Data Vault Pipeline Description - Introduction and orientiation

Data Vault Pipeline Description is a concept and syntax to provide a central data format, that can be used by all tools, needed and used during the design and implementation of data vault platforms.

Even though it is generally an easy to use concept, the description of all provided elements and how to apply them needs some amount of words. Therefore the documentation is distributed over multiple articles.

This articles provides the overview, what you will find here.

PLEASE NOTE: **Knowledge about Data Vault modelling and loading procedures is essential to understand the concept.**

Please consult approriate literature, to learn Data Vault first.

The main articles

DVPD The Concept

The main article about the concept

- motivation of the concept
- Data Vault model and load requirements covered by the concept
- design descisions that have been made and are driving the syntax
- concepts behind not obviously syntax elements
- benefits of the concept for projects / consultants / tool developers

Data Vault method coverage and syntax examples

Provides examples for Data Vult model, especiall all model elements from the book "Building A Scalable Data Warehouse With Data Vault 2.0" by Dan Linstedt and Michael Olschimke from 2016. This is to proofe the completness of the concept.

Besides from that, this is a good entry point to understand the core syntax by looking on examples.

Reference of code syntax elements

Defines and explains syntax and structure of the DVPD core syntax.

This article is highly formalized. The order of elements is not always supporting a learing process.

Reference of model profile syntax

Defines and explains syntax and structure of the model profile syntax.

Additional appliance descriptions

DVPD development workflows

Provides different project scenarios, how the DVPD can help to enhance and decouple the development workflow.

Model and method investigations

Some requirements of the Data Vault Method are not directly described in the books, but are hidden as imlplicit conclusions. The following articles are investigating different aspects and explain the requirements that lead to some syntax concepts and design descisions.

Model topologies and basic field mapping variations

This article provides a complete set of model topologies, wich is an aggregation and combination of the basic patterns, described by the Data Vault modelling method.

Also it explains the basic variations how fields of the source record can be mapped.

Both aspects are used to proof the completness of the syntax via test cases.

Catalog of field mappings in relations

Loading relations is getting complex, when the same hub, link or satellite must be loaded more then once for a single record. This article investigates the scenarios and provides all the background needed to understand the relation concept in DVPD.

It also is one of the main drivers of testcases.

Catalog of field mappings in relations

Deletion detection is a complex problem on its own. To lighten the central concept aritcle, the investigation about all possible variaionts of deletion detection and how to describe it in a syntax is placed in this document.

Model topologies and basic field mapping variations about possible varitions of field

To understand the concept, basic knowledge about the Data Vault Modelling and loading is required.

To create a toolset for loading data into a data vault model, we need to determine the completeness of the toolset. This article investigates the different possibilites how the source fields are mapped, when multiple relations to the same hub are delivered in one row. Example to this requirement are:

- order, referring the customer in different roles (delivery and invoice).
- flight, referring the start and destination airport

Related Document

So also distribution especially according one field to many columns.

Definitions

When describing the data we classify the elements as follows:

field: smallest element of source data. Will always be processed as unity. Will be stored in one or multiple columns in the data vault.

source row: the fixed structure of fields, containing the data of one or more business-objects and their relation in a single row/unit.

table/hub/sat/link: a table in the data vault model

column: a column in a table of the data vault model

business key (bk): data, used to identify business objects

dependent child key (dc): data, containing relation attributes

table key/hub key/link key: The join key of data vault model tables

content: Data that is not used for identification, and just stored in the data model

Property of the source data

Tabularized

Data can be complex in multiple ways, especially when it comes to hierarchical data or document formats. The following approach requires the source data representation to be tabularized(all data is organized in Rows, every row contains all fields). Hierarchical data formats might need multiple transformations(one for each array).

Information types of data

To define the variety of mappings, it is necessary to clarify the types of information, represented by a source field.

- (Part of) the identification of an object
- Attribution or Measure of an object
- Attribution or Measure in a relation

Relations are expressed by having identifications of different objects in the same row.

Note: The data vault main stereotypes map to this classification as follows. hub=object / link=relation / satellite=attribution.

2nd Note: data that is stored in dependent child key columns of a link counts also as identification, since it is needed to address attributes, that are attached by the satellite

Properties of relation data

Relation data always must contain the busniess key columns of all participants. Data sets with multiple relations to the same object must contain multiple instances of the business key fields. It might (but must not) contain multiple instances of content data fields.

There are two flavours for relations in the source data.

- **Business object relation**, is the obvious flavour, covering any relation between businiess objects or self relation in hierarchies
- **data delivery relation**, expresses the circumstance that multiple objects are delivered in the same data row, but without any known business relation meaning

Data delivery relations might be misread as a lack of normalization in the source data. But as the words "without any known" indicate, it might just be a lack of knowledge about a hidden meaning.

DVDP expresses both relation flavours with the same syntax, but allows target models, that will not preserve the relation.

Denormalized data

When source data contains multiple fields, which target the same satellite columns without any different business keys, this might look like denormalized data and trigger the desire to normalize it into a multiactive satellite.

Data vault highly recommends to keep the denormalized structure in the raw vault to allow full auditibility. That's why DVPD core will not support any explicit syntax that allows denormalization in the load phase.

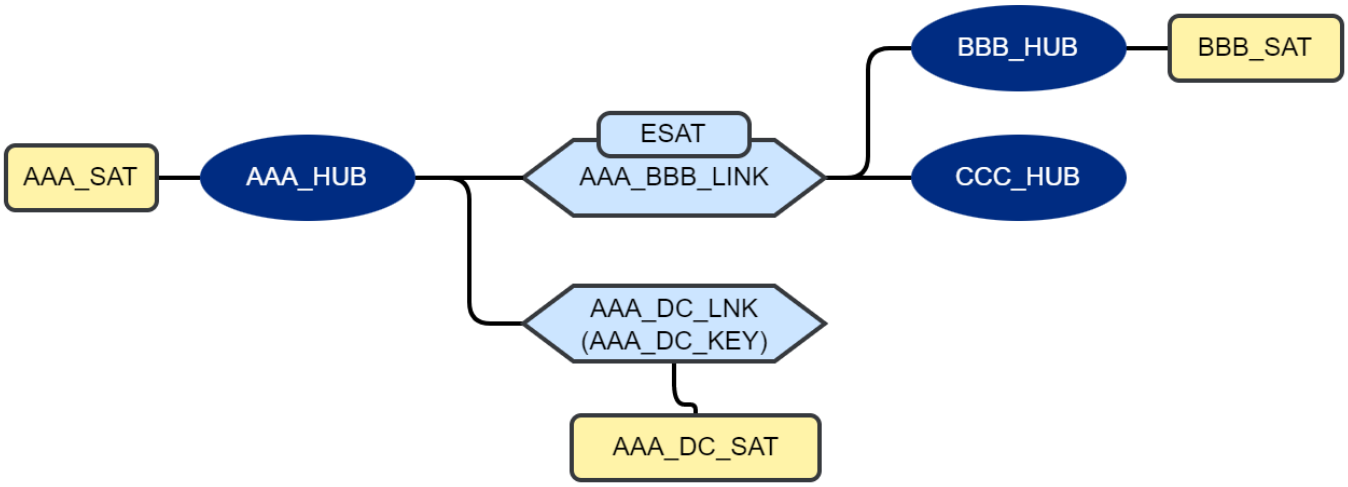
Model topologies

This section identifies the data vault model topologies, that have different properties regarding field mapping variations. The topologies will be used later describe the different mapping scenarions.

