First Guidance...

LSA++ and SAP Business Warehouse powered by SAP HANA

Dynamic Dimensional Modeling through Dynamic Star Schemas and Partitioned Dimensions

Applicable Releases:

SAP Business Warehouse 7.5 powered by SAP HANA

Version 1.1

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1. Introduction

SAP Business Warehouse powered by SAP HANA offers a multitude of new features that enable more permeable, more open, more flexible, in short dynamic, dimensional data models overcoming traditional data warehousing borders. Removing borders between the Data Warehouse Layers will result in less persisted data stores - the LSA++ (Layered Scalable Architecture) for simplified Data Warehousing.

Removing borders between landscape components e.g. between SAP S/4HANA and SAP BW through virtualization instead of data movement will result in more responsiveness to business requirements - the LSA++ for Logical Data Warehousing.

This paper describes the SAP BW powered by SAP HANA Dynamic Star Schema, which is a new modeling pattern partitioning Dimensions (master data) of fact-table InfoProvider using Composite Providers or Open ODS Views of type fact.
Partitioning is a well-known technique when we have to manage complex situations in the broadest sense. We know it from DB-partitioning or from logical/semantical partitioning in SAP BW. Both are bound to
manage complex volume scenarios. We will explain that partitioning or splitting of Dimensions has a different target managing master data of complex entities hosting its attributes in different locations. With the Dynamic Star Schema and partitioned Dimensions we achieve a new degree of dynamics and flexibility without losing the business orientation of SAP BW.

The scenarios discussed in this paper were verified on SAP BW 7.5 SP02 powered by SAP HANA.

2. **SAP BW Classic Dimensional Modeling – SAP BW extended Star Schema, SAP BW powered by SAP HANA Flat Star Schemas**

Classic Dimensional Models in SAP BW has experienced an optimization in terms of performance from the original Extended Star Schema on row-store RDBMS to Flat Star Schemas on SAP HANA (and BWA) column-store. BW Flat Star Schemas on SAP HANA are known as HANA Optimized InfoCubes and as the possibility defining Star Schemas on DSOs for direct querying.

Despite the drastic performance gains of SAP BW Flat Star Schemas on SAP HANA, the modeling properties of a flat Star Schema do not differ from the extended Star Schema – Why?
The InfoObjects of type Characteristic play traditionally a central role setting up a classic dimensional model in SAP BW. InfoObjects define the dimensions of the SAP BW Star Schema. Having the InfoObjects defined in advance setting up a Star Schema in SAP BW is straight forward: The InfoObjects that describe the fact table (DSO, InfoCube) automatically define the associations to the dimensions described by the navigational attributes and hierarchies of an InfoObject. Thus the InfoObjects of a DSO or an InfoCube describe already the complete star schema.

This is a robust way of defining a star schema. If done properly it guarantees consistent, shared dimensions across the star schemas in an SAP BW Data Warehouse.

2.1 Limitations of SAP BW Classic Dimensional Modeling

Nevertheless this automated, not changeable association of dimensions via InfoObjects means limitations with respect to

- Flexibility and adaptability
- Maintenance and stability
- Support of modern federated DWH architectures

This becomes obvious if we look at complex DWH-entities like Material, Business-Partner, etc.

Complex Business Entities:

Customer example:

Challenges of master data modeling:
- Semantical different understanding of a Material
  - PBG – Product corporate
  - PRO – Sales Product
  - ART – Article
  - and a lot more: techn. materials, packaging....
- Elements of material hierarchy as material
- Multitude of attributes

The complexity derives from the fact that different organizational units have different views on an entity or even have different semantics for it. From DWH perspective this means

- Different attributes
- Different ownership of attributes
- Different sources of attributes
• Different stability of attributes
• Different quality and latency
• Different change frequency requirements
• ....

Resulting in volatility of a dimension, which is challenging if a dimension is modeled by a single InfoObject. Introducing additional attributes later on means always maintenance and changes of the productive
  • InfoObject and
  • ELT – (extraction, load, transformation) path

This impacts the overall stability and availability.

