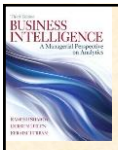

Chapter 2: Data Warehousing

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Learning Objectives

- Understand the basic definitions and concepts of data warehouses
- Learn different types of data warehousing architectures; their comparative advantages and disadvantages
- Describe the processes used in developing and managing data warehouses
- Explain data warehousing operations

(Continued…)

Learning Objectives

- Explain the role of data warehouses in decision support
- Explain data integration and the extraction, transformation, and load (ETL) processes
- Describe real-time (a.k.a. right-time and/or active) data warehousing
- Understand data warehouse administration and security issues

Opening Vignette…

Isle of Capri Casinos Is Winning with Enterprise Data Warehouse

- Company background
- Problem description
- Proposed solution
- Results
- Answer & discuss the case questions.

Questions for the Opening Vignette

1. Why is it important for Isle to have an EDW?
2. What were the business challenges or opportunities that Isle was facing?
3. What was the process Isle followed to realize EDW? Comment on the potential challenges Isle might have had going through the process of EDW development.
4. What were the benefits of implementing an EDW at Isle? Can you think of other potential benefits that were not listed in the case?
5. Why do you think large enterprises like Isle in the gaming industry can succeed without having a capable data warehouse/business intelligence infrastructure?

- ***1. Why is it important for Isle to have an EDW?***
-
- In the gaming industry, companies distinguish themselves based on their customer relationships. An enterprise data warehouse (EDW) gathers and provides the data needed to tell Isle of Capri what customers respond to, so the casinos can adapt their offerings.
- The information provided by the EDW lets Isle deepen its understanding of customers, so it can efficiently give them more of the kinds of entertainment they are looking for.

- ***2. What were the business challenges or opportunities that Isle was facing?***
-
- Isle of Capri Casinos is one of the largest publicly traded gaming companies in the United States, but the gaming business is competitive. Other casinos offer essentially the same games, so Isle must find ways to make its entertainment and hospitality atmosphere one that exceeds customer expectations. Before Isle implemented the EDW, casino managers had to wait to review monthly data until the second week of the following month.
- The time lag made it difficult for casinos to identify what actions were appealing to customers in time to respond. Adding to these business challenges, Hurricane Katrina set back initial efforts to set up a data warehouse at the southeastern company.

- ***3. What was the process Isle followed to realize EDW? Comment on the potential challenges Isle might have had going through the process of EDW development.***
-
- Isle of Capri brought in two expert suppliers. Teradata provided the core solution; IBM Cognos provided expertise in business intelligence. Isle hired a management team that understood how EDW could support decision making at Isle.
- That team would be able to help Isle's managers with the challenge of understanding how they can frame queries and follow-up questions to figure out ways to improve the business. Most likely, the potential of using detailed, up-to-the-minute data would be unfamiliar to many of these managers.

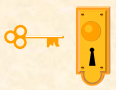
- ***4. What were the benefits of implementing an EDW at Isle? Can you think of other potential benefits that were not listed in the case?***
-
- The implementation of EDW brought several benefits related to the timeliness and detail of the data that became available. Instead of five week-old monthly reports, managers can now study a variety of daily, weekly, and monthly reports. The reports segment data by particular properties and customer groups, so managers can zero in on particular problems and successes, easily making comparisons among properties.
- Managers can submit queries about data sets and receive information within minutes. In this way, managers can find out how particular promotions are affecting customer behavior at particular casinos. The EDW also connects data about casino activity with data about customers' use of hotels and efforts by Isle's hosts. This, too, helps the company target promotions and offer customers incentives they value. Even decisions as detailed as where to locate slot machines can be adjusted to boost profits based on data from the EDW.

- ***5. Why do you think large enterprises like Isle in the gaming industry can succeed without having a capable data warehouse/business intelligence infrastructure?***
-
- In the past, businesses in the gaming industry could succeed without a capable data warehouse/business intelligence infrastructure because their managers knew as much about customers as their competitors' management knew.
- They were all testing ideas for promotion or entertainment and responding to customer behavior at about the same pace. However, when one company such as Isle begins to respond to daily, property-by-property data, choosing the marketing and entertainment options that deliver exactly what most profitably lures customers, competitors without that capability will soon begin to suffer.

Main Data Warehousing Topics

- DW definition
- Characteristics of DW
- Data Marts
- ODS, EDW, Metadata
- DW Framework
- DW Architecture & ETL Process
- DW Development
- DW Issues

Key Fields



- Keys are special fields that serve two main purposes:
  - ***Primary keys*** are unique identifiers of the relation. Examples include employee numbers, social security numbers, etc. *This guarantees that all rows are unique.*
  - ***Foreign keys*** are identifiers that enable a dependent relation (on the many side of a relationship) to refer to its parent relation (on the one side of the relationship).
- Keys can be ***simple*** (a single field) or ***composite*** (more than one field).
- Keys usually are used as indexes to speed up the response to user queries.

Referential Integrity

Can we "delete" customers#5 if orders#1 is still in the database? Why?

customers

pk

customer#	LastName	...	Referred	Region
1001	MORALES		NULL	SE
...				...
1005	GIRARD		NULL	NW
1020	FALAH		NULL	NE

Customers#5 →

orders

pk fk

Order#	customer#	...	ShipZip	ShipCost
1000	1005		98114	2.00
...			...	...
1003	1001		32328	4.00
1012	1007		49002	6.00

orders#1 →

Can we "create" orders#1 if customers#5 is *not* created? Why?

Normalized vs. De-normalized

- We will study the concept and technique of "normalization and de-normalization" (especially for those do not have background on database management) as well as OLTP and OLAP.

More on OLTP vs. OLAP

pk

Owner_ID	Owner Name
1	Jim
2	Joan

fk

pk

Pet_ID	Pet_Name	Owner_ID
1	Fifi	2
2	Butch	1
3	Clover	2
4	Animal	1
5	Tank	1

pk: primary key
fk: foreign key

Fig. Extra-a: A simple database with a relation between two tables.

For those have database background.

- The figure depicts a relational database environment with two tables.
- The first table contains information about pet owners; the second, information about pets. The tables are related by the single column they have in common: Owner_ID.
- By relating tables to one another, we can reduce **redundancy** of data and improve database performance.
- The process of breaking tables apart and thereby reducing data redundancy is called **normalization**.

