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Option #1: Data Loading - Northwind Data

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## Option #1: Data Loading - Northwind Data

In his final Portfolio Project for MIS541-Data Warehousing in Enterprise Environments, the student will extract data from the Northwind OLTP system, transform the data to conform to the star schema model developed in Portfolio Milestones 1 and 2, and finally load the modified data into the Northwind Data Warehouse. After populating the destination tables with the transformed data, the student will provide SQL code that returns the row counts of each populated table, along with a listing of the first ten rows of each table. Lastly, the student will provide a brief synopsis of the lessons learned from his Portfolio Project, along with any recommendations he might give to an organization that plans to develop an enterprise data warehouse.

In this paper, the student models the *order fulfillment* business process. The *grain* of the fact table is one row per order transaction. What are some of the business questions such a dimensional model can answer? These questions include, "What are the total product quantities sold in a given year by quarter and product?" "Which employees, products, and customers generate the most revenue?" and "For a given year, what are our most expensive products to ship and which carriers ship them most often?" The business process, the grain of the fact table, and the business questions, therefore, remain the same between Modules 3, 5, and 8.

The student did, however, incorporate changes into the star schema design. Upon the initial load of the **EMPLOYEE** dimension, the student realized the dimension contained a self-referential constraint, where the *reports\_to* field of the table referenced the *employee\_id* field of each employee's supervisor for every employee that had one. Kimball and Ross (2013) inform us that a dimensional model that represents a ragged variable depth hierarchy via recursive

pointers, as witnessed here, potentially creates a problem because the tree structure representation is entangled with the dimension (Kimball & Ross, 2013).

The solution, suggested by Kimball and Ross (2013), is to build a bridge table that contains all the information about the hierarchical relationship. The grain of the bridge table is one row for "each possible parent to each possible child, including a row that connects the parent to itself' (Kimball & Ross, 2013, p. 217). The student constructed this bridge table manually (without SQL code), using the samples provided by Kimball and Ross and McHugh (2017a) for reference. Figure 22, presented at the end of this paper, provides a listing of the first ten rows of this bridge table. What additional business questions does the bridge table allow us to answer? These questions include the following: "How many people work for a given manager?" "What are the total sales revenues for the employees who report to a given manager, broken down by product?" and "What is the hierarchy of management to whom a given employee reports?" (McHugh, 2017b). As we can see, the MANAGEMENT HIERARCHY bridge table is beneficial for reporting rollup facts related to the hierarchy of management. The use of the bridge table, however, is not mandatory when analyzing facts solely related to employees. Analysts may choose to by-pass the bridge table altogether, joining the EMPLOYEE dimension directly to the **ORDER DETAIL** fact table when reports do not call for metrics regarding hierarchical management relationships. The advantages of bridge tables for ragged hierarchies include limited impacts when nodes and tree structures change (Kimball & Ross, 2013).

Another change to the star schema design involves the *territory* and *region* attributes of the data warehouse. Initially, the student planned to incorporate these attributes into the **EMPLOYEE** dimension. Upon further analysis, however, it turns out these attributes are not tied directly to the **ORDERS** table in the transactional system, as the **EMPLOYEES**,

CUSTOMERS, SHIPPERS, and PRODUCTS tables are, but to the EMPLOYEES table. Each employee serves multiple territories. Each employee is linked to a single transaction. There is, therefore, no way to determine to which territory a particular transaction is linked. We can, however, learn more about territorial and regional sales metrics if we migrate these attributes to the data warehouse. Because each employee is linked to a single transaction, and each employee serves multiple territories, this scenario presents us with a perfect circumstance to model *multivalued dimensions*, where a dimension takes on multiple values at the fact table's grain (Kimball & Ross, 2013).

To model these multivalued dimensions, the student followed the advice of Kimball and Ross (2013) utilizing a group bridge table, which provides two columns, one for the group dimension key and another for each employee's territories grouped into a concatenated list. Figure 26 displays a listing of this table's contents. The group table links both to the **EMPLOYEE** dimension and the **TERRITORY BRIDGE** table. The **TERRITORY BRIDGE** table, in turn, links to the **TERRITORY** dimension, which contains columns for each of the 53 territories and their associated regions. Forty-nine of these territories are associated with employees. The **TERRITORY BRIDGE** table reflects this count. As employees are assigned additional territories, we can add the corresponding rows and values to the bridge tables. Modeling these multivalued dimensions allows us to answer additional business questions such as, "In which territories and regions are revenues highest?"

