

TDWI World Conference – Spring 2005

**Baltimore  
18 May 2005**

**Multidimensional Data Model  
of the SAP Business Information Warehouse™**

**How to build good performing data models with SAP BW**

**Dr. Michael Hahne**

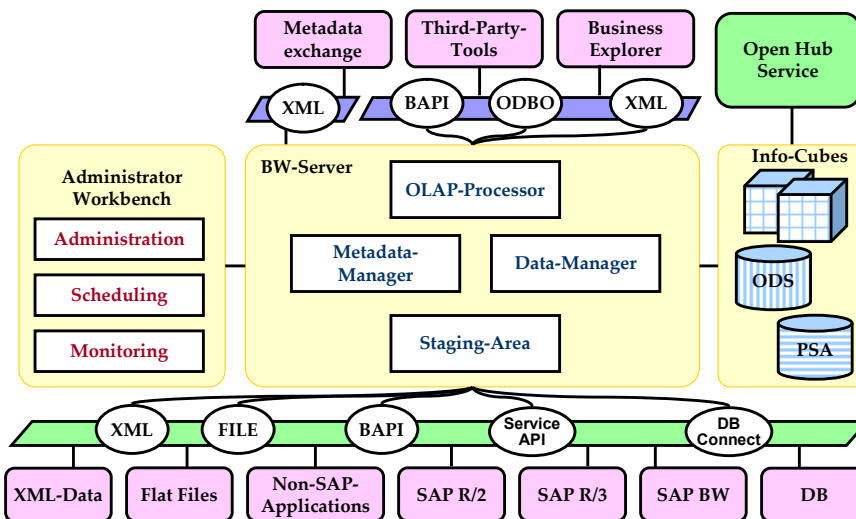
## Agenda

- Architecture of the SAP Business Information Warehouse
- Extended Star Schema of the SAP AG
- Variants for modeling hierarchical dimension structures
- Temporal aspects and time stamping
- Modelling guidelines
- Graphical model representation with Visio™

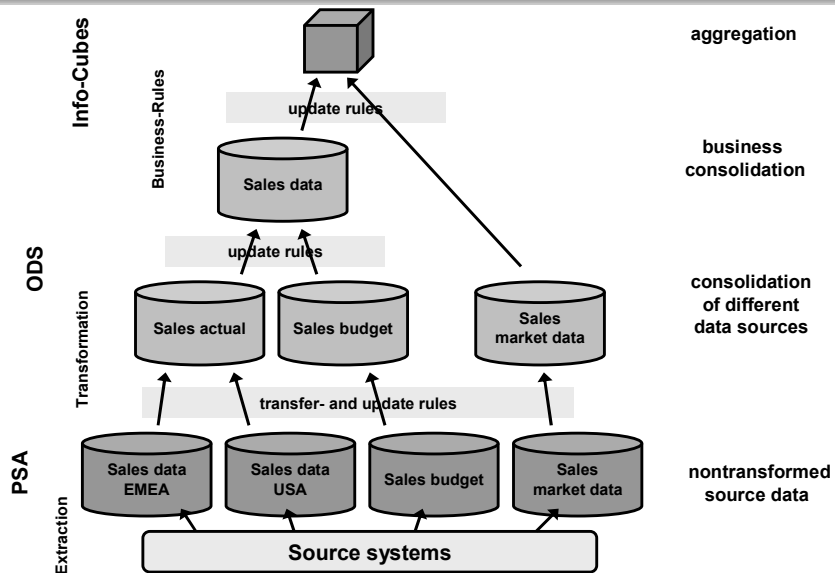
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## Architecture of SAP® Business Information Warehouse



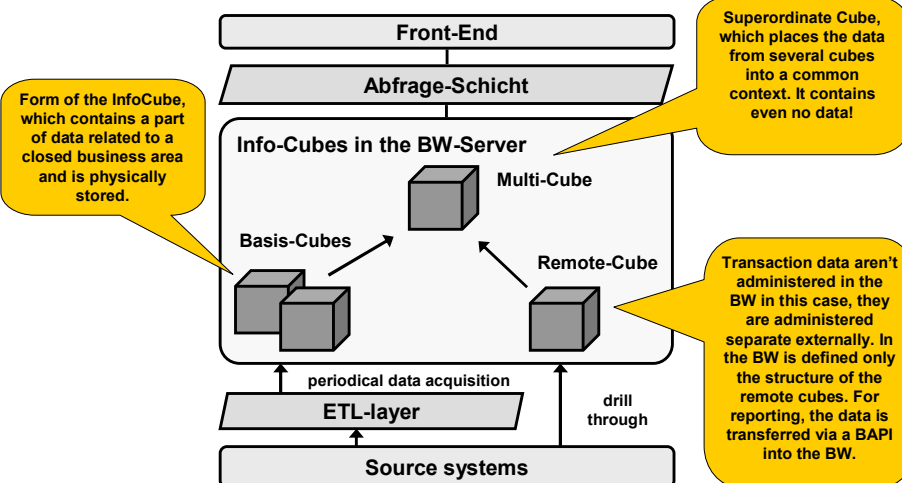
## Data flow and integration architecture



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## Types of Info-Cubes



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## Data targets in SAP® BW

Data targets are objects, in which transactional data is stored for the purpose of reporting and analysis. The most important are:

Info-Cubes

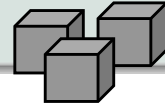


ODS-Objects



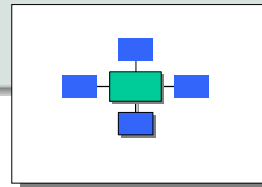
Additionally there are further data targets in BW, which enable for example direct master data reporting (Info-Sets, Info-Objects)

## Definition Info-Cube



- The InfoCube is a **central data storage**, on which are based reports and analyses in SAP® BW. It contains a delimited data volume for example of a specific well-defined business area or business unit.
- InfoCubes contain two data types: **measures** and **characteristics**.
- The term „InfoCube“ designates a table structure, in which some relational tables are linked in the sense of the so-called Star Schema. (multidimensional data storage)
- Star Schema: Dimension tables are grouped star shaped around a central fact table.