OLTP vs. OLAP (cont.)

pk

Owner_ID	Owner Name
1	Jim
2	Joan

fk

pk

Pet_ID	Pet_Name	Owner_ID
1	Fifi	2
2	Butch	1
3	Clover	2
4	Animal	1
5	Tank	1

- Most relational databases which are designed to handle a high number of reads and writes (updates and retrievals of information) are referred to as **OLTP (OnLine Transaction Processing)** systems.
- OLTP systems are very efficient for *high volume activities* such as cashiering, where many items are being recorded via bar code scanners in a very short period of time.
- However, using OLTP databases for **analysis** is generally not very efficient, because in order to retrieve data from multiple tables at the same time, a query containing **joins** must be used.

OLTP vs. OLAP (cont.)

- In order to keep our transactional databases *running quickly and smoothly*, we may wish to create a data warehouse. A **data warehouse** is a type of large database (including both *current* and *historical* data) that has been **denormalized** and **archived**.
- **Denormalization** is the process of intentionally combining some tables into a single table in spite of the fact that this may introduce *duplicate* data in some columns.

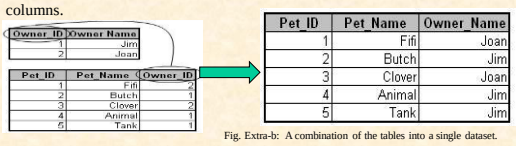


Fig. Extra-b: A combination of the tables into a single dataset.

- The figure depicts what our simple example data might look like if it were in a data warehouse. When we design databases in this way, we ***reduce*** the number of **joins** necessary to query related data, thereby ***speeding*** up the process of analyzing our data.
- Databases designed in this manner are called **OLAP** **(OnLine Analytical Processing)** systems.

Why need Data Warehouses?

- A solution to …
- A solution to bridging the information gap is the ***data warehouses*** which consolidate and integrate information from many different sources and arrange it in a meaningful format for making accurate business decisions.

What is a Data Warehouse?

- A physical repository where *relational* data or *multidimensional* structure (including both current and historical data) are specially organized to provide enterprise-wide, cleansed data in a standardized format for analytical processing activities (i.e., OLAP, data mining, querying, reporting and other decision support apps).
- "The data warehouse is a collection of integrated, subject-oriented databases designed to support DSS functions, where each unit of data is non-volatile and relevant to some moment in time"

A Historical Perspective to Data Warehousing

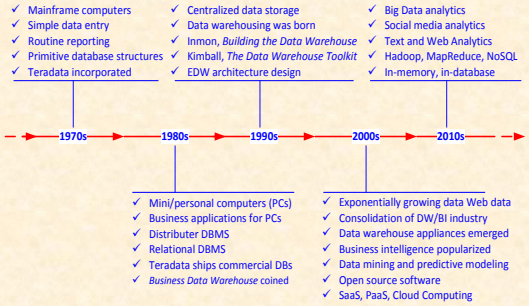


Fig. 2.1 A List of Events That Led to Data Warehousing Development

Characteristics of DW

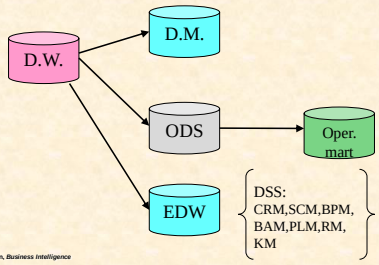
- ***Subject-oriented***
  - e.g. customers, patients, students, products
- ***Integrated***
  - Consistent naming conventions, formats, encoding structures; from multiple data sources
- ***Time-variant*** (time series)
  - Can study trends and changes
- ***Non-volatile***
  - Read-only, periodically refreshed
- Summarized
- Not normalized
- Metadata
- Web based, relational/multi-dimensional
- Client/server
- Real-time and/or right-time (active)

(Three) Types of Data Warehouses

- 1. **Data Mart**
  - A departmental data warehouse that stores only relevant data
    - ✓ ***Dependent data mart***
      - A subset that is created directly from a data warehouse
    - ✓ ***Independent data mart***
      - A small data warehouse designed for a strategic business unit or a department
- 2. **Operational data stores** (ODS)
  - A type of database often used as an interim area for a data warehouse for short-term decisions involving mission-critical apps.
- 3. **Enterprise data warehouse** (EDW)
  - A data warehouse for the enterprise for medium- and long-term decisions.
- Operational marts: An operational data mart and it is created when operational data need to be analyzed multi-dimensionally. Its data come from an ODS.

Types of Data Warehouses

- Metadata
  - Data about data. In a data warehouse, metadata describe the structure of and some meaning about data and the manner of its acquisition and their effective or ineffective use.



An Example of CUSTOMERS Data File (Part of Database)

Customer#	LastName	FirstName	Address	City	State	Zip	Referred	Region	Email
NUMBER(4)	VARCHAR2(10)	VARCHAR2(10)	VARCHAR2(20)	VARCHAR2(12)	VARCHAR2(2)	VARCHAR2(5)	NUMBER(4)	CHAR(2)	VARCHAR2(30)