What are the lessons the student learned from this portfolio project? For one, the student learned to create a dimensional model based on a transactional system. The goals of a dimensional model are to deliver data that are understandable to business users and deliver fast query performance. Star schemas present us with a perfect design architecture to obtain such

goals. Dimensions in star schemas are often denormalized, storing hierarchical descriptive information redundantly. Depending on the goals of the business and underlying data structure, we may incorporate bridge tables into the design to allow analysts to report on hierarchical relationships and multivalued dimensions. Therefore, the student recommends that organizations gain a clear understanding of the business needs and underlying source data early in the design process. Additionally, the student recommends that businesses follow the four-step dimensional design process as outlined by Kimball and Ross (2013): (a) Select the business process, (b) Declare the grain, (c) Identify the dimensions, and (d) Identify the facts. Incorporating conformed dimensions into the data warehouse allows organizations to decrease the time-to-market for future deliverables and leads to agile decision making. By implementing these lessons, being open to feedback, and understanding the potential value a data warehouse offers, the student was able to implement a successful ETL solution for Northwind Traders.

In conclusion, this paper presented the student's process for designing the Northwind Data Warehouse. The business process, the grain of the fact table, and the business questions all remained the same between Modules 3, 5, and 8. The student did incorporate changes to the star schema design, adding bridge tables to model the hierarchy of management relationships and multivalued dimensions. Lastly, this paper presents a brief synopsis of the lessons the student learned and recommendations to future organizations. On the following pages, Figures 1 – 10 display the SQL code to create each warehouse table; Figures 11 – 17 display the SQL code to extract the needed variables from the transactional system and perform any necessary transformations; Figures 18 – 28 display the first ten rows of each table. Lastly, Figures 29 – 32 display the SQL code to load each table, the row counts of each table, the updated star schema, and the SQL code to generate the table listings.

```
customer_koy integer NOT NULL,
customer_koy integer NOT NULL,
customer_nk bpchar COLLATE pg_catalog_"default" NOT NULL,
customer_nk bpchar COLLATE pg_catalog_"default" NOT NULL,
customer_bill_to_cepany_name_character varying(30) COLLATE pg_catalog_"default" NOT NULL,
customer_bill_to_first_name_character varying(30) COLLATE pg_catalog_"default",
customer_bill_to_lats_name_character varying(30) COLLATE pg_catalog_"default",
customer_bill_to_lits_and_aiddle_names_character varying(30) COLLATE pg_catalog_"default",
customer_bill_to_lits_and_aiddle_names_character varying(30) COLLATE pg_catalog_"default",
customer_bill_to_address_character varying(30) COLLATE pg_catalog_"default",
customer_bill_to_rep_fion_character varying(30) COLLATE pg_catalog_"default",
customer_bill_to_to_to_ty_character varying(30) COLLATE pg_catalog_"default",
customer_ship_to_to_ty_thate_character varying(30) COLLATE pg_catalog_"default",
c
CREATE TABLE public.nw_cu
```

#### Figure 1. Customer dimension create statement

```
CREATE TABLE public.nw_employee_dim
          employee key smallint NOT NULL.
        employee_Rey smallint Not Notice employee_Rey smallint Not Notice employee_Inst_name character varying(59) COLLATE pg_catalog."default", employee_last_name character varying(59) COLLATE pg_catalog."default", employee_lob_title character varying(59) COLLATE pg_catalog."default", employee_salutation character varying(15) COLLATE pg_catalog."default",
          employee_birth_date date,
          employee_hire_date date,
employee_address character varying(50) COLLATE pg_catalog."default",
        employee_duniess threater varying(59) COLLATE pg_catalog. "default", employee_region character varying(59) COLLATE pg_catalog. "default", employee_state character varying(59) COLLATE pg_catalog. "default", employee_postal_code character varying(29) COLLATE pg_catalog. "default", employee_country character varying(29) COLLATE pg_catalog. "default", employee_bone_phone_character varying(15) COLLATE pg_catalog. "default", employee_home_phone_character varying(28) COLLATE pg_catalog. "default",
          employee_extension character varying(15) COLLATE pg_catalog."default",
          employee_notes character varying(500) COLLATE pg_catalog."default",
         employee_photo_path character varying(255) COLLATE pg_catalog."default",
CONSTRAINT nw_employee_dim_pkey PRIMARY KEY (employee_key),
CONSTRAINT fk_employee_territory_group FOREIGN KEY (employee_key)
                  REFERENCES public.nw_territory_group (territory_group_key) MATCH SIMPLE ON UPDATE NO ACTION
                  ON DELETE NO ACTION
```