Simple relations

As long, as there are no fields mapped to the same data vault column, the mapping stays simple, regardless of the complexity of the model topology. For every table there is only one set of fields, that has to be used for hashing and loading.

The following example will be used as base to work out the possible mapping variations. It is designed to embed the most common simple models as a subset. By being capable to define this model with DVPD, the coverage of all subsets is also proved.



Multi relations to same hub

For sources that provide multiple relations to the same object in their data, the data vault model must provide a proper structure.
The following approaches are available to represent multiple relations

- a single link with multiple hub keys of the same hub. One for every kind of relation
- dedicated links to the hub for every kind of relation
- a single link but dedicated effectivity satellites for every kind of relation
- a single link with a dependent child key,declaring the relation type
- a single link with a multi active satellite, that contains a column to store the currenty valid relation types (not recommended)

These approaches can also be mixed up, wicht might happen on purpose or due to legacy.

side note: When the relation type is declared in the data(not by the field structure), this is a simple relation from the perspective of the data vault. The relation type is then stored in a dependent child key or a satellite of the link.

The example models in the investigation are created with 3 relations to the same hub, even though this is a rare constellation. This is necessary to prove completeness of the DVDP syntax. Only with 3 Elements or more, it is possible to create subsets with more than 1 element.

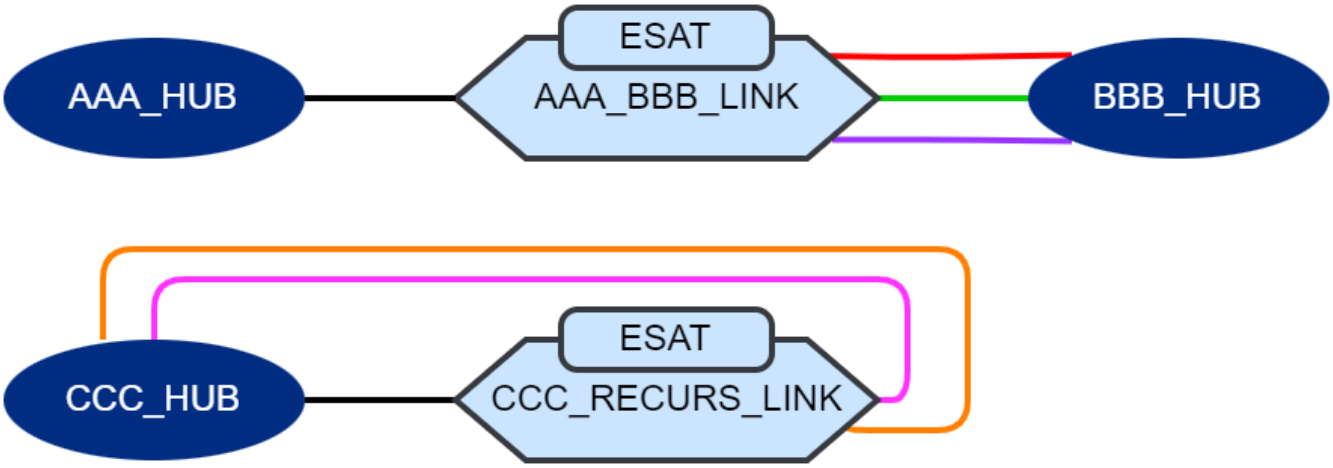
Satellites are omitted in the diagram for simplicity. There can be satellites on every hub and the effective satellites can be replaced by normal satellites, for adding more content to the pure relation information.

Multiple hub keys in link to the same hub (R)

This approach keeps the provided unit of work together but needs complete refactoring when another relation type needs to be added (See also the discussion of the concept in chapter 4.4.4 of the Data Vault 2.0 Book of Dan Linstedt). It uses the minimal amount of tables

- The link contains a hub key for every relation type to the hub
- The hub keys must be named properly to explain the kind of relation, they represent
- Depending on the meaning, one relation might be the "main" object. This relation might use the original hub key column name from the hub. Hierarchical links are a common example for this situation.
- to calculate the link key, all business keys for the multie referenced hub have to be assembled

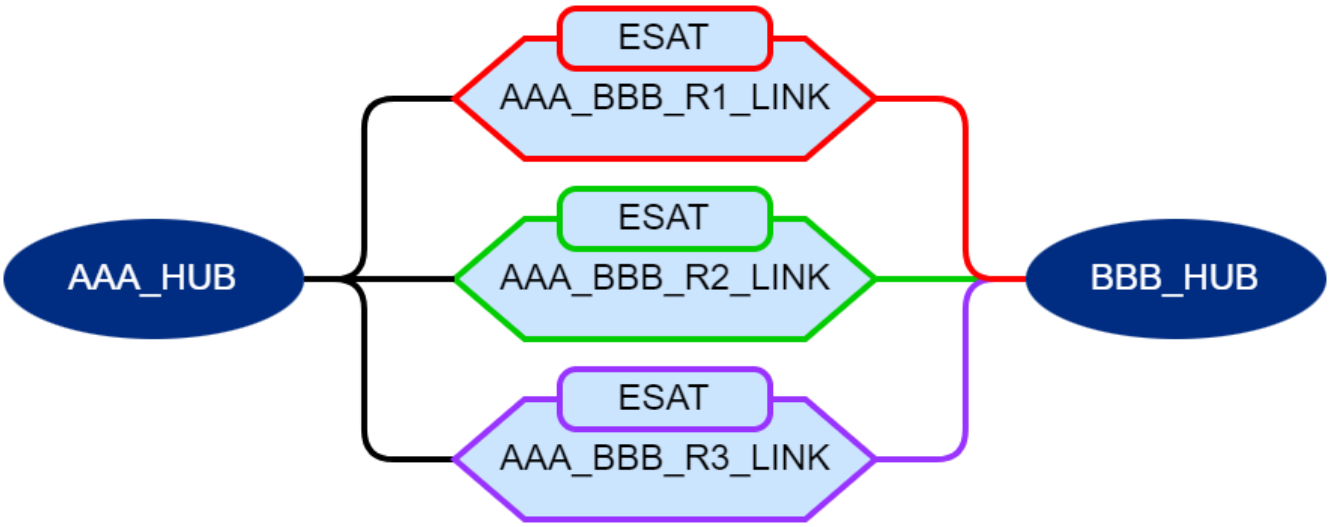
- Link and Esat must be loaded once.
- The multi referenced hub needs a load pass for every reference