	CUSTOMER#	LASTNAME	FIRSTNAME	ADDRESS	CITY	STATE	ZIP	REFERRED	REGION	EMAIL
1	1001	MORALES	BONITA	P.O. BOX 651	EASTPOINT	FL	32328	(null)	SE	bm225@isat.net
2	1002	THOMPSON	RYAN	P.O. BOX 9835	SANTA MONICA	CA	90404	(null)	W	(null)
3	1003	SMITH	LEILA	P.O. BOX 66	TALLAHASSEE	FL	32306	(null)	SE	(null)
4	1004	PIERSON	THOMAS	69821 SOUTH AVENUE	BOISE	ID	83707	(null)	NW	tpier55@isat.net
5	1005	GIRARD	CINDY	P.O. BOX 851	SEATTLE	WA	98115	(null)	NW	cmg101@oep.net
6	1006	CRUZ	MESHEA	82 DIRT ROAD	ALBANY	NY	12211	(null)	NE	cruztop@axe.com
7	1007	GIANA	TAMMY	9153 MAIN STREET	AUSTIN	TX	78710	1003	SW	treetop@oep.net
8	1008	JONES	KENNETH	P.O. BOX 137	CHEYENNE	WY	82003	(null)	N	kenask@isat.net
9	1009	PEREZ	JORGE	P.O. BOX 8564	BURBANK	CA	91510	1003	W	jperez@canet.com
10	1010	LUCAS	JAKE	114 EAST SAVANNAH	ATLANTA	GA	30314	(null)	SE	(null)
11	1011	MCGOVERN	REESE	P.O. BOX 18	CHICAGO	IL	60606	(null)	N	reesemc@isat.net
12	1012	MCKENZIE	WILLIAM	P.O. BOX 971	BOSTON	MA	02110	(null)	NE	wil2244@axe.net
13	1013	NGUYEN	NICHOLAS	357 WHITE EAGLE AVE.	CLERMONT	FL	34711	1006	SE	nguy33@isat.net
14	1014	LEE	JASMINE	P.O. BOX 2947	CODY	WY	82414	(null)	N	jaslee@isat.net
15	1015	SCHELL	STEVE	P.O. BOX 677	MIAMI	FL	33111	(null)	SE	aschell3@isat.net
16	1016	DAUM	MICHELL	9851231 LONG ROAD	BURBANK	CA	91508	1010	W	(null)
17	1017	NELSON	BECCA	P.O. BOX 563	KALMAZOO	MI	49006	(null)	N	beccab88@dgc.com
18	1018	MONTIAGA	GREG	1008 GRAND AVENUE	MACON	GA	31206	(null)	SE	greg336@isat.net
19	1019	SMITH	JENNIFER	P.O. BOX 1151	MORRISTOWN	NJ	07962	1003	NE	(null)
20	1020	FALAH	KENNETH	P.O. BOX 335	TRENTON	NJ	08607	(null)	NE	Kfalah@isat.net

Which one is the "**Metadata**" for CUSTOMERS data file?

Application Case 2.1

A Better Data Plan: Well-Established TELCOs Leverage Data Warehousing and Analytics to Stay on Top in a Competitive Industry

Questions for Discussion

1. What are the main challenges for TELCOs?
2. How can data warehousing and data analytics help TELCOs in overcoming their challenges?
3. Why do you think TELCOs are well suited to take full advantage of data analytics?

- ***1. What are the main challenges for TELCOs?***
-
- To stay competitive, TELCOs must continuously refine everything from customer service to plan pricing.
- The major challenges faced by both entrenched and new companies in this industry include: retaining customers, decreasing costs, fine-tuning pricing models, improving customer satisfaction, acquiring new customers, and understanding the role of social media in customer loyalty.

- ***2. How can data warehousing and data analytics help TELCOs in overcoming their challenges?***
-
- Highly targeted data analytics play an ever more critical role in helping carriers secure or improve their standing in an increasingly competitive marketplace.
- Argentina's Telefónica de Argentina used analytics for its "traceability project," which tracked the factors involved in customer churn, a big problem among phone service carriers.
- France's Bouygues Telecom used BI technologies to facilitate cost reduction through automation via its Teradata-based marketing operations management system, which automates marketing/communications collateral production.
- Pakistan's Mobilink uses BI to help acquire customers and grow their subscriber network, largely aided by social networking.

- ***3. Why do you think TELCOs are well suited to take full advantage of data analytics?***
-
- TELCOs control the telecommunications infrastructure, and acquire much usage data as a result.
- They have the technical expertise to create, deploy, and refine plans to address their business challenges. The industry and mobile technology have expanded and improved over the years, which provides a strong foundation on which to build intelligent solutions.
- The data analytics solutions that have been created to meet these challenges have also improved drastically over the past few years, placing TELCOs in a good position to capitalize on their technological advantages.

2.2 Data Warehousing Process Overview

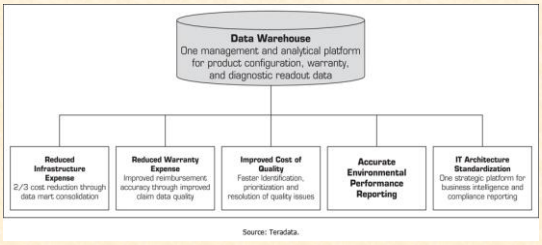


Fig. 2.2 Data-Driven Decision Making – Business Benefits of the Data Warehouse

A Generic DW Framework

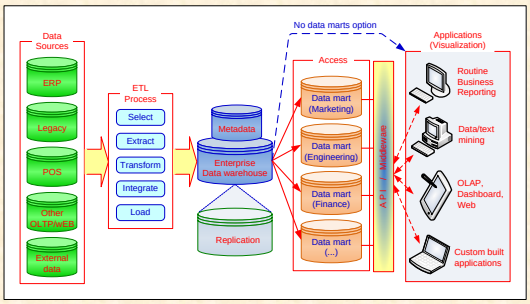


Fig. 2.3 A Data Warehousing Framework and Views

A Generic DW Framework

T3: Back-End (data acquisition software/database server)

T2: Data warehouse (data & software/ apps server)

T1: Front-End (client software/ client server)

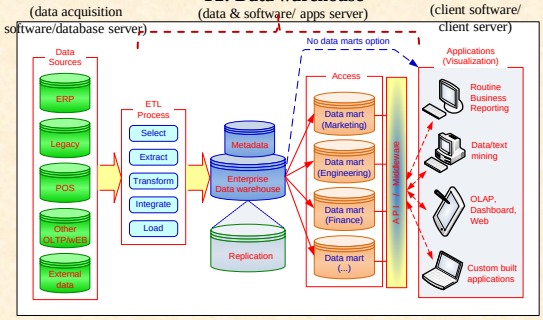


Fig. 2.3 A Data Warehousing Framework and Views

Application Case 2.2

Data Warehousing Helps MultiCare Save More Lives

Questions for Discussion

1. What do you think is the role of data warehousing in healthcare systems?
2. How did MultiCare use data warehousing to improve health outcomes?