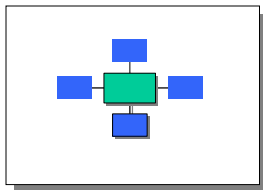
## Star Schema



- The Star Schema is the most frequent kind of representing multidimensional data structures in relational data bases.
- In the Star Schema facts are stored in a separate **fact table**, whereas the characteristics are grouped in **Dimension tables**. The dimension tables are joined to the fact table with foreign key and primary key relationships (DIM ID).
- In this way all data records from the fact table are marked **uniquely** by a value combination of these foreign keys from the dimension tables.

## Pros and cons of the general Star Schema

- ☺ Good performance with the analysis of data
- ☺ Very flexible when adding characteristics and measures



- ☹ Problems come along with
  - N : M relationships and
  - unbalanced (unragged ) hierarchiesbecause of the uniqueness of the primary keys in the dimension tables

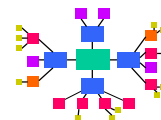
Therefore the SAP AG decided to extend the Star Schema.

Master data is stored separate and independent from InfoCubes in the so called **Extended Star Schema**.

## Extended Star Schema

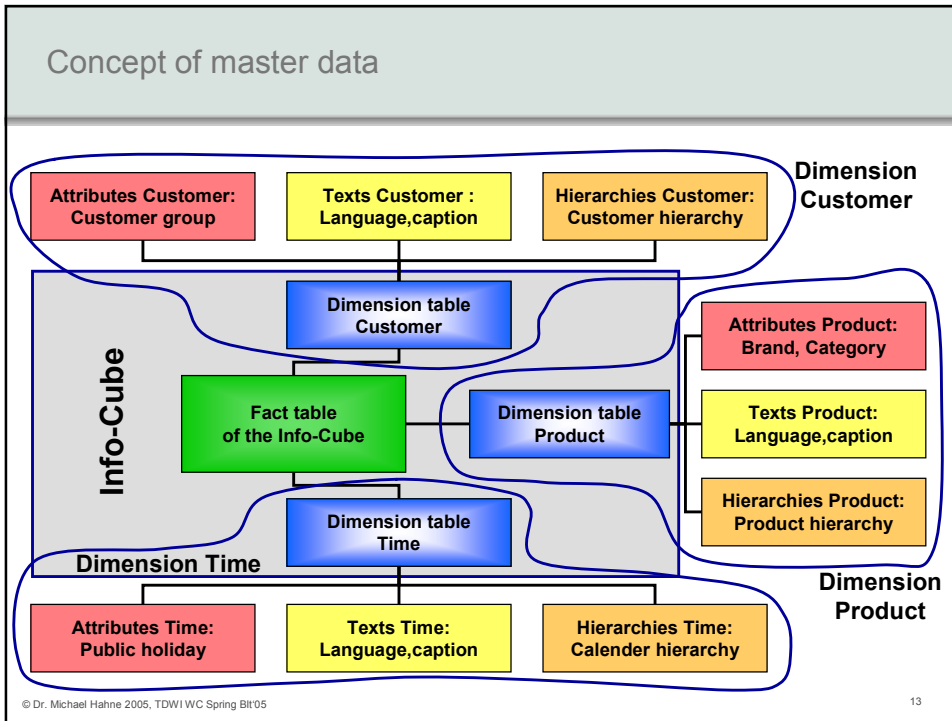
The Extended Star Schema enables access to:

- Master data tables and their corresponding attributes
- Text tables with extensiv multilingual captions
- External hierarchy tables for the structured data access

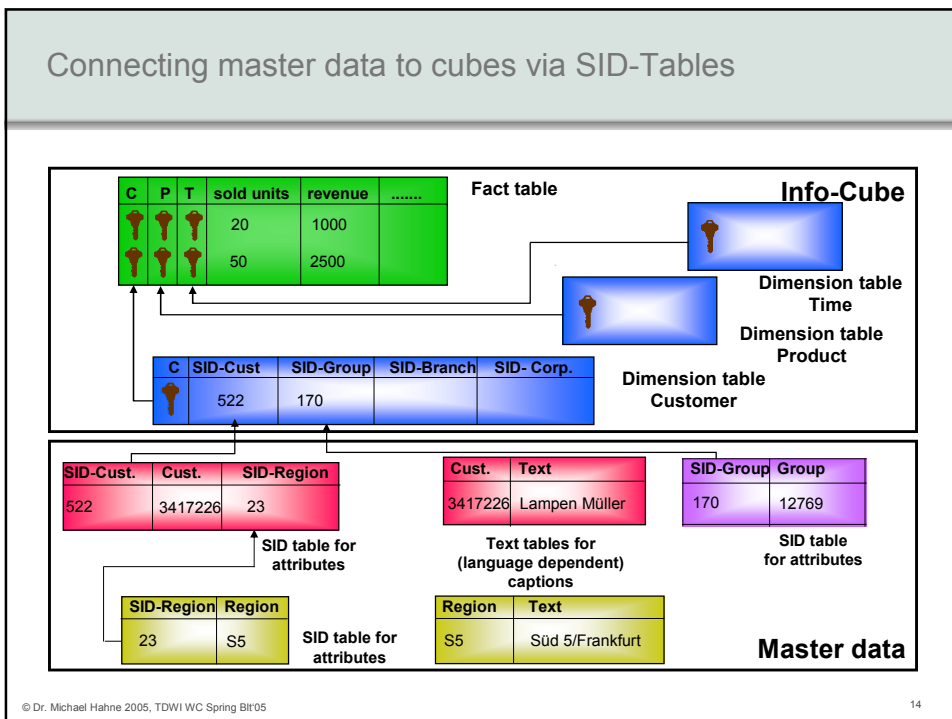


Master data and hierarchy tables are joined to the fact table via the **SID-Tables** (pointer tables) and the dimension tables

## Concept of master data



## Connecting master data to cubes via SID-Tables



## Different master data tables

C	SID-Cust.	SID-Group	SID-Branch	SID-Corp
	522	170		

Dimension table  
Customer

S	SID-Cust.	Cust.
	522	3417226

SID table BIC/SKunde  
Standard SID-Table

P	Cust.	Cust. name
	3417226	Car wash Smith

Master data table BIC/PKunde  
for not time-dependent  
display attributes

Q	Cust.	DateFrom	DateTo	Region
	3417226	...	...	Süd 5/Frankfurt

Master data table BIC/QKunde  
for time dependent  
display attributes

X	SID-Cust.	Cust.	SID-Region
	522	3417226	23

SID table BIC/XKunde  
for not time-dependent  
navigation attributes

Y	SID-Cust.	Cust.	DateFrom	DateTo	SID-Cluster
	522	3417226	...	...	12

SID table BIC/YKunde  
for time dependent  
navigation attributes

## Hierarchy tables

Dim-ID	SID-Cust.	SID-Grp.	SID-Branch	SID-Corp.
	522	170	...	...