We can observe another issue of automated, not changeable association of dimensions if InfoObjects are erroneously used in an InfoProvider. E.g. the InfoObject that should be used is 0MATERIAL but in an InfoProvider occurs ZMATERIAL. This causes a model inconsistency and redundant master data loads that can only resolved via a costly remodeling.
3. Dynamic Dimensional Modeling in SAP BW powered by SAP HANA

SAP BW 7.5 powered by SAP HANA comes with several new features and functions that enable a powerful, yet simple and dynamic way defining and maintaining the dimensional model:

- Separation of persistency modeling from semantics and associations modeling
- Field-based modeling in addition to InfoObjects
- Federation with external data

Each feature by itself and in combination with each other enables a new level of dynamics defining a dimensional model in SAP BW. Probably the most interesting pattern we call the SAP BW Dynamic Star Schema. The following chapter will elaborate this pattern step by step.

4. SAP BW Dynamic Star Schema - Separating Star Schema Modeling from Fact-Table Modeling

The SAP BW powered by SAP HANA Dynamic Star Schema gets its dynamics separating the fact table modeling from star schema modeling.

As an SAP BW powered by SAP HANA Dynamic Star Schema fact table may serve

- SAP BW InfoProvider whereby it is recommended to use the new DataStore Object (advanced) - in short DSO (advanced). Still possible are DSOs (classic) and InfoCubes
- Any table or DB-view (local or remote)

The SAP BW Dynamic Star Schema is modeled using as a rule of thumb

- CompositeProvider – on SAP BW fact-table InfoProvider of Integrated DWH/ Propagation Layer
  - Union-CompositeProvider on InfoProvider if you only want to define the Star Schema
- Open ODS view of type fact – on DB-table/ -view and field-based DSO (advanced) of the Raw DWH / Open ODS Layer that serve as fact tables

CompositeProviders and Open ODS views of type fact define

- Associations of master data (dimensions)
- Semantics for fields
It is important to note that also existing DSOs (classic) and InfoCubes may serve as fact table source for a Dynamic Star Schema using a CompositeProvider! (Note: Open ODS Views do not work on DSO (classic) or InfoCubes.)

The definition of a CompositeProvider on top of DSOs (classic) and InfoCubes is always recommended yet not enforced.

4.1 Scenario 1: SAP BW Dynamic Star Schema – CompositeProvider on InfoProvider w. InfoObjects

First let’s investigate how a star schema definition using a CompositeProvider works on an InfoProvider (fact-table) that is built only with InfoObjects

Scenario 1:

- SAP BW defines all persisted parts of the Dynamic Star Schema
- Fact Table: a DSO (advanced) (or existing DSO (classic) / InfoCube) InfoProvider with only InfoObjects
- Dimensions: InfoObjects
- Dynamic Star Schema: a CompositeProvider on top of the InfoProvider. The CompositeProvider defines the dimensions - associations to InfoObjects and Navigational Attributes
SAP BW Dynamic Star Schema observations:

- The CompositeProvider proposes the InfoObjects of the InfoProvider as standard associated master data (dimensions)

- Navigational Attributes of associated InfoObjects are defined
  - at CompositeProvider level for a DSO (advanced)
  - at DSO (classic) / InfoCube: at CompositeProvider level and at DSOs (classic)/InfoCubes level

- Multiple CompositeProviders on the same fact-InfoProvider define multiple Star Schemas

SAP BW Dynamic Star Schema and InfoObject defining standard Dimension Association:

1. A CompositeProvider with standard association for InfoObjects offers the same functionality like the automated InfoObject association in a DSO (classic)/InfoCube.
2. A CompositeProvider offers the same abstraction to the InfoProvider persistency like the MultiProvider in the Extended/Flat Star Schema.
4.2 Scenario 2: SAP BW Dynamic Star Schema - Virtual Remodeling of InfoProvider

Now we introduce the new possibility actively designing an SAP BW star schema. I.e. we can model the associations of master-data (dimensions)!
Firstly let’s stick to Dimensions defined by InfoObjects.
Scenario 2: Like Scenario 1 – in addition