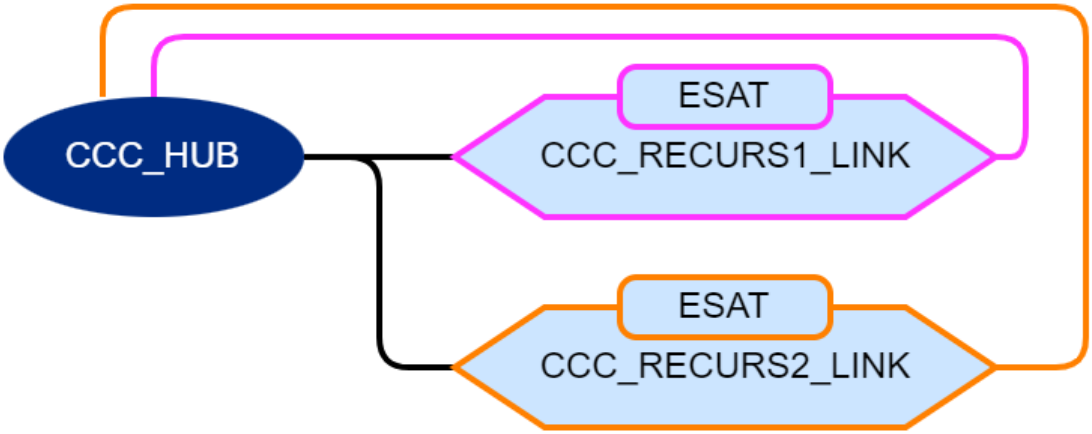


Dedicated link tables for every relation (L)

This approach is extendable without any impact to existing structures but might suffer from breaking the unit of work, and creating "phantom relations".(See also the discussion of the concept in chapter 4.4.4 of the Data Vault 2.0 Book of Dan Linstedt)

- the link key calculation only uses the business key fields for their specific relation
- every link contains one hub key for each linked hub
- every Link and Esat must be loaded once.
- The multi referenced hub needs a load pass for every reference

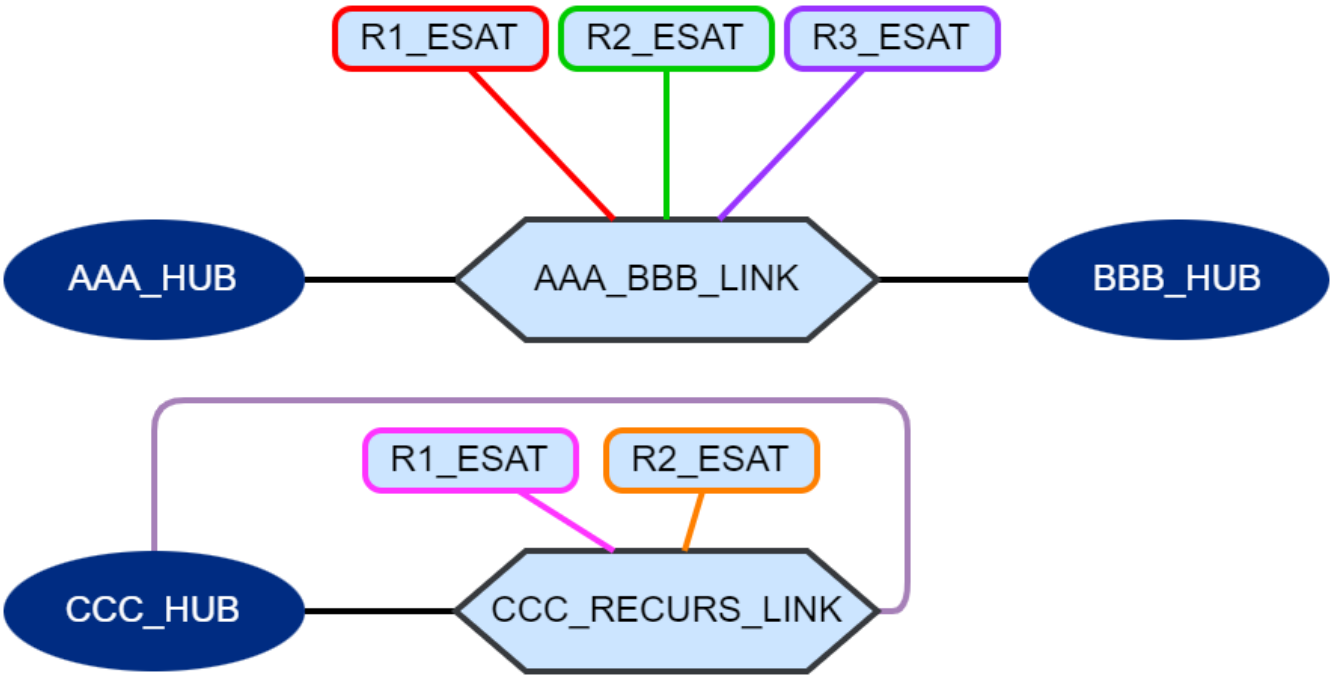




Single link table with relation specific effectivity satellites (E)

This method reduced the number of link tables , without loosing the flexibility of the multi link approach. It suffers from the same "phanton relation" issue.

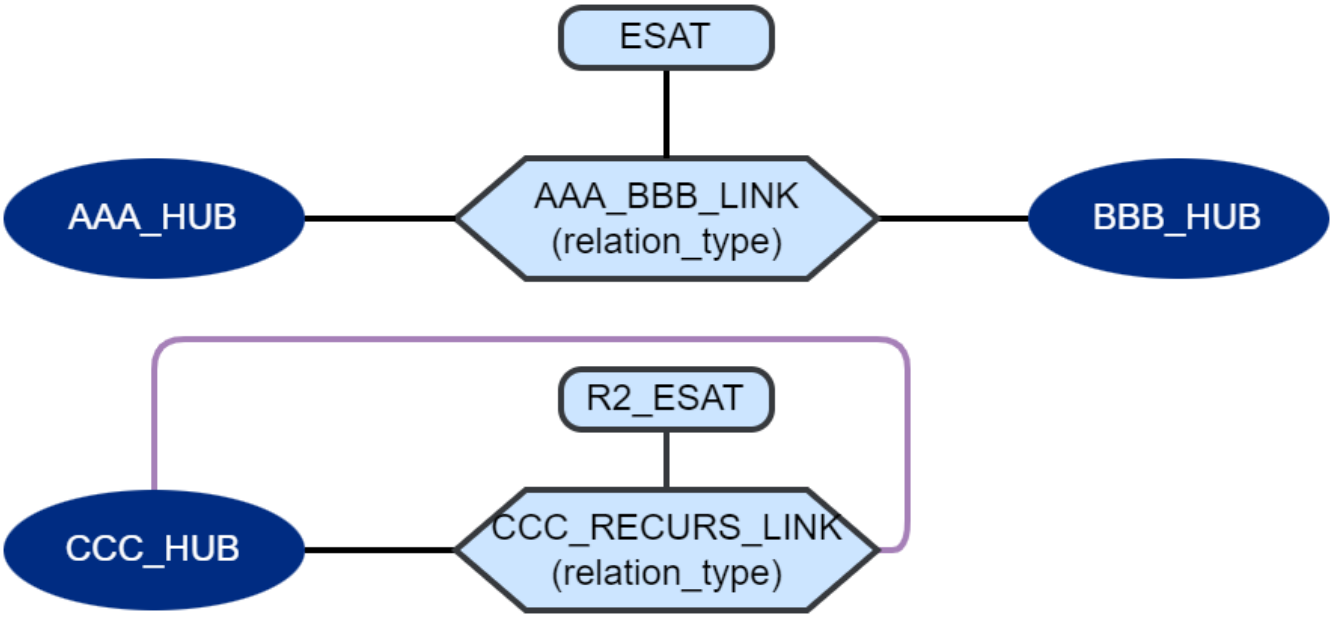
- the link only contains one reference to each hub
- for every relation, there must be a separate the link key calculation only using the business key fields for a specific relation
- every Esat must be loaded once
- The link and the multi referenced hub needs a load pass for every reference



Single link table with a dependent child key declaring the relation type (D)

This method uses the minimal amount of tables and allows extention of relations without any structure modification. It even can be extented without change of running pipelines, by just adding a new one for the new releations. On the downside it hides the different kind of relations in the data, instead of communicating it through model elements.