Dimension table Customer

S	SID-Cust.	Customer
	522	3417226

SID table /BIC/SKunde  
Standard SID-Table

I	SID of Hierarchy	pred	succ
	234	-21	522

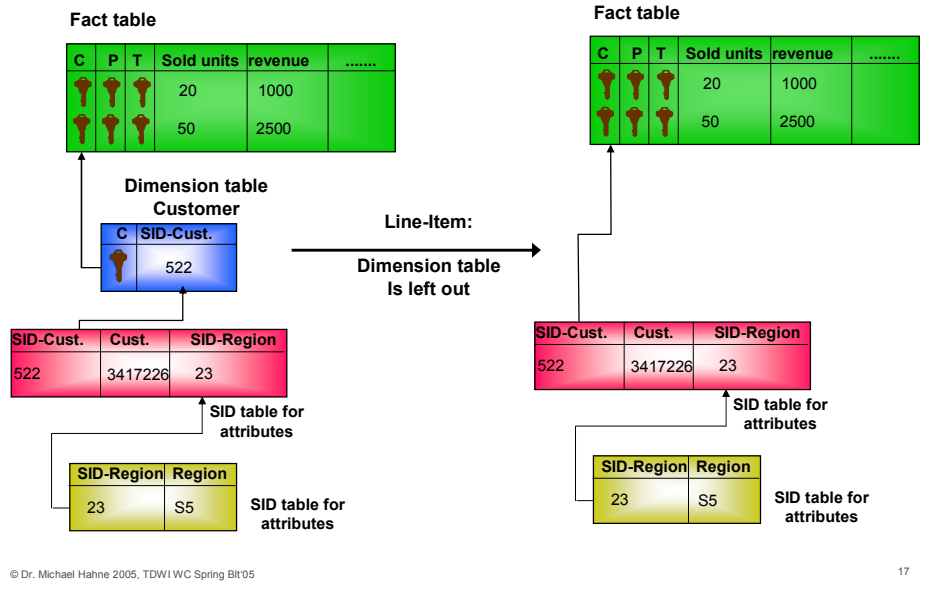
Hierarchy table /BIC/IKunde  
Parent-Child-Tuple of the hierarchies

K	SID of Hierarchy	node	SID
	234	Cust.Group A	-21

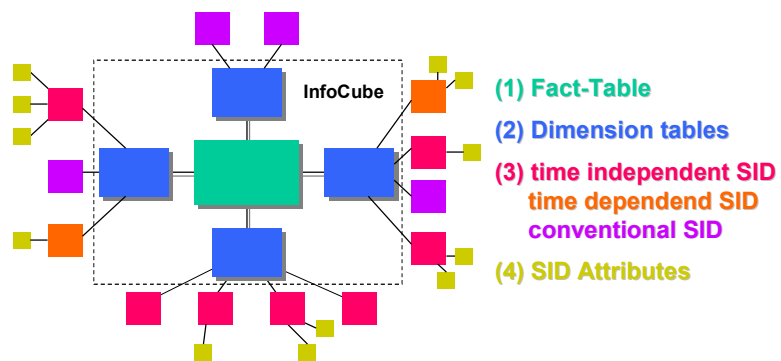
Hierarchy table /BIC/KKunde  
Text nodes of the hierarchies



## Line-Item dimensions



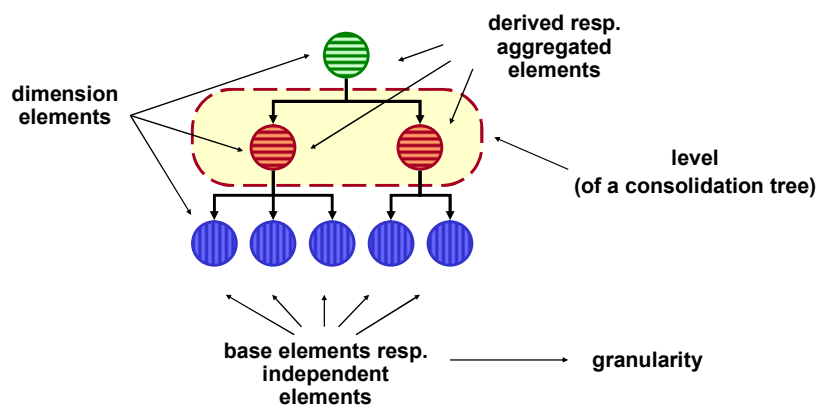
## Complexity of the extended Star at a glance



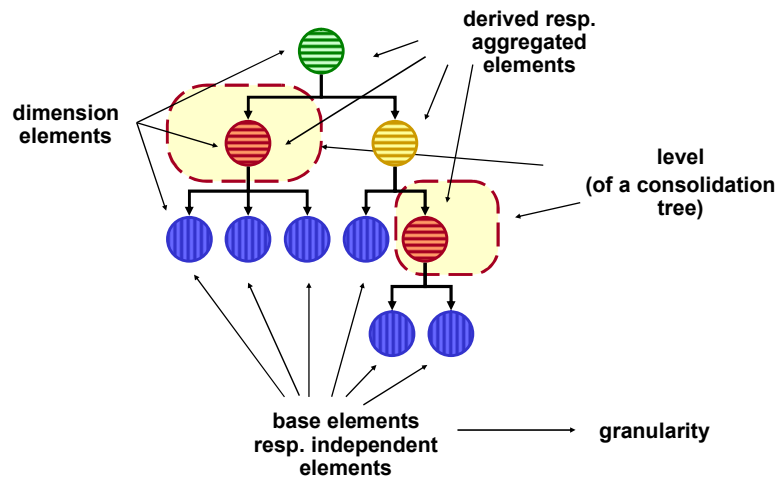
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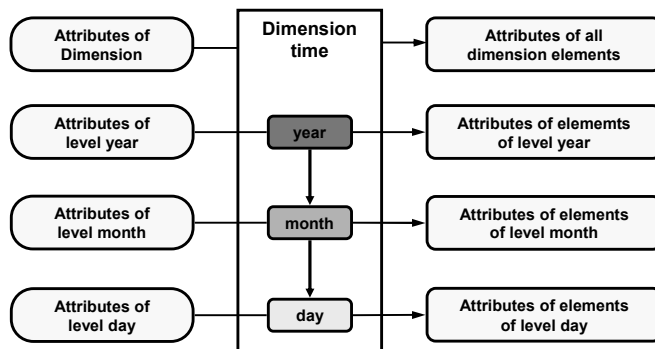
## Dimensions and balanced hierarchies