DW Architecture

- Three-tier architecture

  T1: Client (front-end) software that allows users to access and analyze data from the warehouse

  T2: The data warehouse that contains the data & software

  T3: Data acquisition software (back-end)

  Advantage:

  separation of the functions of the DW, which **eliminates** resource constraints and makes it possible to easily create data marts.

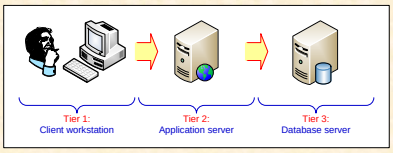
- Two-tier architecture

  Last 2 tiers in three-tier architecture is combined into one

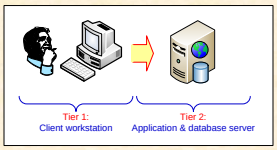
  Sometimes there is only one tier ?

DW Architectures

3-tier architecture

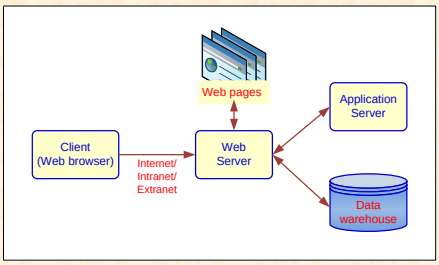


2-tier architecture



1-tier Architecture ?

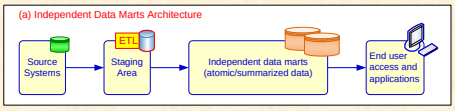
A Web-based DW Architecture



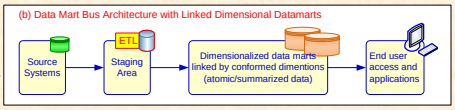
Advantages: ease of access, platform independence, and lower cost.

Alternative DW Architectures

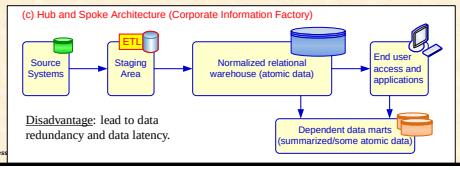
Advantage: the simplest and the least costly.
Disadvantage: Least effective



Advantage: maintaining data consistency.
Disadvantage: performance is not satisfactorily.

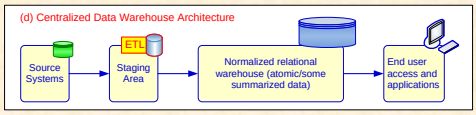


Advantage: for building scalable and maintainable infrastructure

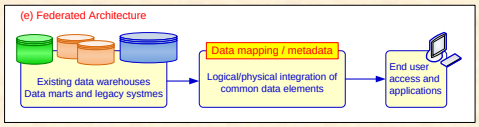


Disadvantage: lead to data redundancy and data latency.

Alternative DW Architectures



Advantage: simplifying data management and administration. This architecture is advocated by Teradata Corp, advises using DW without any DM.



Advantage: to supplement DW, not replace them

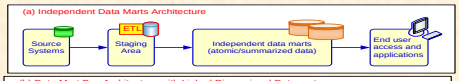
The most common platform for hosting the DW was: Oracle (41%), MS (19%) then IBM (18%)

Which architecture is the best?

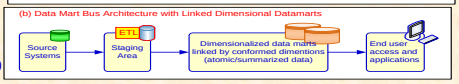
Survey

Alternative DW Architectures – Best?

#4 (12%)



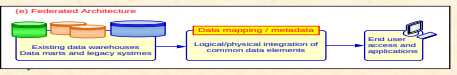
Kimbal
#2 (26%)



Inmon
#1 (39%)

#3 (17%)

#5 (4%)



Data Warehousing Architectures

Ten factors that potentially affect the architecture selection decision:

1. Information interdependence between organizational units
2. Upper management's information needs
3. Urgency of need for a data warehouse
4. Nature of end-user tasks
5. Constraints on resources
6. Strategic view of the data warehouse prior to implementation
7. Compatibility with existing systems
8. Perceived ability of the in-house IT staff
9. Technical issues
10. Social/political factors

Data Integration and the Extraction, Transformation, and Load (ETL) Process

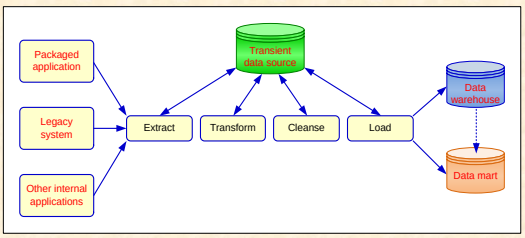
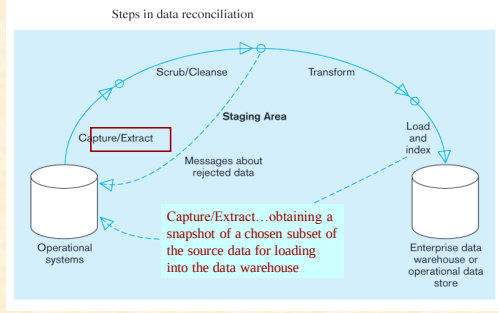


Fig. 2. 9 The ETL Process

The ETL Process – another perspective and example

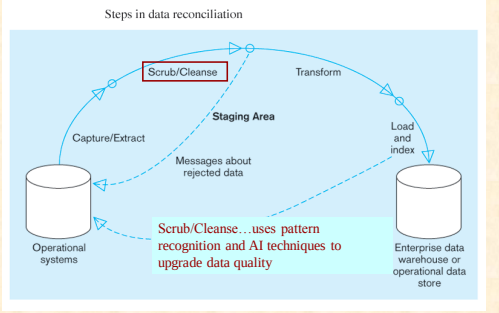
- Capture/Extract - ***E***
- Scrub or data cleansing
- Transform - ***T***
- Load and Index - ***L***

ETL = Extract, transform, and load



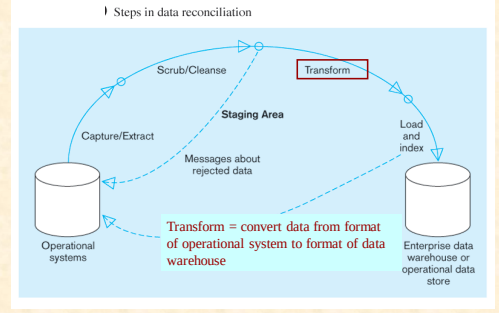
Static extract = capturing a snapshot of the source data at a point in time