### Figure 2. Employee dimension create statement

```
CREATE TABLE public.nw_territory_group
       territory_group_key smallint NOT NULL,
territory_list text COLLATE pg_catalog."default",
CONSTRAINT pk_nw_territory_group_bridge PRIMARY KEY (territory_group_key)
```

## Figure 3. Territory group dimension create statement

```
territory group key smallint NOT NULL,
territory key smallint NOT NULL,
territory key smallint NOT NULL,
CONSTAINT Fk, me_territory_bridge PRIMARY KEY (territory_group_key, territory_key),
CONSTAINT Fk, me_lorget_territory_dim FOREIGN KEY (territory_key)
REFERENCES public_mm_territory_dim (territory_key) MATCH SIMPLE
ON UPDATE NO ACTION
ON DELETE NO ACTION,
CONSTAINT Fk_employee_territory_group FOREIGN KEY (territory_group_key)
REFERENCES public_mm_territory_group (territory_group_key) MATCH SIMPLE
ON UPDATE NO ACTION
ON DELETE NO ACTION
```

## Figure 4. Territory bridge dimension create statement

```
territory_key smallint NOT NULL,
territory_nk integer NOT NULL,
territory_character varying(59) COLLATE pg_catalog."default",
region character varying(50) COLLATE pg_catalog."default",
CONSTRAINT pk_nw_territory_dim PRIMARY KEY (territory_key)
```

#### Figure 5. Create territory dimension statement

```
superior_key integer NOT NULL
superior_key_integer NOT NULL,
subordinate_key_integer NOT NULL,
depth_from_parent_integer,
top_parent_flag_character(1) COLLATE pg_catalog_"default",
lowest_child_flag_character(1) COLLATE pg_catalog_"default",
lowest_child_flag_character(1) COLLATE pg_catalog_"default",
CONSTRAINT pg_management_lherarchy_bridge PRIMARY KEY (superior_key, subordinate_key),
CONSTRAINT fk_subordinate_employee FOREION KEY (subordinate_key)
MEFFERENES public.mc_memployee_dim (employee_key) MATCH SIMPLE
ON UPDATE NO ACTION
ON UPDATE NO ACTION
ON DELETE NO ACTION,
CONSTRAINT fk_superior_employee FOREIGN KEY (superior_key)
REFERENCES public.nm_employee_dim (employee_key) MATCH SIMPLE
ON UPDATE NO ACTION
ON DELETE NO ACTION
```

Figure 6. Management bridge create statement

```
date key integer NOT NULL,
full_date date,
day_of_week smallint,
day_num_in_month smallint,
day_num_overall smallint,
day_name character varying(9) COLLATE pg_catalog."default",
day_abbrev character(3) COLLATE pg_catalog."default", weekday_flag character varying(25) COLLATE pg_catalog."default",
week_num_in_year smallint,
week_num_overall smallint,
week_begin_date date,
week_begin_date_key integer,
month smallint.
month_num_overall smallint,
month_name character varying(9) COLLATE pg_catalog."default",
month_abbrev character(3) COLLATE pg_catalog."default",
quarter smallint,
year smallint,
yearmo integer,
fiscal month smallint,
fiscal_quarter smallint,
fiscal_year smallint,
last\_day\_in\_month\_flag\ character\ varying \ensuremath{\textbf{(25)}}\ \ \textbf{COLLATE}\ pg\_catalog."default", same\_day\_year\_ago\_date\ date,
CONSTRAINT nw_date_dim_pkey PRIMARY KEY (date_key)
```