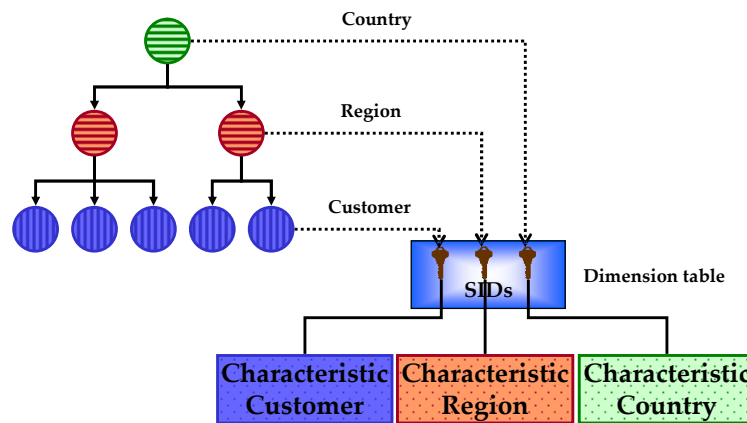
## Unbalanced hierarchies



## Attributes



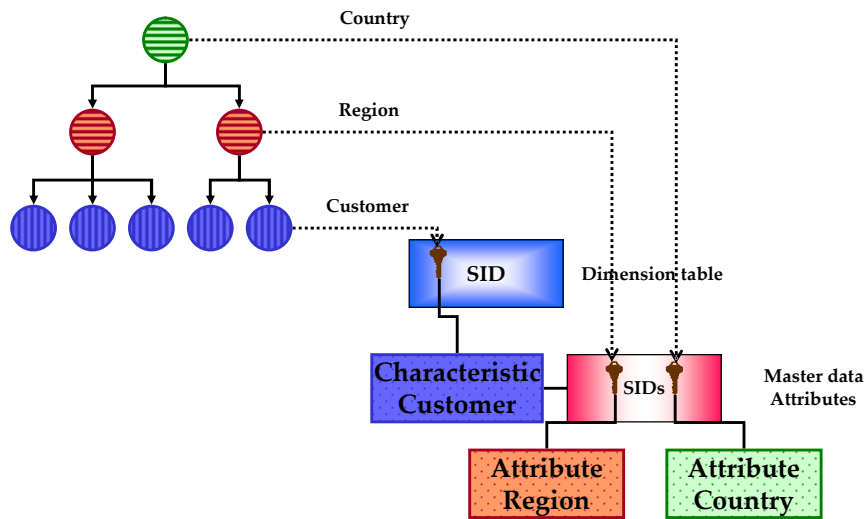
## Hierarchies within a dimension via characteristics



## Hierarchies within a dimension via characteristics

- each level is represented by an InfoObject → number of levels should be fixed
- generally faster than attributes and external hierarchies
- include the higher hierarchical levels to aggregates
- no predefined drill down paths

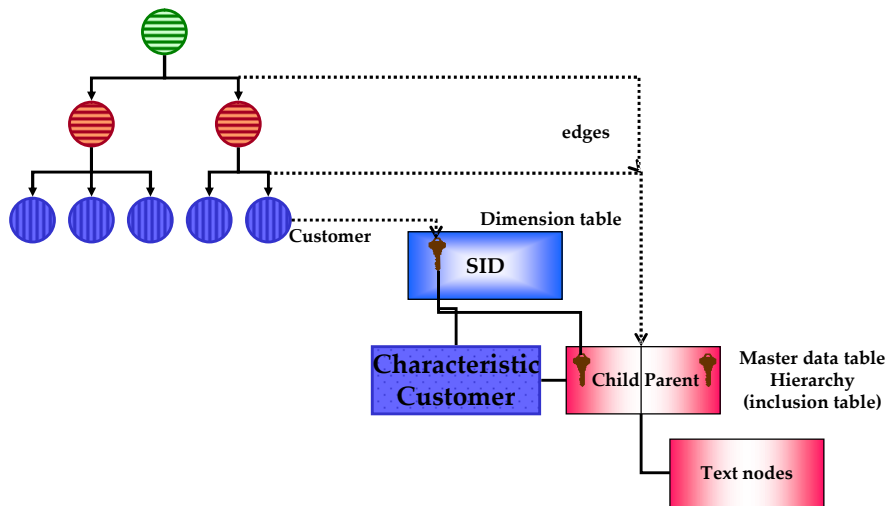
## Navigation attributes as basis of hierarchical structures



## Navigation attributes as basis of hierarchical structures

- each level is represented by an InfoObject → number of levels should be fixed
- include the higher hierarchical levels to aggregates
- no predefined drill down paths
- bad Performance without aggregates
- increased flexibility for reorganisation

## External hierarchies in BW



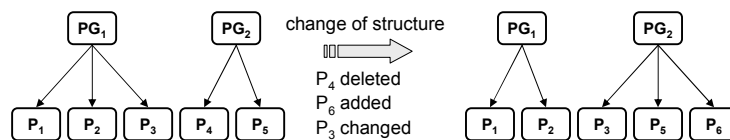
## External hierarchies in BW

- Reasonable in the case of frequent changes of dimension structure
- Enables unbalanced structures
- Several hierarchies possible per Info-Object
- Poor performance similar to navigational attributes
- Problems with big hierarchies
- In the case of time dependency only time stamping the whole structure enables aggregates