- The standard association of an InfoProvider InfoObject is exchanged with another InfoObject

BW on HANA Dynamic Dimensional Modeling
Scenario 2: BW Dynamic Star Schema - Virtual Remodeling of InfoProvider

SAP BW Dynamic Star Schema observations:
- The association of an InfoObject is maintainable. You can replace the standard association of the source InfoObject with another InfoObject that fits (format, length and of course content)

- SAP Business Warehouse Dynamic Star Schema and Remodeling of InfoObjects of an InfoProvider InfoObject:
  3. The SAP BW Dynamic Star Schema allows exchanging the standard association derived from the fact table InfoProvider InfoObject with another InfoObject. That means a remodeling of erroneously modeled InfoProviders (also DSOs (classic) and InfoCubes) using an improper InfoObject can be done on virtual CompositeProvider level
4.3 Scenario 3: SAP BW Dynamic Star Schema - Partitioned Dimensions using InfoObjects

Now as we know that we can model/ influence the association of an InfoObject of an InfoProvider fact-table i.e. that we can influence the dimension assignment, we want to go a step further assigning two different InfoObjects to the same InfoObject of a fact-InfoProvider:

Scenario 3: Like Scenario 1 – in addition
- New attributes of an existing entity arrive. The new attributes have a different owner/source than the attributes of the existing InfoObject. Thus we have a situation like described in chapter 2.1:
  - We model the new attributes in a new InfoObject
  - In a CompositeProvider we want to associate to the InfoProvider (Fact-table) InfoObject the new InfoObject in addition to the existing InfoObject association

**SAP BW Dynamic Star Schema observations:**
- You can map a source InfoObject multiple times to CompositeProvider target-fields (target area).
  - Edit the target-field name and change the name (which is as standard the name of the InfoObject) to a different name – the assignment from source to target persists
  - Drag the source InfoObject again to the new target field. Now we have the source InfoObject assigned to two CompositeProvider target-fields
In the CompositeProvider output area you can now associate different InfoObjects (dimensions) to the CompositeProvider fields.

Define Navigational Attributes for each associated InfoObject.

All this applies also to DSOs (classic) and InfoCubes InfoProviders as source object of a CompositeProvider.

**BW on HANA Dynamic Dimensional Modeling**

**Partitioned, multiple Dimensions via InfoObject Associations in Composite Provider**

Attributes of a DWH entity behave differently caused by different owners: corporate, business unit, country, etc.

- Attributes of different owners should not be stored together in a single dimension.
- It is recommended to store the DWH-entities attributes of different owners from different sources in dedicated BW objects.

SAP BW Dynamic Star Schema and Partitioned Dimensions via InfoObjects:

4. You may partition the attributes of an entity across multiple InfoObjects.
   - Different ownership and properties drive the partitioning of the attributes into different InfoObjects.
   - The CompositeProvider allows assigning a source InfoObject to multiple CompositeProvider fields. The CompositeProvider fields can then be associated with different InfoObjects.
o All this applies also to DSO/InfoCubes InfoProviders as source object of a CompositeProvider
o A CompositeProvider defining a Dynamic Star Schema brings the partitioned dimensions together again

4.4 Scenario 4: SAP BW Dynamic Star Schema - Partitioned Dimensions across LSA++ Layers

Ok, what’s next? The DWH world has changed and we find the new paradigm of virtualization instead of persisting data. The answer of the LSA++ is propagating permeability and emancipation of the layers
  o LSA++ layer permeability means transferring only those data to a subsequent layer if they experience a significant transformation or significant increase of service offering
  o LSA++ layer emancipation means that any layer within the DWH and outside of the DWH provides own value being a potential target for querying and analytics

Scenario 4: Like Scenario 3 - in addition
- New attributes of an existing entity arrive. The new attributes have a different owner/source than the attributes of the existing InfoObject.
- We model a DSO (advanced) with the new attributes defined as fields and store the new ,master data in the DSO (advanced)
- The ADSO is a member of the Raw DWH/ODS Layer
- We define an Open ODS view of type master on the (master data) ADSO defining semantics, text handling etc.
- In a CompositeProvider we want to associate the new Open ODS view type master in addition to the InfoProvider (Fact-table) InfoObject

BW on HANA Dynamic Dimensional Modeling
Scenario 4: BW Dynamic Star Schema - Partitioned Dimensions across LSA++ Layers

BW Dynamic Star Schema observations:
  o In a CompositeProvider you can assign a source InfoObject to multiple CompositeProvider target-fields. The CompositeProvider target-fields can then be associated with different InfoObjects or Open ODS views of type master.