CREATE TABLE public.nw date dim

#### Figure 7 Date dimension create statement

```
CREATE TABLE public.nw_product_dim
      product_key smallint NOT NULL,
      product_description character varying(59) COLLATE pg_catalog."default", category_name character varying(59) COLLATE pg_catalog."default", category_description character varying(75) COLLATE pg_catalog."default",
      category_picture bytea,
      quantity_per_unit character varying(50) COLLATE pg_catalog."default",
      list unit price money.
      units_in_stock smallint,
units_on_order smallint,
reorder_level smallint,
     discontinued smallint,
CONSTRAINT nw_product_dim_pkey PRIMARY KEY (product_key)
```

#### Figure 8. Product dimension create statement

```
shipper key smallint NOT NULL.
shipper_key smallint NOT NULL, shipper_monapy.name character varying(40) COLLATE pg_catalog."default" NOT NULL, shipper_full_phone character varying(24) COLLATE pg_catalog."default", shipper_phone_country_code character varying(15) COLLATE pg_catalog."default", shipper_phone_area_code character varying(15) COLLATE pg_catalog."default", shipper_phone_telephone_number_character varying(15) COLLATE pg_catalog."default",
CONSTRAINT pk_shipper PRIMARY KEY (shipper_key)
```

### Figure 9. Shipper dimension create statement

```
required_date_key integer NOT NULL,
shipped_date_key integer,
customer_key smallint NOT NULL,
product_key smallint NOT NULL,
product key smallint NOT NULL,
employee key smallint NOT NULL,
employee key smallint NOT NULL,
siliper key smallint NOT NULL,
order_lime_number smallint NOT NULL,
order_lime_list_unit.price money NOT NULL,
order_lime_list_unit.price money NOT NULL,
order_lime_discount money NOT NULL,
order_lime_discount money NOT NULL,
order_lime_discount money NOT NULL,
extended_discount_dollar_smount money,
extended_smale_dollar_amount money,
extended_cost_dollar_amount money,
extended_gross_profit_dollar_smount money,
extended_gross_profit_dollar_smount money,
extended_cost_dollar_dollar_dollar_smount money,
  CONSTRAINT pk_fact_order_details PRIMARY KEY (order_date_key, required_date_key,
  customer_key, product_key,
employee_key, shipper_key),
constraint fk_order_customer FOREIGN KEY (customer_key)
  CONSTRAINT Th_order_customer FOREIGN KEY (customer_key)

REFERENCES public-mg_ustomer_dim (customer_key) MATCH SIMPLE

ON UPDATE NO ACTION

ON DELETE NO ACTION,

CONSTRAINT Th_order_order_date FOREIGN KEY (order_date_key)

REFERENCES public-mg_date_dim (date_key) MATCH SIMPLE

ON UPDATE NO ACTION

ON DELETE NO ACTION,

CONSTRAINT for order_product FOREIGN KEY (orduct_key)
   UN DELETE NO ACTION,

CONSTRAINT Knoder product FOREIGN KEY (product key)

REFERENCES public-nm, product_dim (product_key) MATCH SIMPLE
ON UPDATE NO ACTION,
ON DELETE NO ACTION,
  CONSTRAINT fk_order_required_date FOREIGN KEY (required)
                  REFERENCES public.nw_date_dim (date_key) MATCH SIMPLE
REFERENCES public.rw_date_dim (date_key) MATCH SIMPLE ON UPDATE NO ACTION, ON DELETE NO ACTION, ON DELETE NO ACTION, CONSTRAINT 'fk_order_shipped_date FOREIGN KEY (shipped_date_key) REFERENCES public.rw_date_dim (date_key) MATCH SIMPLE ON UPDATE NO ACTION ON DELETE NO ACTION, CONSTRAINT 'fk_order_shipper FOREIGN KEY (shipper_key) REFERENCES public.rw_shipper_dim (shipper_key) MATCH SIMPLE ON UPDATE NO ACTION ON DELETE NO ACTION
```