Incremental extract = capturing changes that have occurred since the last static extract



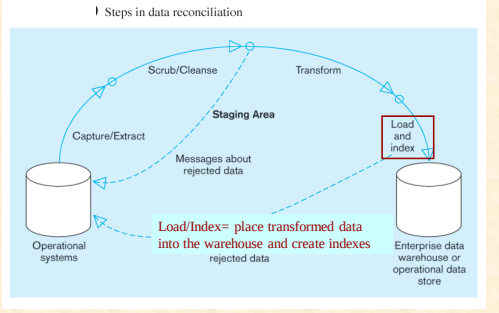
Fixing errors: misspellings, erroneous dates, incorrect field usage, mismatched addresses, missing data, duplicate data, inconsistencies

Also: decoding, reformatting, time stamping, conversion, key generation, merging, error detection/logging, locating missing data



Record-level:
Selection – data partitioning
Joining – data combining
Aggregation – data summarization

Field-level:
single-field – from one field to one field
multi-field – from many fields to one, or one field to many



Refresh mode: bulk rewriting of target data at periodic intervals

Update mode: only changes in source data are written to data warehouse

Data Integration and the Extraction, Transformation, and Load (ETL) Process

- **ETL** = **E**xtract **T**ransform **L**oad
- Data integration

  Integration that comprises three major processes: data access, data federation, and change capture.
- Enterprise application integration (EAI)

  A technology that provides a vehicle for pushing data from source systems into a data warehouse
- Enterprise information integration (EII)

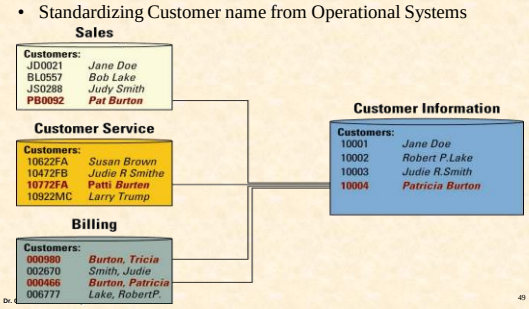
  An evolving tool space that promises real-time data integration from a variety of sources, such as relational or multidimensional databases, Web services, etc.

Information Cleansing or Scrubbing

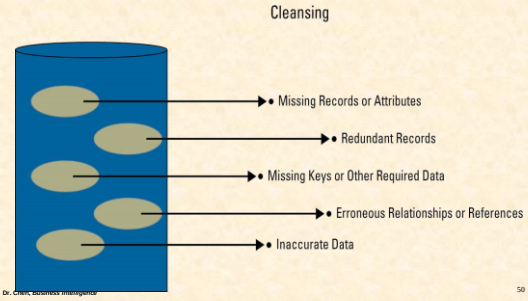
- An organization must maintain high-quality data in the data warehouse
- ***Information cleansing or scrubbing*** – a process that weeds out and fixes or discards inconsistent, incorrect, or incomplete information

Information Cleansing or Scrubbing

- Standardizing Customer name from Operational Systems

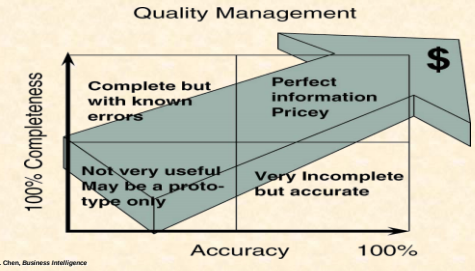


Information Cleansing or Scrubbing



Information Cleansing or Scrubbing

- Accurate and complete information



Data Warehouse Development

- Data warehouse development approaches
  - (1) Inmon Model: *EDW* approach **(top-down)**
    - ✓ Adapts traditional RDB tools to the development needs of an EDW
  - (2) Kimball Model: *Data mart* approach **(bottom-up)**
    - ✓ Employs dimensional data modeling.
  - Which model is best?
    - ✓ There is no one-size-fits-all strategy to DW
  - One alternative is the hosted warehouse
- Data warehouse structure:
  - The Star Schema vs. Relational
- **Table 2.3** provides a comparative analysis between EDW and Data Mart approach

Application Case 2.5

Starwood Hotels & Resorts Manages Hotel Profitability with Data Warehousing

Questions for Discussion

1. How big and complex are the business operations of Starwood Hotels & Resorts?
2. How did Starwood Hotels & Resorts use data warehousing for better profitability?
3. What were the challenges, the proposed solution, and the obtained results?

Data Warehousing Strategy

- A data warehouse strategy is a blue print for the successful introduction of the DW.
- The strategy should describe
  - ***Where*** the company wants to go,
  - ***Why*** it wants to go there,
  - ***What*** it will do ***when*** it gets there
- It needs to take into consideration the organization's vision, structure, and culture.

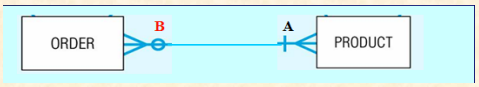
Additional Data Warehouse Considerations
Hosted Data Warehouses

- Benefits:
  - Requires minimal investment in infrastructure
  - Frees up capacity on in-house systems
  - Frees up cash flow **(why?)**
  - Makes powerful solutions affordable
  - Enables solutions that provide for growth
  - Offers better quality equipment and software
  - Provides faster connections
  - … more in the book

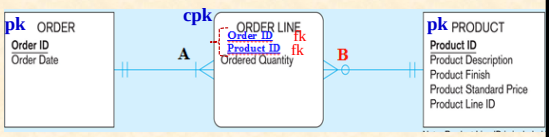
Representation of Data in DW

- **Dimensional Modeling** – a retrieval-based system that supports high-volume query access
  - Not only accommodate but also boost the processing of complex multidimensional queries.
- Two means
  - **1. Star schema** – the most commonly used and the simplest style of dimensional modeling
    - ✓Contain a **fact table** surrounded by and connected to several **dimension tables**
    - ✓Fact table contains the *descriptive* attributes (numerical values) needed to perform decision analysis and query reporting, and *foreign keys* are used to link to dimension table.
    - ✓Dimension tables contain *classification* and *aggregation* information about the values in the fact table (i.e., attributes describing the data contained within the fact table).
  - **2. Snowflakes schema** – an extension of star schema where the diagram resembles a snowflake in shape