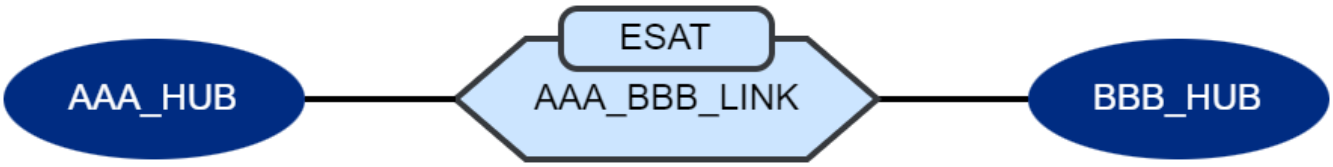
- the link only contains one reference to each hub
- for every relation, there will be a separate link key calculation only using the business key fields for a specific relation and the relation specific value in the dependent child key
- Link, esat and the multi referenced hub need a load pass for every reference



Normalize multiple relations (N)

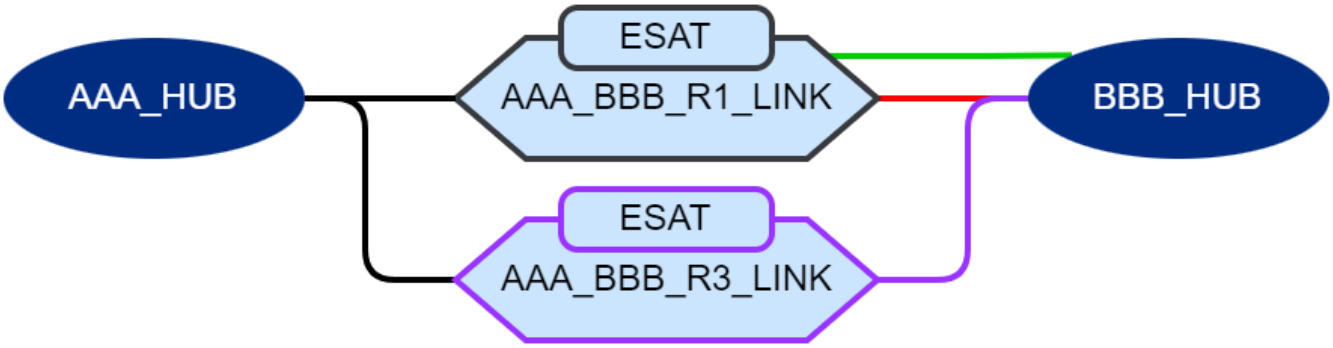
This approach omits any kind of structure to distinguish the different relations presented by the fields the same source row. This reduces the number of tables and connections to a simple model but will prevent a full reconstruction of the source dataset, since the precises field origin of the data gets lost.

- the link only contains one reference to each hub
- Link, esat and the multi referenced hub need a load pass for every reference



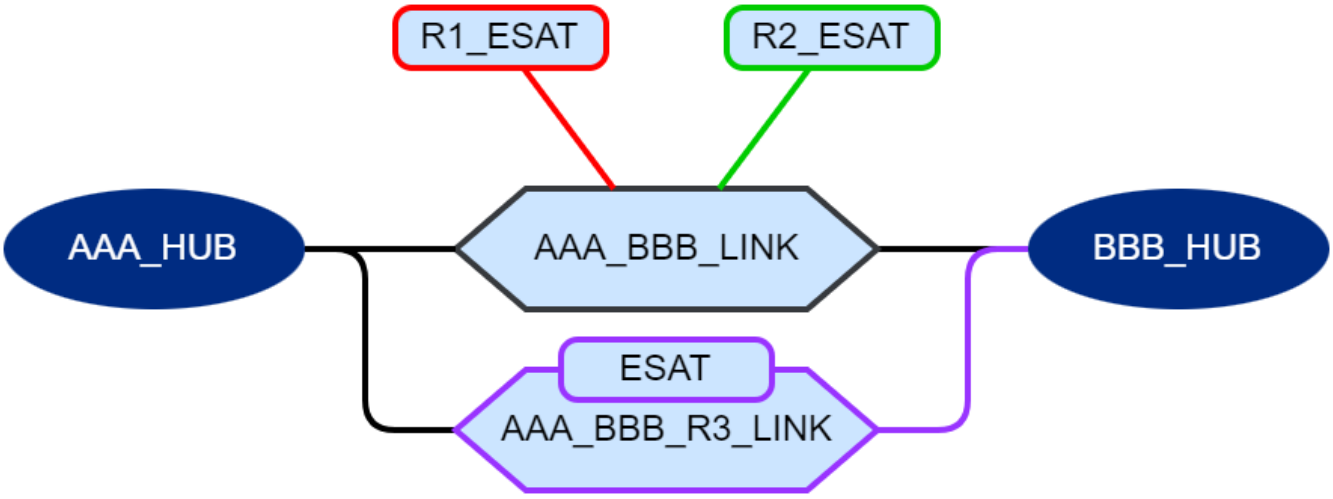
Mix of multi related link and normal link (R+L)

This model is a combinational edge case to challange the ablities of the DVPD syntax and compiler. It might occur through model legacy.



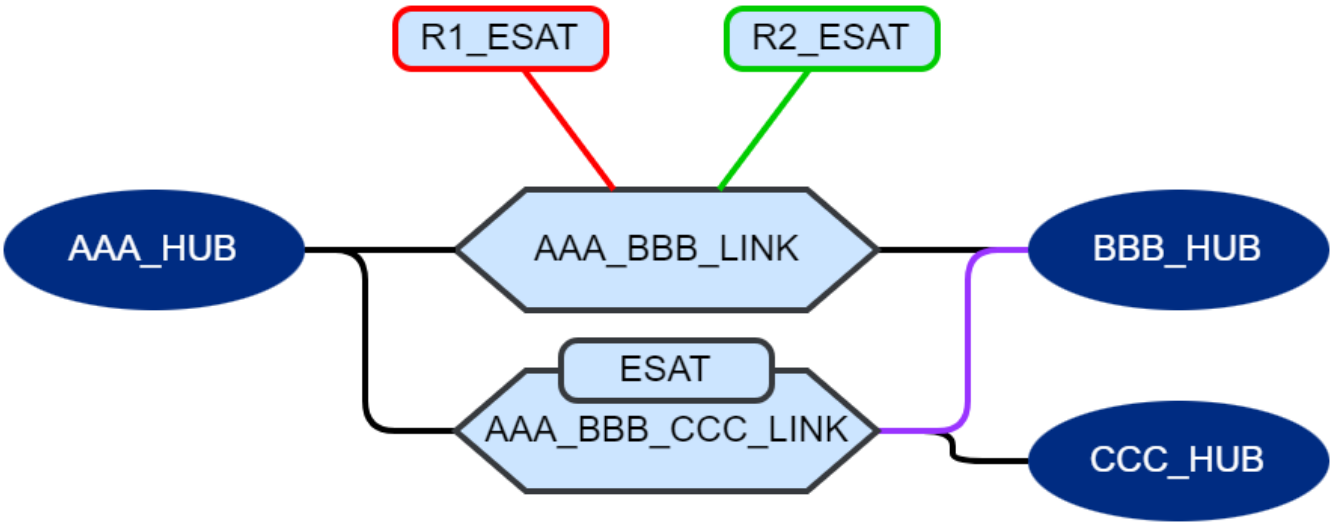
Relation specific effectivity satellites + parallel link (E+L)