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## Time dependency: changes in consolidation trees



## Example of “Slowly Changing Dimensions”

### Product dimension in 2003-04

Product	Productgroup
P A	PG X
P B	PG X
P C	PG Y
P D	PG Y

### Product dimension in 2003-05

Product	Productgroup
P A	PG X
P B	PG Y (changed)
P C	PG Y
P D	PG Y
P E	PG Y (new)

### Fact table

Product	Period	Revenue
P A	2003-04	100
P B	2003-04	100
P C	2003-04	100
P D	2003-04	100
P A	2003-05	100
P B	2003-05	100
P C	2003-05	100
P D	2003-05	100
P E	2003-05	100

## Reporting requirements - Szenarios

### Reporting scenario actual structure

Productgroup	Rev. 2003-04	Rev. 2003-05
PG X	100	100
PG Y	300	400

### Reporting scenario old structure

Productgroup	Rev. 2003-04	Rev. 2003-05
PG X	200	200
PG Y	200	200

### Reporting scenario historical truth

Productgroup	Rev. 2003-04	Rev. 2003-05
PG X	200	100
PG Y	200	400

### Reporting scenario comparable results

Productgroup	Rev. 2003-04	Rev. 2003-05
PG X	100	100
PG Y	200	200



## Scenario I : Report with actual structure

Product dimension in 2003-05

Product	Productgroup
P A	PG X
P B	PG Y (changed)
P C	PG Y
P D	PG Y
P E	PG Y (new)

Fact table

Product	Period	Revenue
P A	2003-04	100
P B	2003-04	100
P C	2003-04	100
P D	2003-04	100
P A	2003-05	100
P B	2003-05	100
P C	2003-05	100
P D	2003-05	100
P E	2003-05	100

Productgroup	Revenue 2003-04	Revenue 2003-05
PG X	100	100
PG Y	300	400

## Query path „actual structure“ with navigational attributes

S-table of Productgroup

Productgroup SID	Productgroup
4711	PG X
4712	PG Y

X-table of Product

Product SID	Product	Productgroup SID
1001	P A	4711
1002	P B	4712
1003	P C	4712
1004	P D	4712
1005	P E	4712

Fact table

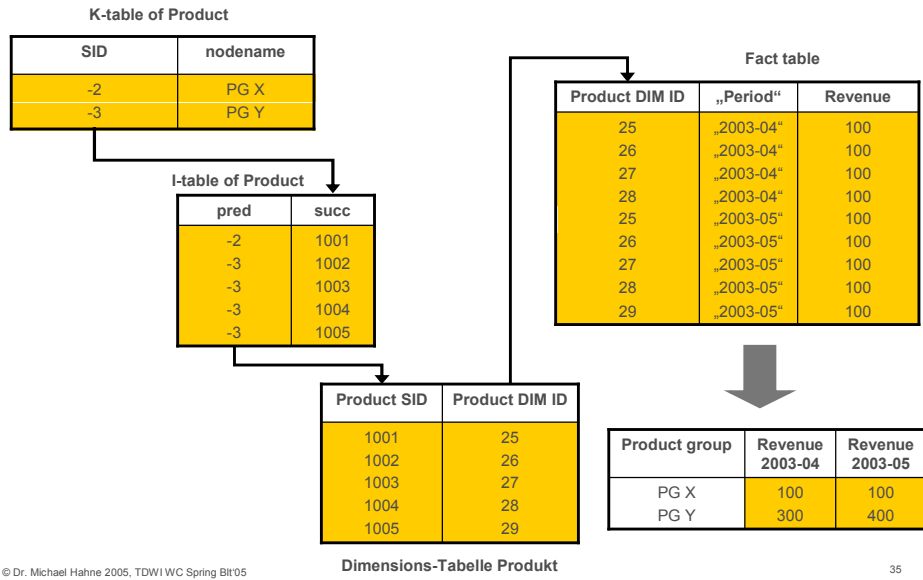
Product DIM ID	„Period“	Revenue
25	„2003-04“	100
26	„2003-04“	100
27	„2003-04“	100
28	„2003-04“	100
25	„2003-05“	100
26	„2003-05“	100
27	„2003-05“	100
28	„2003-05“	100
29	„2003-05“	100

Product SID	Product DIM ID
1001	25
1002	26
1003	27
1004	28
1005	29

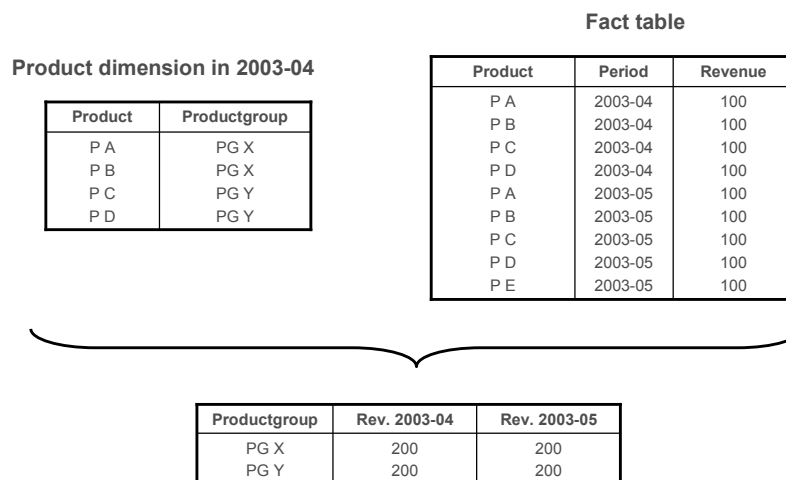
Productgroup	Revenue 2003-04	Revenue 2003-05
PG X	100	100
PG Y	300	400