Fact Table vs. Dimensional Table



Many to Many Relationship (M:N)



Dimensional Table | Fact Table | Dimensional Table

Star versus Snowflake Schema

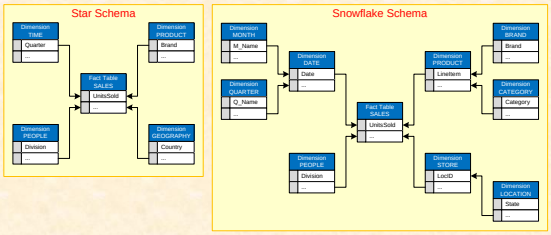
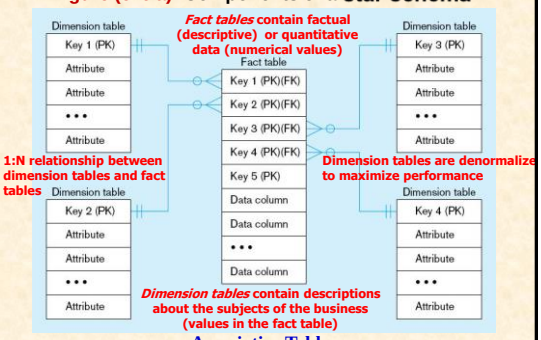


Figure (extra): Components of a star schema



Associative Table

Excellent for ad-hoc queries, but bad for online transaction processing

Figure (extra) Star schema example

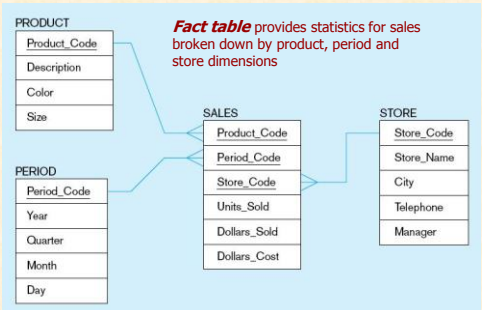
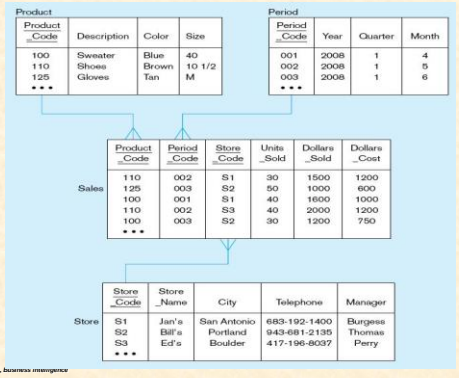


Figure (extra) Star schema with sample data



Multidimensionality

- Multidimensionality
  - The ability to organize, present, and analyze data by several dimensions, such as sales by region, by product, by salesperson, and by time (four dimensions)
  - In a data warehouse and data mart, information is *multidimensional*, it contains layers of columns and rows
- Multidimensional presentation
  - Dimensions: a dimension is a particular attribute of information such as products, salespeople, market segments, business units, geographical locations, distribution channels, country, or industry
  - Measures: money, sales volume, head count, inventory profit, actual versus forecast
  - Time: daily, weekly, monthly, quarterly, or yearly

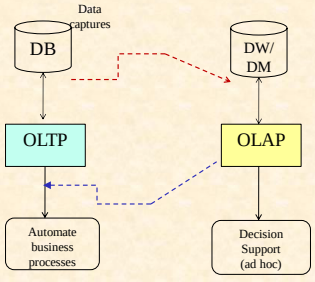
Analysis of Data in DW

- OLTP vs. OLAP…
- OLTP (online transaction processing)
  - Capturing and storing data from ERP, CRM, POS, …
  - The main focus is on efficiency of routine tasks
- OLAP (Online analytical processing)
  - Converting data into information for decision support
  - Data cubes, drill-down / rollup, slice & dice, …
  - Requesting ad hoc reports
  - Conducting statistical and other analyses
  - Developing multimedia-based applications
  - …more in the book

OLAP and its Applications

- What software and function that enable you to create OLAP and its applications?
- ANSWER
  - EXCEL with
  - **Pivot table**

OLTP and OLAP - Rely Heavily on Each Other



OLAP vs. OLTP

TABLE 2.5 A Comparison Between OLTP and OLAP

Criteria	OLTP	OLAP
Purpose	To carry out day-to-day business functions	To support decision making and provide answers to business and management queries
Data source	Transaction database (a normalized data repository primarily focused on efficiency and consistency)	Data warehouse or data mart (a nonnormalized data repository primarily focused on accuracy and completeness)
Reporting	Routine, periodic, narrowly focused reports	Ad hoc, multidimensional, broadly focused reports and queries
Resource requirements	Ordinary relational databases	Multiprocessor, large-capacity, specialized databases
Execution speed	Fast (recording of business transactions and routine reports)	Slow (resource intensive, complex, large-scale queries)

OLAP Operations

- **Cube**
  - a multidimensional data structure that allows fast analysis of data.
  - ***common term for the representation of multidimensional information***
- **Slice**
  - a subset of a multidimensional array (via rotations)
- **Dice**
  - a slice on more than two dimensions
- **Drill Down/Up**
  - navigating among levels of data ranging from the most summarized (up) to the most detailed (down) (via aggregation and disaggregation)
- **Roll Up**
  - computing all of the data relationships for one or more dimensions
- **Pivot**
  - used to change the dimensional orientation of a report or an ad hoc query-page display

Variations of OLAP

- Multidimensional OLAP (MOLAP)
  - OLAP implemented via a *specialized multidimensional* database (or data store) that summarizes transactions into multidimensional views ahead of time
  - **Cube structure**
- Relational OLAP (ROLAP)
  - The implementation of an OLAP database on top of an existing *relational* database and does not require pre-computation and storage of information.
- Database OLAP and Web OLAP (DOLAP and WOLAP); Desktop OLAP,…