This model is a combinational edge case to challange the ablities of the DVPD syntax and compiler. It might occur through model legacy.



Relation specific effectivity satellites + parallel link with 3rd hub (E+3)

This model is used to create an edge case for mapping combinations of attributes needed for the BBB_HUB.

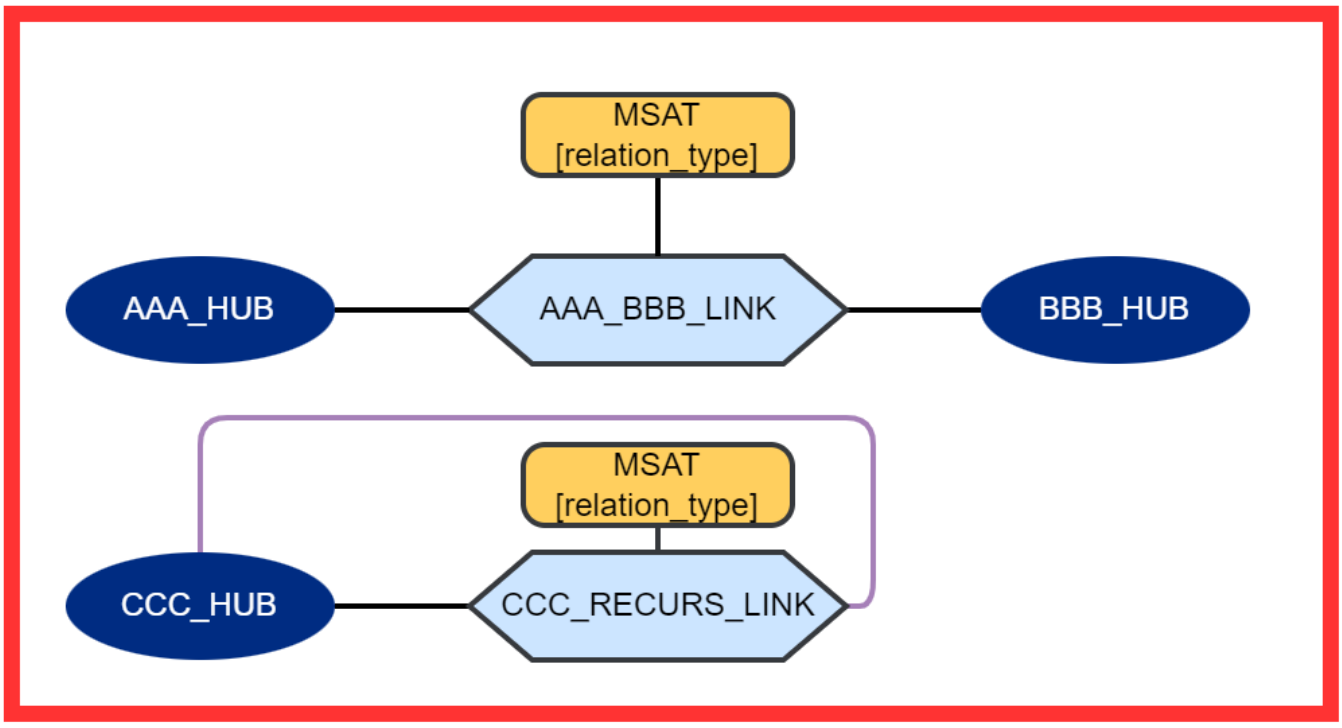


Out of scope edge cases

To keep the syntax of DVPD within a manageable complexity, some edge cases will be placed out of scope, since they are far from expected model requirements and can be solved by other designs.

Single link table with a multiactive satellite, that contains a column to store the relation type

Although completly valid for relation type information, that is contained in the data, it can't be used for relation declaraton inbetween objects of the same row, since it would need the creation of additional staging rows to feed the multiactive satellite. Creating new rows during staging has a high risk of duplicating data or generate data, that was not in the source. Also the disadvantage of hiding relations in the data is the same as for the dependent child key approach.