Figure 10. Order detail fact table create statement

```
сору
                                                                                 сору
    select product_id as product_key,
        product_name as product_description,
                                                                                     select distinct
        category_name as category_name,
                                                                                     e.employee_id as employee_key,
        description as category_description,
                                                                                     first_name as employee_first_name,
        picture as category_picture,
                                                                                     last_name as employee_last_name,
        quantity_per_unit,
                                                                                     title as employee job title.
        unit_price as list_unit_price,
                                                                                     title_of_courtesy as employee_salutation,
        units_in_stock,
units_on_order,
                                                                                     birth_date as employee_birth_date,
                                                                                     hire_date as employee_hire_date,
        reorder_level,
                                                                                     address as employee_address,
        discontinued
                                                                                     city as employee_city,
    from products join categories
    on products.category_id = categories.category_id
                                                                                         when region is not null then region
                                                                                         else 'Not Applicable
to 'C:/Users/Public/Documents/dim_products_ETL.csv' delimiter ',' header csv;
                                                                                     end as employee region.
Figure 11. Product dimension extract
                                                                                         when state_name is not null then state_name
    select e.employee_id, string_agg(territory_description, ', '
                                                                                         else 'Not Applicable'
       {\color{red} \textbf{order by}} \ {\color{red} \textbf{territory\_description}}) \ {\color{red} \textbf{as}} \ {\color{red} \textbf{territory\_list}}
                                                                                     end as employee_state,
    from employees e
                                                                                     postal_code as employee_postal_code,
   join employee_territories et
                                                                                     country as employee_country,
   on e.employee_id = et.employee_id
join territories t
                                                                                     home_phone as employee_home_phone,
                                                                                     extension as employee_extension,
       on et.territory_id = t.territory_id
                                                                                     photo as employee photo.
    group by e.employee_id, e.first_name
                                                                                     notes as employee_notes,
    order by e.employee_id
                                                                                     photo_path as employee_photo_path,
to 'C:\Users\Public\Documents\territory_group_bridge_ETL.csv' csv delimiter ',' header;
                                                                                     r.region_id as region_key,
                                                                                     region_description as employee_region_description
Figure 12. Territory group extract
                                                                                     from employees e
сору
                                                                                        join employee_territories et
    select row_number() over () as territory_key,
                                                                                     on e.employee_id = et.employee_id
            t.territory_id as territory_nk,
                                                                                        ioin territories t
            territory description as territory,
                                                                                     on et.territory_id = t.territory_id
            region_description as region
                                                                                        join region r
    from employees e
                                                                                     on t.region_id = r.region_id
    join employee_territories et
                                                                                       left join us states
    on e.employee id = et.employee id
       right join territories t
                                                                                     on e.region = us states.state abbr
    on et.territory_id = t.territory_id
        join region r
                                                                                 TO 'C:\Users\Public\Documents\dim_employee_ETL.csv' DELIMITER ',' CSV HEADER;
    on t.region_id = r.region_id
    order by e.employee id
                                                                                Figure 16. Employee dimension extract
to <code>'C:\Users\Public\Documents\territory_dim_ETL.csv'</code> csv delimiter <code>','</code> header; ^{copy}_{()}
Figure 13. Territory dimension extract
                                                                                    replace(order_date::text, '-', '') as order_date_key,
replace(required_date::text, '-', '') as required_date_key,
replace(shipped_date::text, '-', '') as shipped_date_key,
                                                                                   select e.employee_id, row_number() over ()
    from employees e
    join employee_territories et
    on e.employee_id = et.employee_id
       join territories t
    on et.territory_id = t.territory_id
    order by e.employee_id
to 'C:\Users\Public\Documents\territory_bridge_ETL.csv' csv delimiter ',' header;
Figure 14. Territory bridge extract
    select row_number() over() as shipper_id, * from
       company_name as shipper_company_name,
          phone as shipper_full_phone,

1 as shipper_full_country_code,
       end as shipper_phone_area_code,
       case
          Figure 17. Order detail fact extract
       end as shipper_phone_telephone_number
TO 'C:\Users\Public\Documents\dim_shipper_ETL.csv' DELIMITER ',' CSV HEADER;
```