Dimension Table Product

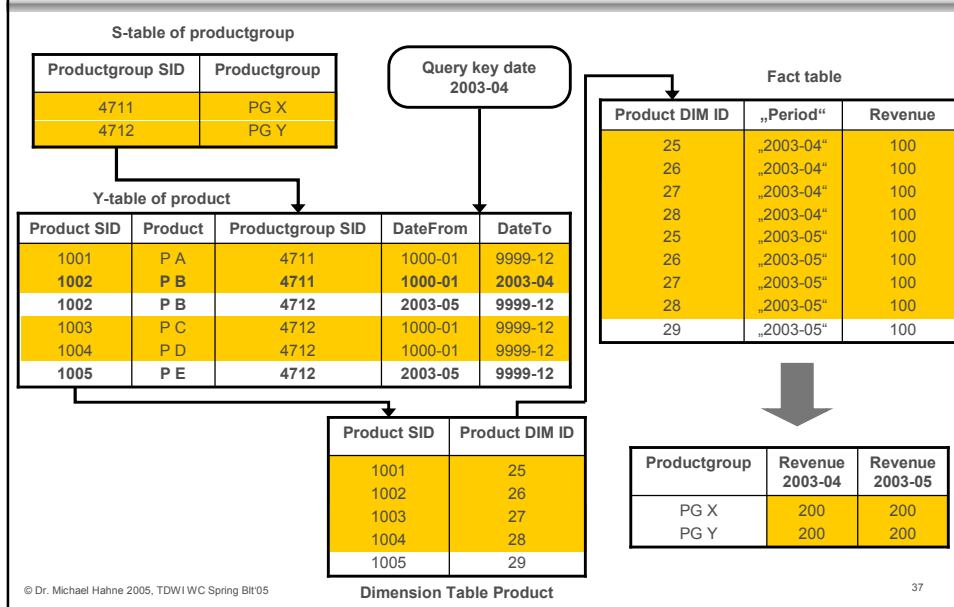
## Query path „actual structure“ with external hierarchy



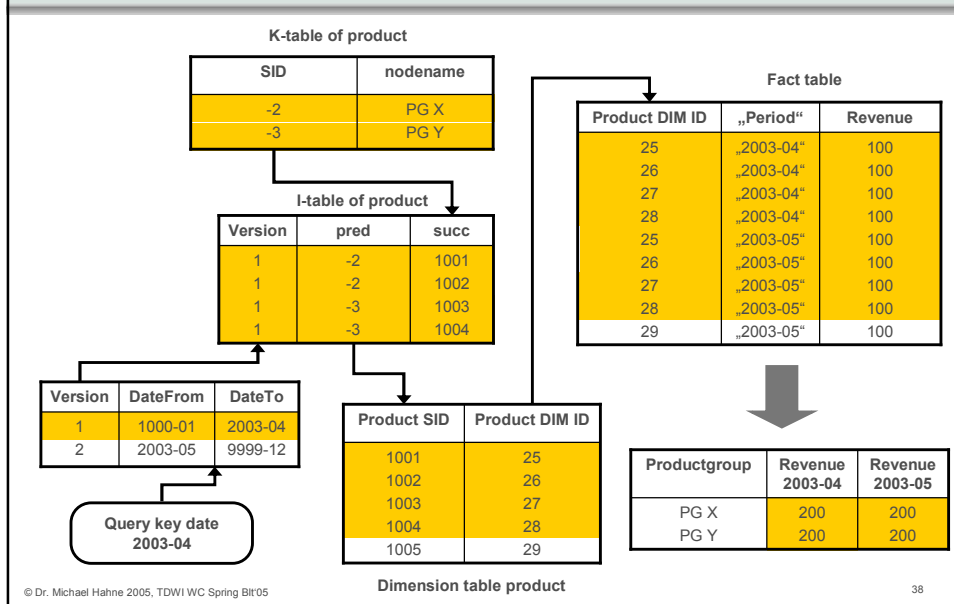
## Szenario II : Report with old structure



## Query path „old structure“ with time-dep. nav. attributes



## Query path „old structure“ with time-dependent hierarchy



## Szenario III : Report with historical truth

### Product dimension in 2003-04

Product	Productgroup
P A	PG X
P B	PG X
P C	PG Y
P D	PG Y

### Product dimension in 2003-05

Product	Productgroup
P A	PG X
P B	PG Y (changed)
P C	PG Y
P D	PG Y
P E	PG Y (new)

### Fact table

Product	Period	Revenue
P A	2003-04	100
P B	2003-04	100
P C	2003-04	100
P D	2003-04	100
P A	2003-05	100
P B	2003-05	100
P C	2003-05	100
P D	2003-05	100
P E	2003-05	100

Productgroup	Rev. 2003-04	Rev. 2003-05
PG X	200	100
PG Y	200	400

## Query path „historical truth“ with characteristics

### S-table of productgroup

Productgroup SID	Productgroup
4711	PG X
4712	PG Y

### Fact table

Product DIM ID	„Period“	Revenue
25	„2003-04“	100
26	„2003-04“	100
27	„2003-04“	100
28	„2003-04“	100
25	„2003-05“	100
30	„2003-05“	100
27	„2003-05“	100
28	„2003-05“	100
29	„2003-05“	100

Product SID	Productgroup SID	Product DIM ID
1001	4711	25
1002	4711	26
1002	4712	30
1003	4712	27
1004	4712	28
1005	4712	29

