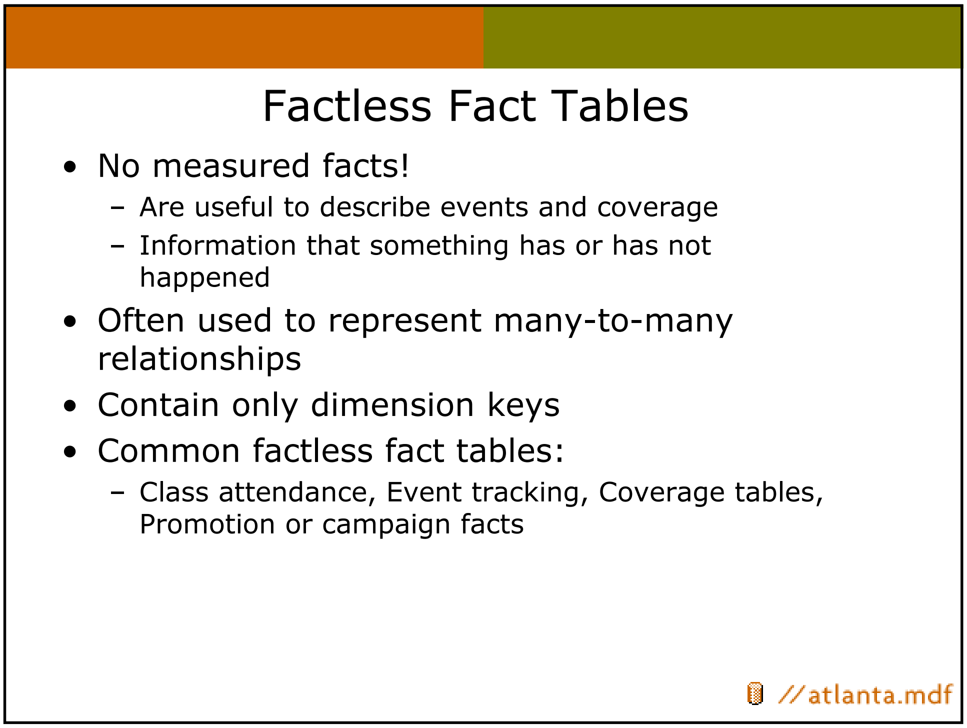
Transactional Fact Tables

- Most common type of fact table
- Track the occurrence of events, each detailed event is captured into a row in the fact table
- Measures are typically additive across all dimensions
- Common transactional fact table types
  - Sales, Visits, Web-page hits, Account transactions



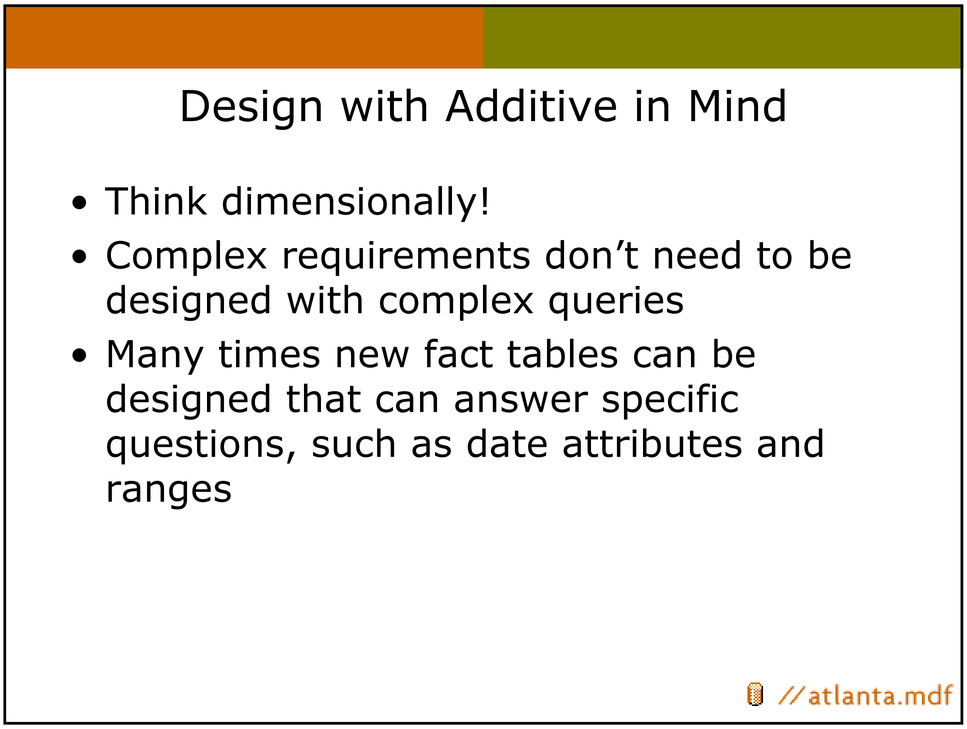
Snapshot Fact Tables

- Known as inventory level fact tables
- “Snapshot” in time of quantities in stock or balances of accounts
- Time dimension used to identify grain
- Non additive measures across time, but typically additive across all other dimensions
- Common transactional fact table types
  - Inventory levels, Event booking levels, Chart of account balance levels