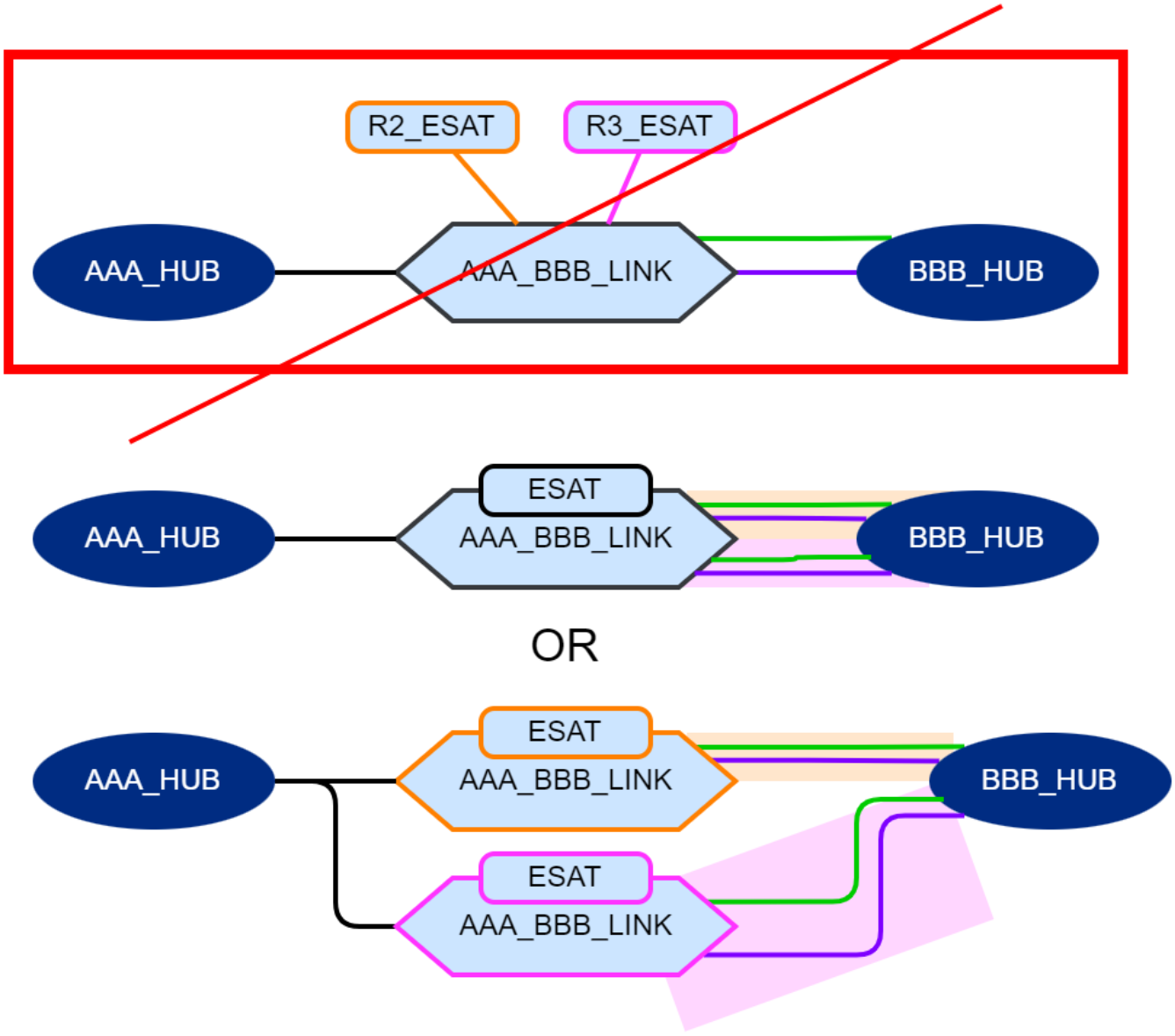


mixing esat and multi refererence

Mixing different approaches at the same link is not supported. In the example two relations are expressed with two references to the hub and then are "multiplied" by two more relation types represented by esat. This makes no sense in the combination, at least not under the constraint, that we always only load a single tabularized source
data structure.

It might be an expression of the following:

- all 4 relations are a unit of work
- pairs of 2 relations are a unit of work and are modelled seperatly

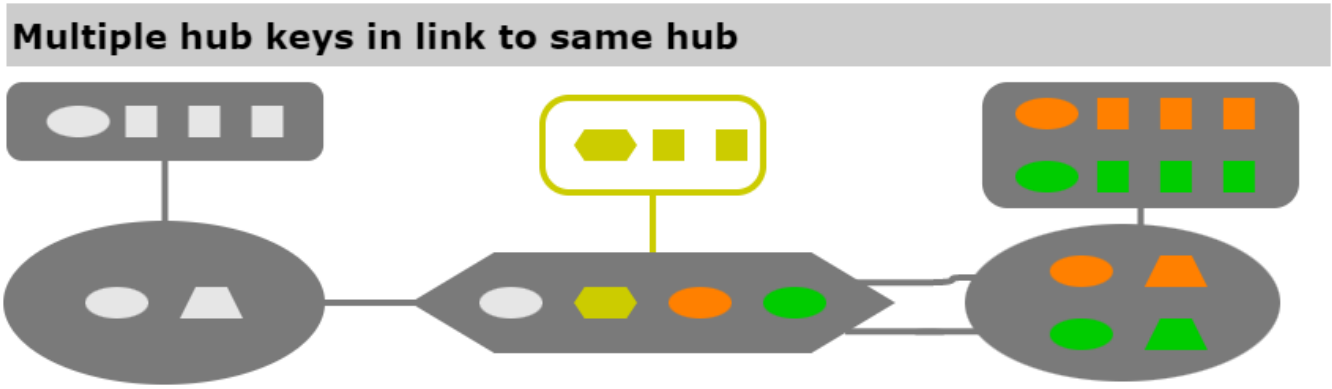


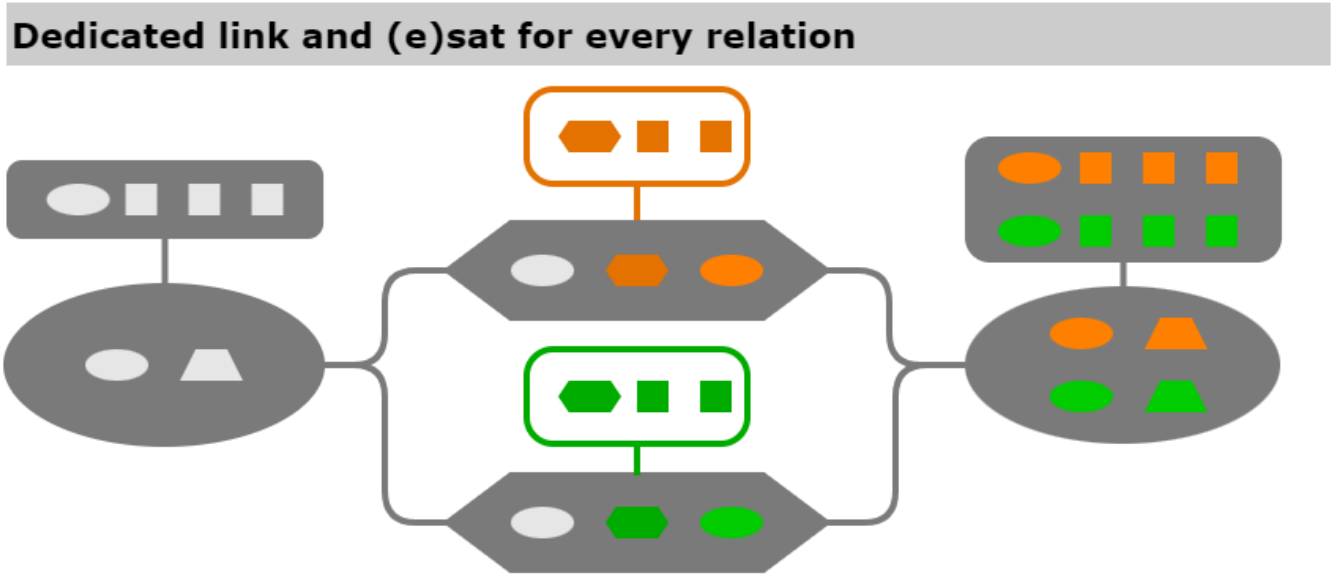
The same information can be modeled either with a link, having 4 relations to the same hub, or by modelling two links, keeping the pairs.