Fig. 2.11 Slicing Operations on a Simple Tree-Dimensional Data Cube

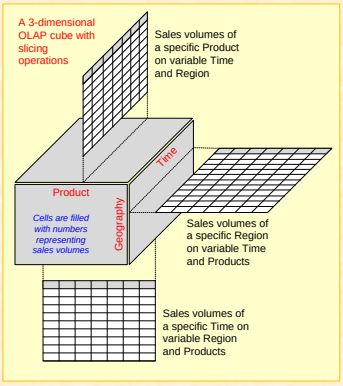


Figure (extra): Slicing a data cube

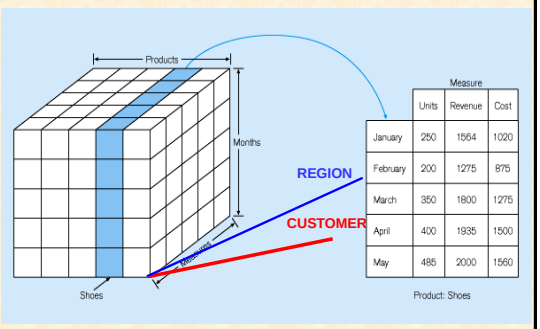


Figure (extra): Multidimensional Analysis

- ***Cube*** – common term for the representation of multidimensional information

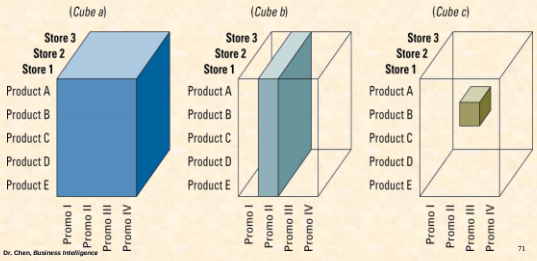


Figure (extra): Example of drill-down

Starting with summary data, users can obtain details for particular cells

Summary report

Brand	Package size	Sales
SofTowel	2-pack	$75
SofTowel	3-pack	$100
SofTowel	6-pack	$50

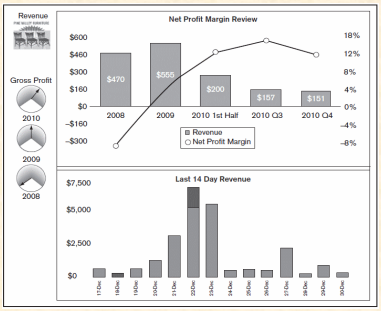
Drill-down with color added

Brand	Package size	Color	Sales
SofTowel	2-pack	White	$30
SofTowel	2-pack	Yellow	$25
SofTowel	2-pack	Pink	$20
SofTowel	3-pack	White	$50
SofTowel	3-pack	Green	$25
SofTowel	3-pack	Yellow	$25
SofTowel	6-pack	White	$30
SofTowel	6-pack	Yellow	$20

Figure (extra): Business Performance Mgmt (BPM)

Sample Dashboard

BPM systems allow managers to measure, monitor, and manage key activities and processes to achieve organizational goals. Dashboards are often used to provide an information system in support of BPM.



Charts like these are examples of **data visualization**, the representation of data in graphical and multimedia formats for human analysis.

Technology Insights 2.2
Hands-On DW with MicroStrategy

- A wealth of teaching and learning resources can be found at TUN portal

  www.teradatauniversitynetwork.com

- The available resources include scripted demonstrations, assignments, white papers, etc…

Successful DW Implementation- Things to Avoid

- Data warehousing risks are more serious (than other IT projects) because DW are *expensive*, *time-and-resource demanding*, *large-scale* project.
- Therefore, a successful DW implementation should avoid:
  - Starting with the wrong sponsorship chain
  - Setting expectations that you cannot meet
  - Engaging in politically naive behavior
  - Loading the data warehouse with information just because it is available
  - Believing that data warehousing database design is the same as transactional database design
  - Choosing a data warehouse manager who is technology oriented rather than **user oriented**

Failure Factors in DW Projects

- Lack of executive sponsorship
  - What are the "three" types of people should be involved in any project?
  - (1) **(Top) Manager**
  - (2) **Specialist**
  - (3) **Users**
- Unclear business objectives
- Cultural issues being ignored
  - Change management
- Unrealistic expectations
- Inappropriate architecture
- Low data quality / missing information
- Loading data just because it is available

Massive DW and Scalability

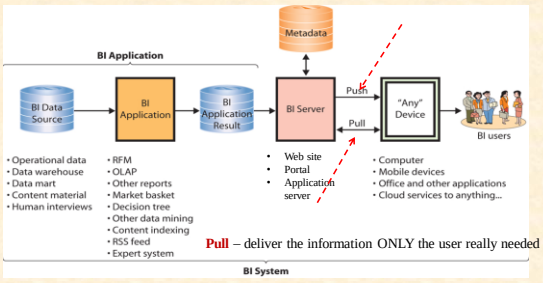
- **Scalability**
  - The main issues pertaining to scalability:
    - ✓ The amount of data in the warehouse
    - ✓ How quickly the warehouse is expected to grow
    - ✓ The number of concurrent users
    - ✓ The complexity of user queries
  - Good scalability means that queries and other data-access functions will grow linearly with the size of the warehouse

Real-time/Active DW/BI

- Enabling real-time data updates for real-time analysis and real-time decision making is growing rapidly
  - RDW may be successful if the organization develops a sound methodology to handle project risks, incorporates proper planning, and focuses on quality assurance activities.
  - RDW is also known as active data warehouse (ADW)
  - Push vs. **Pull** (of data)
- Concerns about real-time BI
  - Not all data should be updated continuously
  - Mismatch of reports generated minutes apart
  - May be cost prohibitive
  - May also be infeasible

How are business intelligence applications delivered?

- This figure shows the components of a generic BI system. A BI application server delivers results in a variety of formats to devices for consumption by BI users. A BI server provides two functions: 1) *management* and 2) *delivery*.