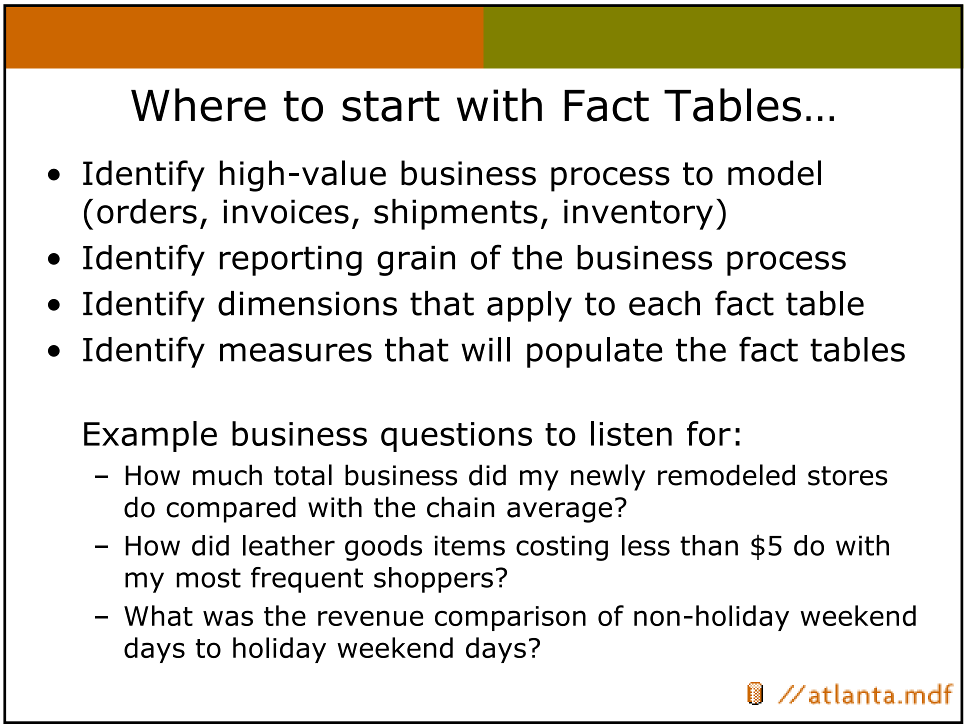
Factless Fact Tables

- No measured facts!
  - Are useful to describe events and coverage
  - Information that something has or has not happened
- Often used to represent many-to-many relationships
- Contain only dimension keys
- Common factless fact tables:
  - Class attendance, Event tracking, Coverage tables, Promotion or campaign facts



Design with Additive in Mind

- Think dimensionally!
- Complex requirements don’t need to be designed with complex queries
- Many times new fact tables can be designed that can answer specific questions, such as date attributes and ranges