SAP BW Dynamic Star Schema observations:

BW Dynamic Star Schema modeling

Define Composite Provider

InfoObject 1
InfoObject 2
PROD_CORP
PROD_CORP 2
Key Fig. 1
Key Fig. N

Define DSO (advanced)
(Advanced, DataCaravel)

Multiple Associations to source InfoObject as partitioned dimensions
  - LSA++ Simplified DWH – Associations of Open ODS Views integrating Row DWH/ODS Layer
  - New-Attributes of Open ODS Views

Multiple Associations to source InfoObject as partitioned dimensions

Master Open ODS View

Fields (and InfoObjects)

DSO (advanced)

Generate Dimensions table(s)
SAP BW Dynamic Star Schema and Partitioned Dimensions across LSA++ Layers:

5. You can partition the attributes of an entity into various InfoObjects and/ or DSOs (advanced). The choice depends on the layer- and service requirements

- Using Fields defining a DSO (advanced) means an additional level of dynamics in dimensional modeling (bottom up).
- An Open ODS view of type master defines semantics, authorizations, text handling etc. on fields of the master data stored in a DSO (advanced)
- A CompositeProvider may associate Open ODS views of type master like InfoObjects. SAP BW Dimension Partitioning using Open ODS views of type master facilitates dimensions across LSA++ Layers within SAP BW. Again a CompositeProvider on top of a fact-InfoProvider brings the partitioned dimensions together.

4.5 Scenario 5: SAP BW Dynamic Star Schema – Partitioned, Federated Dimensions

LSA++ layer permeability and emancipation is not restricted to the SAP BW-DWH itself. The layer regardless where they reside (in- or outside of the SAP BW DWH) may overlap and the borders are no longer strict. Any system in the landscape is a potential source of information valid integrating with the SAP BW DWH core content.

Scenario 5: Like Scenario 4 – it differs in

- New attributes of an existing DWH-entity from a remote source shall firstly be virtually integrated
- Modeling a persistency in SAP BW (InfoObject, DSO (advanced)) is for now not an option
- A SAP HANA remote source connection exists (SAP HANA smart data access/ Integration)
- We define an Open ODS view of type master on a table/ view offered by the remote source
- SAP BW generates a HANA virtual table for the Open ODS View
- In the Open ODS view type master we assign semantics, defining text handling etc.
- In a CompositeProvider we associate to fact-data the new Open ODS view type master on remote master data in addition to an existing association to an InfoObject
SAP BW Dynamic Star Schema observations:

- The CompositeProvider facilitates associations to Open ODS views of type master regardless of the location of master data source

  This applies also to DSOs (classic) and InfoCubes InfoProviders as source object of a CompositeProvider.

- SAP BW Dynamic Star Schema and Partitioned, Federated Dimensions:

  6. SAP BW Dimension Partitioning enables solutions

    - Where certain attributes of a DWH-entity reside inside SAP BW (InfoObject or DSO (advanced) hosted) and others outside of SAP BW offered as DB-table/view

    - Where SAP BW offers cleansed, consistent valued attributes of an entity and the non-SAP BW source offers e.g. real-time valued attributes

  7. Open ODS views of type master

    - Define those parts of a dimension (or an entire dimension) that reside outside of SAP BW regardless whether the attributes reside on the local HANA-DB or on a remote DB.

    - Address non-SAP BW master data and defining semantics on non-SAP BW master data.

    - Generate an SAP HANA virtual table on a remote table/view.