Pull – deliver the information ONLY the user really needed

Components of Generic Business Intelligence System (Kroenke, *Using MIS 6e 2013*)

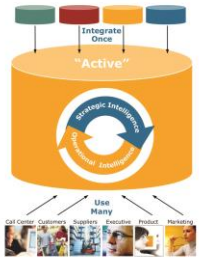
Enterprise Decision Evolution and Data Warehousing

Real-Time/Active DW at Teradata

Active Access
Front-Line operational decisions or services supported by near-real-time (NRT) access; Service Level Agreements of 5 seconds or less

Active Load
Intra-day data acquisition; Mini-batch to NRT trickle data feeds measured in minutes or seconds

Active Events
Proactive monitoring of business activity initiating intelligent actions based on rules and context; to sys-tems or users supporting an operational business process



Active Workload Management
Dynamically manage system resources for optimum performance and resource utilization supporting a mixed-workload environment

Active Enterprise Integration
Integration into the Enterprise Architecture for delivery of intelligent decisioning services

Active Availability
Business Continuity to support the requirements of the business (up to 7X24)

Traditional versus Active DW

Traditional Data Warehouse Environment	Active Data Warehouse Environment
Strategic decisions only	Strategic and tactical decisions
Results sometimes hard to measure	Results measured with operations
Daily, weekly, monthly data currency acceptable; summaries often appropriate	Only comprehensive detailed data available within minutes is acceptable
Moderate user concurrency	High number (1,000 or more) of users accessing and querying the system simultaneously
Highly restrictive reporting used to confirm or check existing processes and patterns; often uses predeveloped summary tables or data marts	Flexible ad hoc reporting, as well as machine-assisted modeling (e.g., data mining) to discover new hypotheses and relationships
Power users, knowledge workers, internal users	Operational staffs, call centers, external users

DW Administration and Security

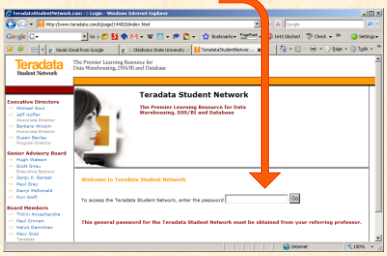
- Data warehouse administrator (DWA)
  - DWA should…
    - ✓ have the knowledge of high-performance software, hardware and networking technologies
    - ✓ possess solid business knowledge and insight
    - ✓ be familiar with the decision-making processes so as to suitably design/maintain the data warehouse structure
    - ✓ possess excellent communications skills
- Security and privacy is a pressing issue in DW
  - Safeguarding the most valuable assets
  - Government regulations (HIPAA, etc.)
  - Must be explicitly planned and executed

The Future of DW

- ***Sourcing…***
  - *Web, social media, and Big Data*
  - Open source software
  - SaaS (software as a service)
  - *Cloud computing*
- ***Infrastructure…***(architectural: hardware and software enhancements)
  - Real-time DW and Columnar (vs. Relational DB – stored as rows)
  - Data warehouse appliances (best-of-breed philosophy in the future)
  - Data management practices/technologies
  - In-database & In-memory processing New DBMS ***("super-computing")***
  - Advanced analytics
  - …

Free of Charge DW Portal for Teaching & Learning

- www.TeradataUniversityNetwork.com
- Password to signup: <check with your instructor>



Big Data And Data Warehousing

- Two paradigms in BI:
  - **Data Warehouse** and **Big Data**.
  - Both are competing each other for turning data into actionable information.
- However, in recent years, the variety and complexity of data made *data warehouse* incapable of keeping up the changing needs.
- Big Data
  - A new paradigm that the world of IT was forced to develop, not because the ***volume*** of the structured data but the ***variety*** and the ***velocity***.
- Big data and analytics will be further discussed in chapter 6.

Conclusion

- The future of data warehousing seems to be full of *promises* and *significant challenges*. As the world of business becomes more global and complex, the need for business intelligence and DW tools also become more prominent.
- The fast improving IT tools and techniques seem to be moving in the right direction to address the needs of the future BI systems.

End of Chapter Application Case

- Continental Airlines Flies High with its Real-Time Data Warehouse

1. Describe the benefits of implementing the Continental Go Forward strategy.

- This strategy consisted of a number of interrelated, concurrent actions. The first version of the overall strategy had the benefit of restoring Continental (CO) to profitability and giving it first-place rankings by many airline industry metrics.
- The second phase of the strategy led to savings of $41 million and a reduction of $7 million in fraud in the first year alone. Its revenue increased by over $500 million in six years. A data warehouse played a critical role in the second phase.

2. Explain why it is important for an airline to use a real-time data warehouse.

- It's important for an airline to use real-time data warehouse because many airline decisions cannot be made with week-old, or even day-old, data.
- An example is frequent flyer award availability on a given flight. Airlines limit these so as not to give away too many seats that would otherwise be sold. Award seat allocation is usually automated. Travelers can check availability online. American Airlines (and probably others) offers expanded award availability to the 30,000 or so people who fly at least 100,000 miles per year with them. When one of these wants an award seat that is not available online, he or she can request it by phone. The agent must decide whether or not to make it available. If the flight is selling slowly, the traveler gets the seat, even if the computer hasn't allocated it for award. If it is likely to sell out, the seat isn't offered, even to this select group. To make this decision, telephone agents (and the Yield/Revenue Management staff, which agents can consult) need *up-to-the-minute*, or at least *up-to-the-hour (i.e., real-time)*, information.

4. Identify the major differences between the traditional data warehouse and a real-time data warehouse, as was implemented at Continental.

- A traditional data warehouse moves data from operational databases to the DW on a scheduled basis, typically daily or weekly. This provides consistent data for analyses performed during one update cycle, but does not make current information available for decisions that require it.
- A real-time DW, as was implemented at CO, moves data (from legacy systems) into the DW on an hourly or even more frequent basis.

5. What strategic advantage can Continental derive from the real-time system as opposed to a traditional information system?

- By having real-time data available through its data warehouse, CO can make decisions using up-to-date information. While data warehousing applications which focus on long-term decisions aren't affected much by the last hour's, day's or even week's data, lower-level short-term decisions are.
- As the use of the DW is extended to these decisions and *down* in the organization, current data become necessary. By having real-time (or near-real-time) data in the system, CO obtains a strategic advantage by making better decisions.

End of the Chapter

- Questions, comments