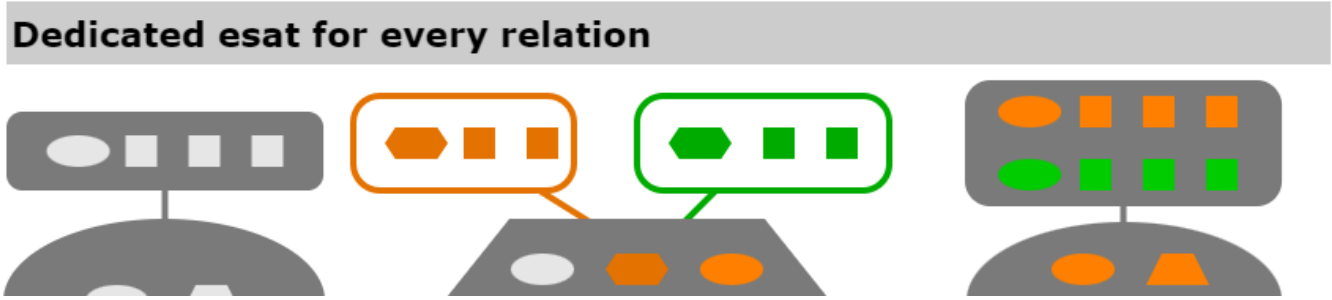
Relation participation

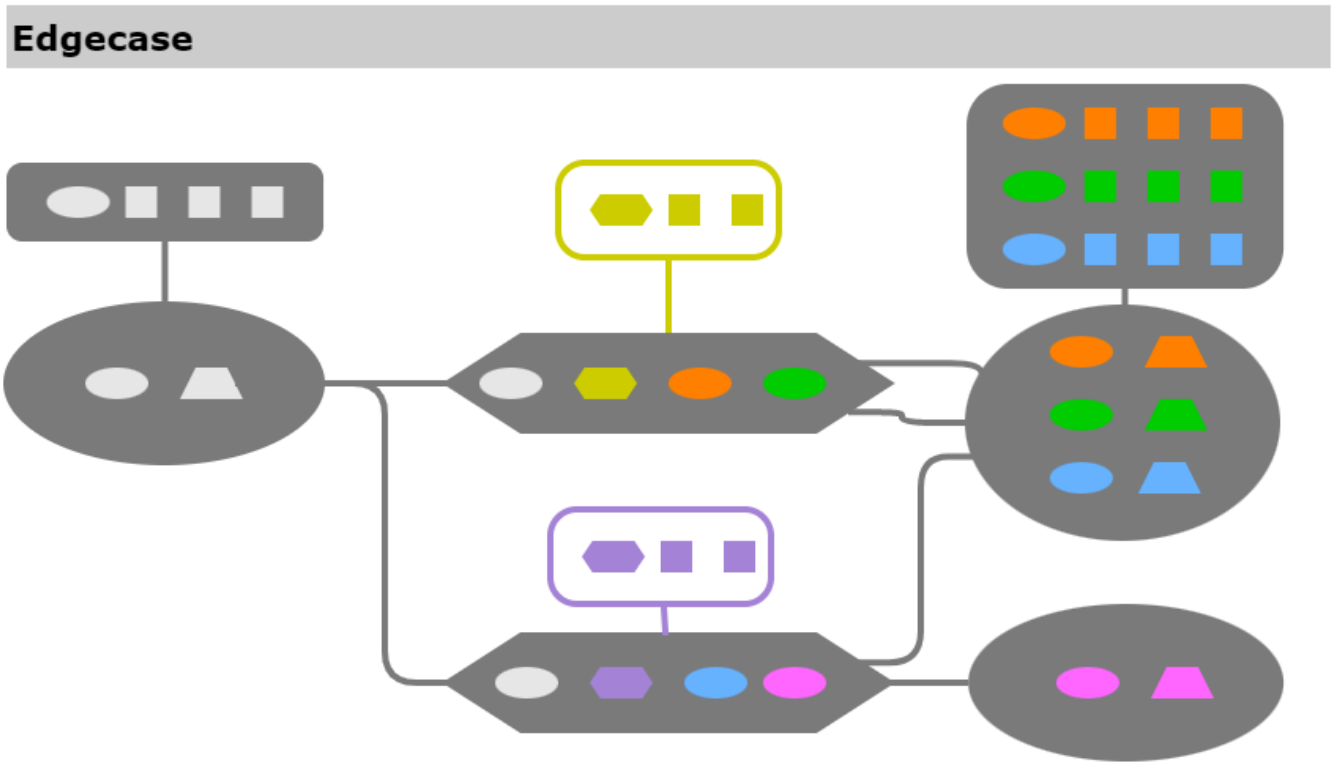
Observerations and conclusions

1-Multiple relations are only possible with multiple sets of business keys field for the hub, they refer.
2-From 1. -> every kind of multi relation to a hub needs business key field mappings, that are restricted to a relation
3-hubs need to be loaded for every relation declared by their business key mappings
4-links can only contribute to relations, that are declared in the hubs they connect
5-a link with multiple references to the same hub, need relation specific columns
6-a link with multiple references to the same hub, can only have satellites that contribute to the relation set, provided in the link.
7-satellites on links contribute to every relations, they have a field mapping for
8-effectivity satellites need to declare the relation they track, due to the lack of a field, that would declare it
9-link satellites can only contribute to relations, the link can contribute according to its parents
10-Different dependent child keys for different relations can only be modeled with relation specific links or relation specific satellites. (If only the dependend child key appears multiple times in the source data set, this must be solveld by normalizing the data)









Participation of fields

When mapping fields to a multi related model, there are the following possibilites how a field will contribute or participate to the modelled relations:

- to one (+) or a subset of specific relations (~)
- to all relations (*)

Depending on the function of the data, the field might be mapped to one or multiple model tables that are maybe of different stereotypes. Therefore the field can contain

- part of a business key (bk)
- a dependent child key (dc)
- part of a hubs satellite data (hsd)
- part of a links satellite data (lsd)

Participation to a relation is declared at every table mapping of the field. If not declared, a field is considerd to participate in every relation, when it is the only field mapped to the target, else it will be assigned only to the "main"(unnamed) relation. To declare the participation on a subset, that contains the "main"(unnamed) relation and another one, the syntax provides the reserved relation name "/" for the unnamed relation.

A target column must only have one field mapped in every specific relation.

Participation of hubs

Hubs participate to all relations that contain a full set of fields mapped to the business keys.

- The full set of business keys is determined by the relation with the most business key columns.
- relations with different or incomplete column outcome will fail the consistency check
- relations without any contribution by a connected link/link satellite will trigger a warning since there might be unnecessary data loaded.

These rules cover the "simple case" (no extra relations), since fields without any relation declaration belong to the "main"(unnamed) relation .

Participation of links with explicit relation mapping

These links have at least on explicit relation declaration in their parent mapping.

- they participate only in the relations, that are represented by the connections
- the hubs, targeted with an explicit relation must participate at the same relations
- if a hub is referenced more then once, the hub key names in the link must be adapted
    - names for the main(unnamed) reference will stick to the name in the hub
    - names for the named references must be declared or will be extended by a hard rule (mostly the concatenation of hub key name and relation name)
- Undeclared relations in the link belong to a "main" relation, so theses hubs must participate to the main(unnamed) relation
- Satellites on these kind of link are not allowed to declare a relation

Participation of simple links

These links have no explicit relation declaration to a hub (an therefore only one reference column for every hub).

- these links participate to all relations that are
    - are declared at their satellites
    - are declared at the mapping of their dependent child keys
- all relations, the link contributes must be known by at least one hub, the link is connecting

This also covers the simple common model use case, since without declaration a sattelite contributes to the main(unnamed) relation.