Dimension table product

Productgroup	Rev. 2003-04	Rev. 2003-05
PG X	200	100
PG Y	200	400

## Szenario IV : Report with comparable Results

### Product dimension in 2003-04

Product	Productgroup
P A	PG X
P B	PG X
P C	PG Y
P D	PG Y

### Product dimension in 2003-05

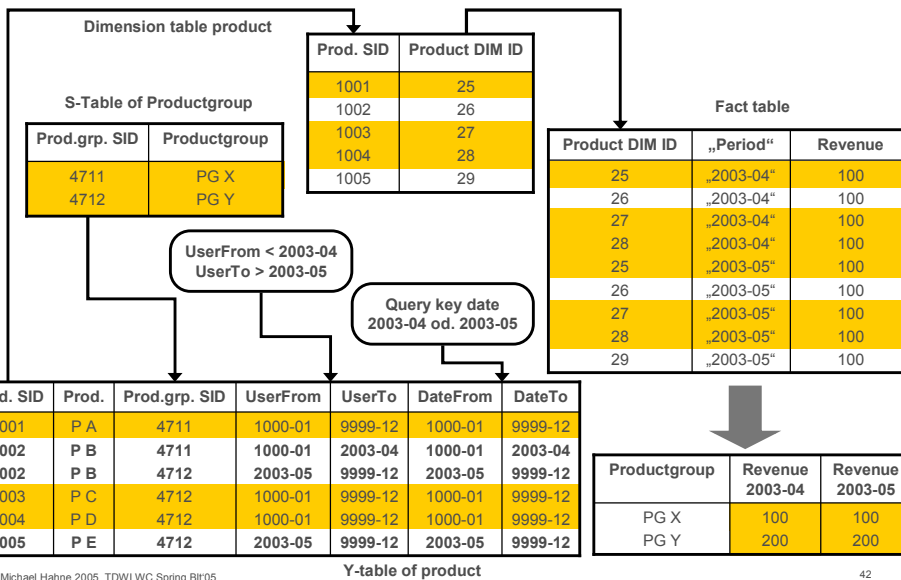
Product	Productgroup
P A	PG X
P B	PG Y (changed)
P C	PG Y
P D	PG Y
P E	PG Y (new)

### Fact table

Product	Period	Revenue
P A	2003-04	100
P B	2003-04	100
P C	2003-04	100
P D	2003-04	100
P A	2003-05	100
P B	2003-05	100
P C	2003-05	100
P D	2003-05	100
P E	2003-05	100

Productgroup	Rev. 2003-04	Rev. 2003-05
PG X	100	100
PG Y	200	200

## Query path „comparable results“ with time-dependent navigational attributes



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## Modelling Guidelines

- **Modelling of dimensions**
- **Design of Info-Provider**

## Guidelines for conceptual modelling of dimensions

- Number of dimensions should be between four and ten ( optimal between six and eight)
- Number of hierarchy levels (at most seven hierarchy levels)
- Number of elements per consolidation element (a maximum of fifteen to twenty elements is advisable)
- Determination of dimensions
  - 1:1-relationship unsuitable (-> attributes)
  - 1:N-relationship determine dimension hierarchy
  - M:N-relationship rather two different dimensions)

## Guidelines for logical modelling of dimensions

- Model characteristics with high cardinality as a line item dimension
- Attributes that change frequently should be modelled as own dimension (use line item where possible!)
- Group characteristics with very low cardinality (e.g. scenario) in one dimension in order to reduce the number of dimensions and to fulfill the restriction of 16 dimensions at most
- Distribute characteristics of a hierarchy with high cardinality to separate dimensions (parent characteristics in own dimension)

## Criteria for the decision-making aid of the logical modelling of dimension structures in the BW

- Versioning
- Scope
- Performance
- Navigational paths
- Unbalanced dimension structures
- Leaves with multiple parent elements
- Structural changes and reorganisation

## Hierarchy-Guideline: Versioning

External hierarchy	Hierarchy within a dimension (characteristics)	Hierarchy defined by navigational attributes
<ul style="list-style-type: none"> <li>• Transactional view isn't possible (no „as posted“)</li> <li>• Different types of views are possible (hierarchy versions and time-dependent hierarchies)</li> </ul>	<ul style="list-style-type: none"> <li>• Only the transactional view („as posted“) is possible</li> </ul>	<ul style="list-style-type: none"> <li>• Transactional view isn't possible (no „as posted“)</li> <li>• Time-dependent attributes enable different views</li> </ul>



## Hierarchy-Guideline: Scope

External hierarchy	Hierarchy within a dimension (characteristics)	Hierarchy defined by navigational attributes
Hierarchy is part of master data and valid for each Info-Cube in the system (where the underlying Info-Object is used)	Only valid in the Info-Cube	Hierarchy is part of master data and valid for each Info-Cube in the system (where the underlying Info-Object is used)

## Hierarchy-Guideline: Performance

External hierarchy	Hierarchy within a dimension (characteristics)	Hierarchy defined by navigational attributes
Aggregates should be used for good query performance	Good performance (even without aggregates)	Aggregates should be used for good query performance

## Hierarchy-Guideline: Navigational paths

External hierarchy	Hierarchy within a dimension (characteristics)	Hierarchy defined by navigational attributes
Drill-down path is predefined by the structure of the consolidation tree	Levels can be skipped because there isn't a predefined drill-down path (all characteristics in a dimension are equal)	Levels can be skipped because there isn't a predefined drill-down path (all navigational attributes of a characteristic are equal)

## Hierarchy-Guideline: Unbalanced dimension structure

External hierarchy	Hierarchy within a dimension (characteristics)	Hierarchy defined by navigational attributes
Unbalanced hierarchies are possible	Each characteristic corresponds to a certain level of the hierarchy, therefore only balanced structures are possible	Each characteristic corresponds to a certain level of the hierarchy, therefore only balanced structures are possible

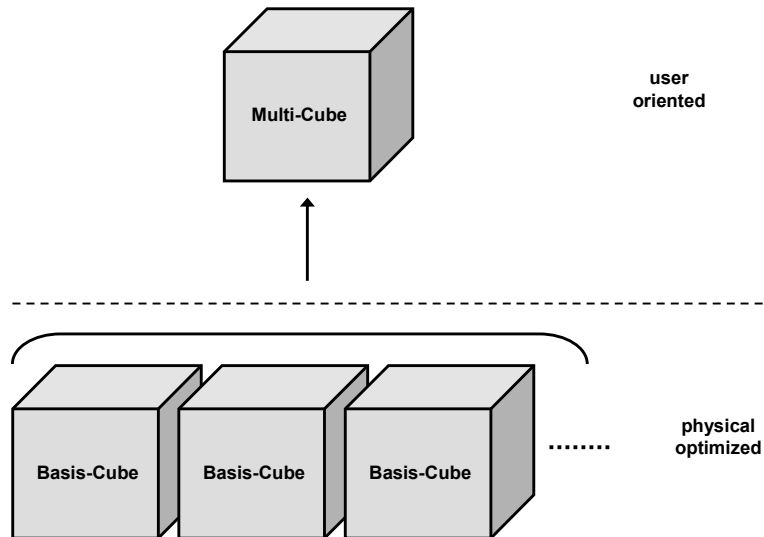
## Hierarchy-Guideline: Leaves with multiple parent elements