    - Offer strong format transformation capabilities for source fields

    - Offer a service-level orientation enabling transition of virtualization to SAP BW persisted storage (DSO (advanced))

  8. Again a CompositeProvider on top of a fact-InfoProvider brings a partitioned, federated dimension together again.

  9. The partitioned dimension pattern enables federation of master data. It is an essential part of a modern SAP BW LSA++ for Logical Data Warehousing integrating with low effort/on short notice additional master data into our existing SAP BW dimensional model
**4.6 Scenario 6: SAP BW Dynamic Star Schema - Fact Table w. Fields and Partitioned Dimensions**

The dynamics of dimensional modeling in SAP BW powered by SAP HANA is not restricted to master data. Also modeling fact data with DSOs (advanced) provides additional flexibility and dynamics using fields instead or in addition of InfoObjects.

Scenario 6: Like Scenario 4/5 but differs in

- The fact-table InfoProvider is a DSO (advanced) of the Raw DWH/ ODS Layer
  - The DSO (advanced) contains fields, InfoObjects are possible
  - The fields have SAP BW-compatible formats (e.g. no INTEGER formats s. below)
In a CompositeProvider we associate to fields of a fact-data DSO (advanced) multiple InfoObjects and/or Open ODS views of type master.

SAP BW Dynamic Star Schema observations:
- The CompositeProvider handles from modeling perspective InfoObjects and SAP BW-compatible fields in the same fashion i.e. Fields and InfoObjects of a fact-table DSO (advanced) can associate (partitioned) master data / dimensions.

SAP BW Dynamic Star Schema and Partitioned Dimensions on Fields of fact-table InfoProvider:
1. Using fields modeling a fact-table DSO (advanced) of the LSA++ ODS/ Raw DWH Layer brings additional dynamics offering solutions in SAP BW on SAP HANA. Using fields is a core pattern of LSA++ for Simplified Data Warehousing.

If the Fact-DSO (advanced) contains only fields with SAP BW-compliant formats (s. below) you can define directly a CompositeProvider on this ADSO. In the CompositeProvider you define
- Semantics of the fields (like aggregation behavior for key-figures)
- Associations of master data (InfoObject/Open ODS view type master) to fact-Fields, which works in the same way like for InfoObjects.
- Associations of partitioned master data (dimensions) to a fact-Fields.

4.7 SAP BW Dynamic Dimensional Modeling and Fields as Characteristics

Common for all the Dynamic Star Schema scenarios we discussed so far is that
- They are defined by a CompositeProvider
- The fact-data are hosted by SAP BW InfoProviders
- The InfoProviders are defined by
  - InfoObjects (DSO (advanced), DSO (classic), InfoCube) or
  - SAP BW-compatible Fields (DSO (advanced))
The emphasis is on Fields that are SAP BW-compatible. So it’s time talking about Fields.

In general using Fields defining fact- and master-data in SAP BW DSOs (advanced) or working with remote data means:

- More dynamic, cheaper bottom-up modeling, more options
- Working and integrating data that are closer to the source i.e. data of the Raw DWH/ ODS Layer or a remote source

It means on the other hand that the more we want to integrate or store raw data the more increases the need to handle a variety of data formats: SAP BW-formats / ABAP-formats / DB-Formats.

This is the reason that SAP BW powered by SAP HANA comes with two kind of views defining a Dynamic Star Schema allowing efficient models on either SAP BW related InfoProvider or raw/ field data related InfoProvider/ sources:

- The CompositeProvider
- The Open ODS view of type Fact

The following picture shows, which ABAP-Field-formats used in a DSO (advanced) can be handled by which SAP BW-view

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11. A CompositeProvider on a fact-table InfoProvider defines a Dynamic Star Schema if the InfoProvider contains only InfoObjects and/or SAP BW-compatible fields (no INTEGER fields)
12. An Open ODS views transforms source formats into SAP BW compatible formats on the fly as far as possible. (For example INTEGER formats to CHAR formats).
13. If an Open ODS view cannot transform source-field formats on the fly you can define an InfoSource on the source offering all the SAP BW transformation capabilities. The Open ODS views is then defined on the InfoSource
SAP BW Dynamic Star Schema and Open ODS Views of type Fact:

14. Like a CompositeProvider defines an Open ODS view of type fact a SAP BW Dynamic Star Schema on a fact-source, i.e.

- Semantics for fields (characteristic, key-figure, ...)
- Associations of master data (dimensions)
- Associations of partitioned master data (partitioned dimensions)

15. An Open ODS view of type fact is necessary integrating field-level fact-data for

- Remote fact data (DB-table/view)
- DSOs (advanced) with Change-log and Activation-Queue if not SAP BW-compatible field-formats exist

16. There are some restrictions to be observed with respect to Open ODS views on DSOs (advanced)

- An Open ODS view defined on a DSO (advanced) always accesses the active-table. It follows that an Open ODS view of type fact does not support
  - Near Line-Storage hosted data
  - Cube-like DSOs (advanced)
- That does not mean any restriction with respect to remote fact-data

4.8 Scenario 7: SAP BW Dynamic Star Schema - Fact Table Federation and Partitioned Dimensions

We cannot discuss here all the powerful functionality of Open ODS views of type fact. We only focus on the possibilities defining a Dynamic Star Schema.

With SAP BW powered by SAP HANA also remote fact data can be integrated on the fly using Open ODS views type fact.

Scenario 7:

- The fact-table resides outside and are offered as DB-table or DB-view (SQL- or HANA-View)
  - The table or view may reside locally on the same HANA-DB or on a remote data base accessible via SAP HANA smart data access
- We define an Open ODS view of type fact on such a source
- In the Open ODS view of type fact we associate to fact-fields multiple Open ODS views of type master and InfoObjects
SAP BW Dynamic Star Schema observations:

- Associating master data (dimensions) and even partitioned master data in an Open ODS views of type fact works like we know it from a CompositeProvider

SAP BW Dynamic Star Schema and Open ODS Views of type Fact:

17. Any Open ODS views allow exchanging the source against another source keeping the semantics and associations
   - Open ODS views are an important feature establishing the LSA++ Logical Data Warehouse
   - Open ODS views allow generation of a DataSource and a DSO (advanced) based on the Open ODS view definition

18. Open ODS views of type fact can be used in a CompositeProvider as part of a fact-table Union or Join

5. SAP BW Dynamic Dimensional Modeling and Performance

Elaborating the seven scenarios I hope that you got an impression how dynamic and flexible the dimensional modeling in SAP BW powered by SAP HANA can be.

But as always in life there is ‘no free lunch’. Gaining flexibility and dynamics in our model means on the other hand that we have to pay for it. The flexibility gains are achieved splitting the dimensions in smaller, more stable persisted pieces – resulting in partitioned dimensions. The partitioned dimensions have to be combined (joined) again and query time – that may mean a performance penalty depending on the join-complexity and partition sizes.

A second performance aspect comes with the usage of Fields. Using Fields instead of InfoObjects means costs interpreting the data at query time. Costs that you have formerly spent modeling and loading InfoObjects.
At the end virtualization must always pay back in business value at reasonable costs.

6. Summary

SAP BW powered by SAP HANA offers a powerful new way modeling a star schema: the SAP BW Dynamic Star Schema.

The SAP BW Dynamic Star Schema is modeled either by

- A CompositeProvider or by
- An Open ODS view of type fact

Depending on the fact-table source.

**BW on HANA Dimensional Modeling – BW on HANA Dynamic Star Schema (Details)**

It is powerful modeling pattern as the Dynamic Star Schema allows

- combining fact data and master data (dimensions) across the layer borders – within SAP BW and outside SAP BW (federation)
- combining partitioned master data (dimensions)

Spanning the SAP BW Dimensional Modeling across the DWH-layers and beyond is a fundament defining a modern SAP BW powered by SAP HANA LSA++.

Partitioning of master data of complex entities and bringing them virtually together again in a SAP BW Dynamic Star Schema offers a new degree of modeling flexibility and responsiveness to business requirements.
www.sap.com/about.html

SAP First Guidance Collection:
http://scn.sap.com/docs/DOC-28467