Participation of satellites

Satellites contribute to all relations that contain a full set of fields, mapped with relation declaration to the satellite.

- The full set of satellite columns is determined from the relation with the most columns.
- relations with different column outcome will fail the consistency check
- all relations, the satellites contributes must be known by the parent

The simple common model use case is covered by participating on the main(unnamed) relation when without any declaration.

Participation of effectivity satellites

Effectivity satellites contribute to the relation of their parent link. In case of a link, that collects multiple relations (see Modell pattern "E" above), a declaration of the relation is needed and allowed at the satellite.

- the relations, the satellites contributes must be known by the parent link

The simple common model use case is covered by participating in the relation of the link.

Catalog of field mappings

The following table lists combinations of field mappings and models as an orientation and to define the test set, a DVPD compiler must solve.

- **Model**: Short notation of the model by just specifing the links with
  <multiplicity><Hub>[<multiplicity><hub>]...<approach(RLEDS)> + ...
  (multiplicity os only provided when greater then 1)
  - A2BE = Link from A to B with 2 references to B, modeled as effectivity satellites
  - 3AR = Link with 2 references from A to A
  - AB3CR+ABC = Link from A to B and C with 3 references to C + Link to A,B,C
  - A3BL = 3 separate Links from A to B
- **field distribution**: Comma separated list of the incoming fields and their mapping. <letters of tables>[:<letters of relations>]
  - Letters from A to G represent hubs in upper case and satelliets on the hubs on lowercase
  - Capital Letters in square brackets represent a link, that connects the hubs of the letters - Field is a dependent child key
  - small Letters in square brackets represent a satelllite on a link that connects the hubs of the letters
  - small letters from T to W declare a relation name this field will participate
  - A,a,B,b = 4 Fields, each mapped to one of the tables (Hub A, Sat of Hub A, Hub B, Sat of Hub B)
  - AB,A,B,a,b,[ab] = 1 Feld used in Hub A and B, all other are separated. "[ab]"= Satellite on the Link of A and B.
  - ABC,A,B:t,B:u,C,a = 1 Field used in all hubs (ABC), 1 field exclusivly in A hub, 1 field for B hub in relatiom t, one field for b hub in relation u, one field for C hub, one field in Sattelite if A hub.
- **relation overlap**: Short notation of the content participation in relations.
  <content type (bk,dc,hs,ls)><relation participation (+,~,*,-,%)><number of target tables> [&]
  - BK1+ = Business key in one table used for one relation
  - BK2* & BK1+ & hsd1+ = Business key in 2 tables for all relations and business key in one table single relations an hub sattelite content in 1 table and one relation
  - BK1~ & ls1~ = Business key in 1 table and link satellite content in more then one but not all relations
  - BK1+ & hs1- = Business key in 1 table and hub satellite processed only in 1 relatiion
  - BK1+ & hs1% = Business key in 1 table and hub satellite processed only in subset of relatiions
- **Test**: Number of the test case, that will cover this setting (set *italic* when not implemented yet, set to "-" when his combination is not possible)

Genric case matrix

The generic cases all use a 1:1 field distribution. Every field is mappe to only one target column

Model	A3BR	A3BL	A3BE	A3BD	3AR	A3BN
relation ovrlap						
BK1+	*201*	*301*	*401*	*501*	*601*	*101*
BK1~	*202*	*302*	*402*	*502*	-	*102*
BK1*	*203*	*303*	*403*	*503*	*603*	*103*
BK2+	*211*	*311*	*411*	*511*	-	*111*
BK2~	*212*	*312*	*412*	*512*	-	*112*
BK2*	*213*	*313*	*413*	*513*	-	*113*
BK2* & BK1+	*215*	*315*	*415*	*515*	-	*115*
BK2* & BK1~	*216*	*316*	*416*	*516*	-	*116*
BK2* & BK1*	*217*	*317*	*417*	*517*	-	*117*
BK1+ & HS++	**220**	*320*	*420*	*520*	*620*	*120**
BK1+ & HS~+	*221*	*321*	*421*	*521*	-	*121*
BK1+ & HS~~	**222**	*322*	*422*	*522*	**622**	*122**
BK1+ & HS*+	*223*	*323*	*423*	*523*	*623*	*123*
BK1+ & HS*~	*224*	*324*	*424*	*524*	-	*124*
BK1+ & HS**	*225*	*325*	*425*	*525*	*625*	*125*
BK1~ & HS++	*226*	*326*	*426*	*526*	*626*	*126*
BK1~ & HS~+	**227**	**327**	**427**	**527**	-	*127**
BK1~ & HS~~	*228*	*328*	*428*	*528*	-	*128*
BK1~ & HS*+	*229*	*329*	*429*	*529*	*629*	*129*
BK1~ & HS*~	*230*	*330*	*430*	*530*	-	*130*
BK1~ & HS**	*231*	*331*	*431*	*531*	*631*	*131*
BK1* & HS++	*232*	*332*	*432*	*532*	*632*	*132*
BK1* & HS~+	*233*	*333*	*433*	*533*	-	*133*
BK1* & HS~~	*234*	*334*	*434*	*534*	-	*134*
BK1* & HS*+	*235*	*335*	*435*	*535*	*635*	*135*
BK1* & HS*~	*236*	*336*	*436*	*536*	-	*136*
BK1* & HS**	*237*	*337*	*437*	*537*	*637*	*137*
BK1+ & LS1+	-	*341*	*441*	*541*	*641*	-

Model	A3BR	A3BL	A3BE	A3BD	3AR	A3BN
BK1+ & LS1~	-	*342*	*442*	*542*	-	-
BK1+ & LS1*	*243*	*343*	*443*	*543*	*643*	*143*
BK1~ & LS1+	-	*344*	*444*	*544*	-	-
BK1~ & LS1~	-	*345*	*445*	*545*	-	-
BK1~ & LS1*	*246*	*346*	*446*	*546*	-	*146*
BK1* & LS1+	-	*347*	*447*	*547*	*647*	-
BK1* & LS1~	-	*348*	*448*	*548*	-	-
BK1* & LS1*	*249*	*349*	*449*	*549*	*649*	*149*
BK1+ & HS--	*281*	*381*	*481*	*581*	-	*181*
BK1+ & HS%%	**282**	*382*	**482**	*582*	-	*182**
BK1+ & HS*%	*283*	*383*	*483*	*583*	-	*183*
BK1~ & HS--	*284*	*384*	*484*	*584*	-	*184*
BK1~ & HS%%	**285**	*385*	**485**	*585*	-	*185**
BK1~ & HS*%	*286*	*386*	*486*	*586*	-	*186*
BK1* & HS--	*284*	*384*	*484*	*584*	-	*184*
BK1* & HS%%	*285*	*385*	*485*	*585*	-	*185*
BK1* & HS*%	*286*	*386*	*486*	*586*	-	*186*

Designed cases (700-999)

Model	field distribution	test
ABC	ABC,A,B,C,a,b,c	**701**
A2BCR	ABC,A,B:t,B:u,C,a,b,c	**702**
ABCL+ABL	ABC,A,B:t,B:u,C,a,b,c	**703**
A2BR+ACL	ABC,A,B:t,B:u,C,a,b,c	**704**