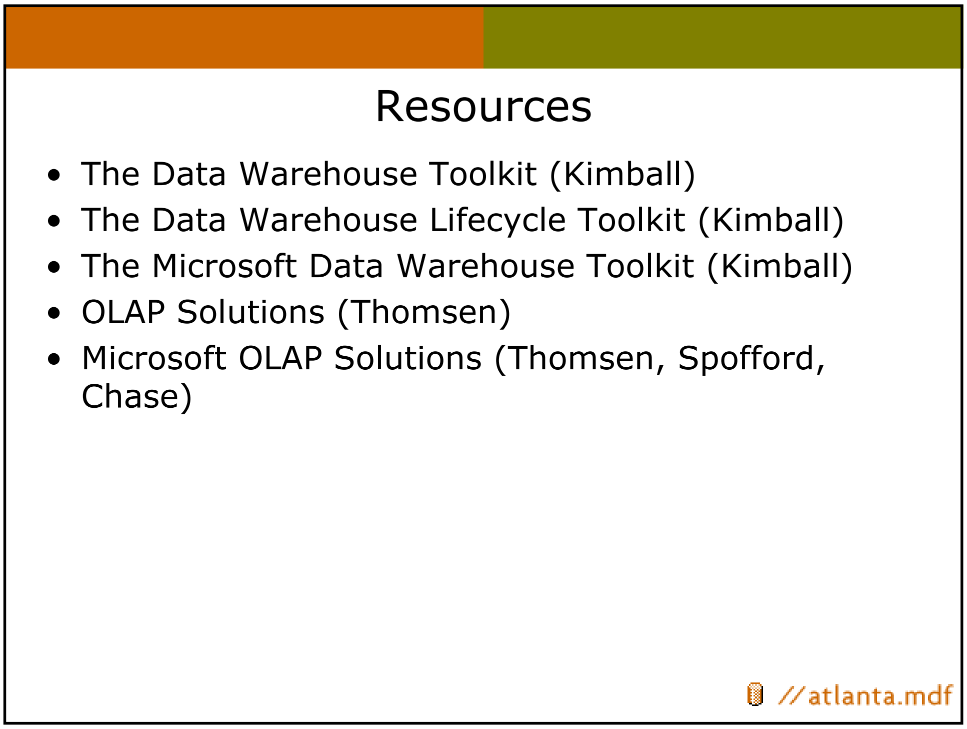


Where to start with Fact Tables…

- Identify high-value business process to model (orders, invoices, shipments, inventory)
- Identify reporting grain of the business process
- Identify dimensions that apply to each fact table
- Identify measures that will populate the fact tables

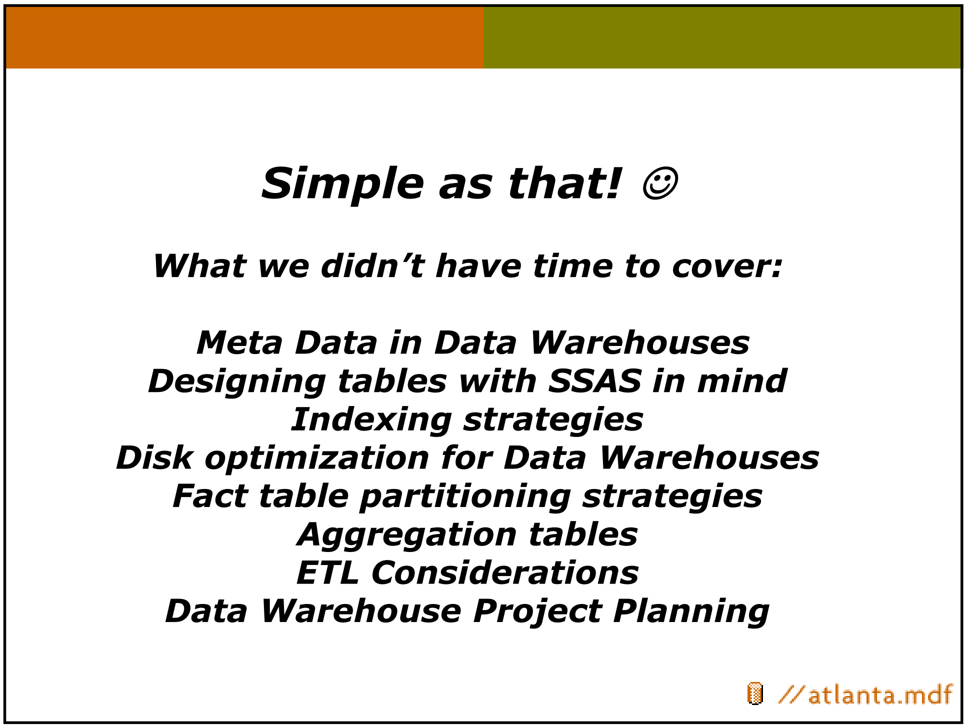
Example business questions to listen for:

- How much total business did my newly remodeled stores do compared with the chain average?
- How did leather goods items costing less than $5 do with my most frequent shoppers?
- What was the revenue comparison of non-holiday weekend days to holiday weekend days?



Resources

- The Data Warehouse Toolkit (Kimball)
- The Data Warehouse Lifecycle Toolkit (Kimball)
- The Microsoft Data Warehouse Toolkit (Kimball)
- OLAP Solutions (Thomsen)
- Microsoft OLAP Solutions (Thomsen, Spofford, Chase)



Simple as that! ☺

What we didn't have time to cover:

Meta Data in Data Warehouses
Designing tables with SSAS in mind
Indexing strategies
Disk optimization for Data Warehouses
Fact table partitioning strategies
Aggregation tables
ETL Considerations
Data Warehouse Project Planning

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