External hierarchy	Hierarchy within a dimension (characteristics)	Hierarchy defined by navigational attributes
Many-many relationships between the levels of the hierarchy are possible and consolidated correctly	Many-many relationships between hierarchy levels are only possible in the way they are defined by the transactions („as posted“ view)	Many-many relationships between levels are impossible

## Hierarchy-Guideline: Structural changes and reorganisation

External hierarchy	Hierarchy within a dimension (characteristics)	Hierarchy defined by navigational attributes
Quick change and reorganisation possible	Reloading cube(s) is required for reorganisation	Reorganisation is possible (additional attributes and/or changes of master data)

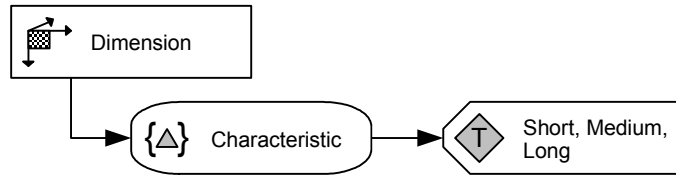
## 2-Layer concept of Cube-Modelling



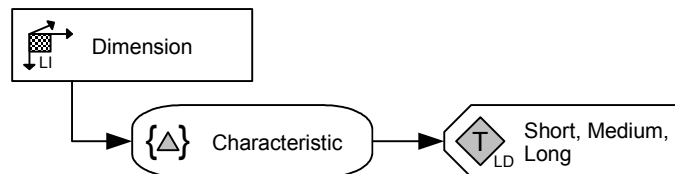
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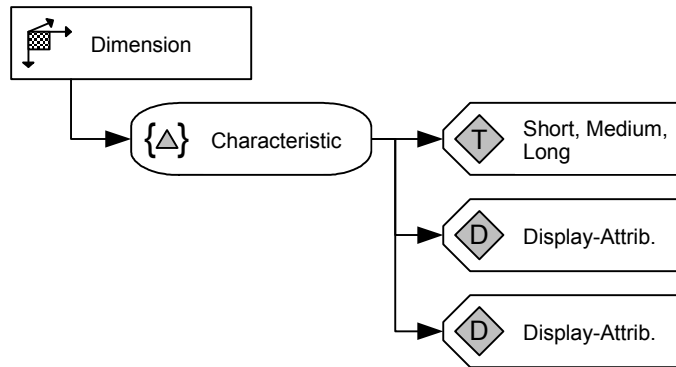
## Dimension with one characteristic



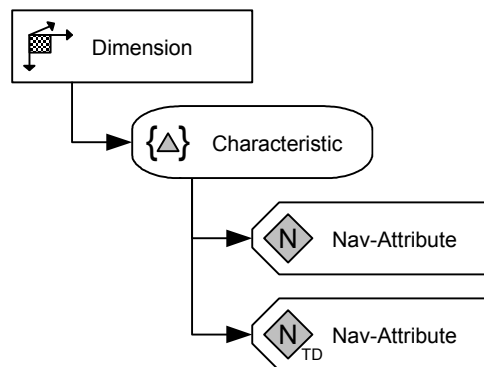
## Line-Item-Dimension



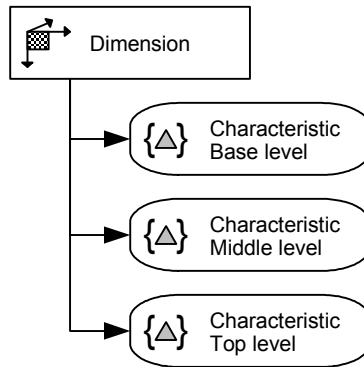
## Display attributes of a characteristic



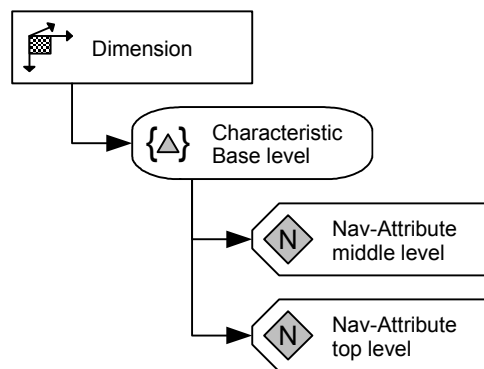
## Navigational attributes of a characteristic



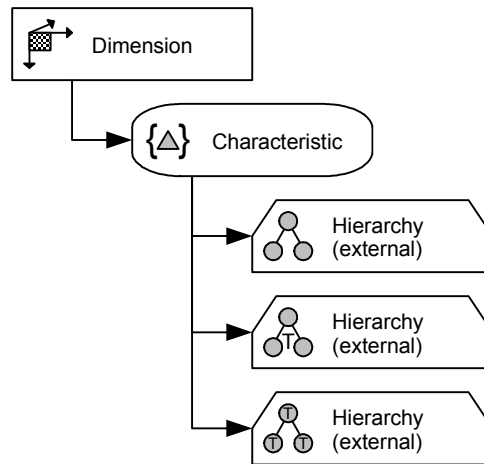
## Hierarchy within a dimension with characteristics



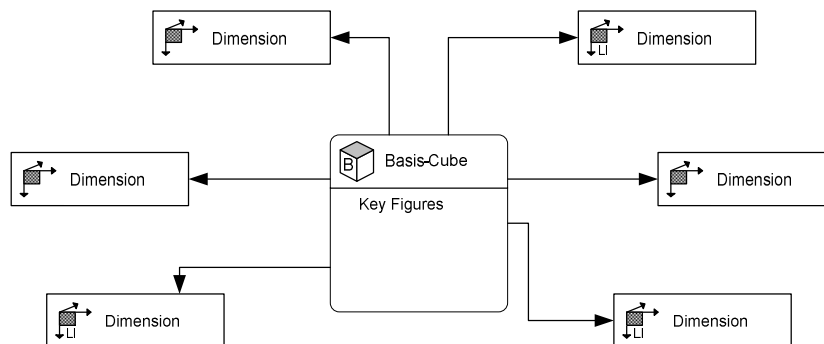
## Hierarchical structure with navigational attributes



## External hierarchy



## Modelling of Basis-Cubes





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