Figure 15. Shipper dimension extract

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Note, key Note integer	full_date / day_of_week	/ day, number /	dey_num_overall smaller	dey_name character varying (%)	deg_abbrev ven	ekday_flag iracter karying (25)	/ weeknamulicy smaller	week_num_overs	of week,begin,date week	k_begin_date_key / 1	month month/num_everall smaller month/num_everall	rooth, charact	neme month, a characte	obbrev y quart or (5) y small	et / smallet /	yearno / fecel_mont steger / smallet	n focel_querter smaller	/ fecal year /	fest_day_in_month_flag character varying (25)	/ same_day_ye
19960704 19960708	1999-07-04 1999-07-05	1 1		1 Thursday 2 Fodey		ekday ekday		27	1 1996-07-01	19960701 19960701	7	1.34y 1.34y	M		3 1996 3 1996	199607	1	1 1997	Not Month End Not Month End	1995-07-04 1995-07-05
19960707	1996-07-05 1996-07-07	2 2		1 Saturday 4 Sunday		ekend ekend		27	1 1996-07-01 1 1996-07-01	19960701 19960701	7	1 July 1 July	All All		3 1996 3 1996	199607	1	1 1997	Not Morth End Not Morth End	1995-07-06 1995-07-07
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Figure 28. Order detail fact table

```
copy nw_customer_dim
from 'C:\Users\Public\Documents\dim_customer_ETL.csv' delimiter ',' csv header;
copy nw_shipper_dim
from 'C:\Users\Public\Documents\dim_shipper_ETL.csv' delimiter ',' csv header;
copy nw_employee_dim
from 'C:\Users\Public\Documents\dim_employee_ETL.csv' delimiter ',' csv header;
copy nw_date_dim
from 'C:\Users\Public\Documents\dim_date_ETL.csv' delimiter ',' csv header;
copy nw_product_dim
from 'C:\Users\Public\Documents\dim_products_ETL.csv' delimiter ',' csv header;
copy nw_management_hierarchy_bridge
from 'C:\Users\Public\Documents\bridge_management_hierarchy_ETL.csv' delimiter ',' csv header;
copy nw_territory_group
from 'C:\Users\Public\Documents\bridge_management_hierarchy_ETL.csv' delimiter ',' csv header;
copy nw_territory_dim
from 'C:\Users\Public\Documents\bridge_fTL.csv' delimiter ',' csv header;
copy nw_territory_bridge
from 'C:\Users\Public\Documents\bridge_ETL.csv' delimiter ',' csv header;
copy nw_territory_bridge
from 'C:\Users\Public\Documents\bridge_ETL.csv' delimiter ',' csv header;

copy nw_order_detail_fact
from 'C:\Users\Public\Documents\bridge_ftl.csv' delimiter ',' csv header;

SELECT relname,n_live_tup
FROM pg_stat_user_tables
GOBER BY n_live_tup DESC;
```

Figure 29. Load statements and SQL to generate table counts

relname name	n_live_tup bigint
nw_date_dim	2191
nw_order_detail_fact	2155
nw_customer_dim	91
nw_product_dim	77
nw_territory_dim	53
nw_territory_bridge	49
nw_management_hierarchy_bridge	20
nw_territory_group	9
nw_employee_dim	9
nw_shipper_dim	6

Figure 30. Row counts of all ten tables

### Northwind Data Warehouse Star Schema

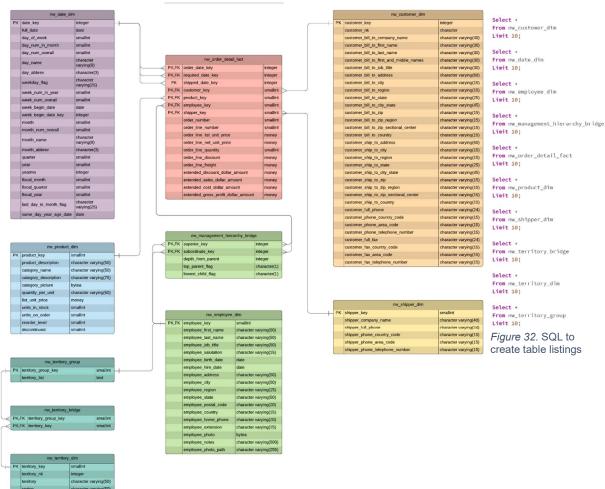


Figure 31. Northwind Data Warehouse Star Schema

# References

- Kimball, R., & Ross, M. (2013). *The data warehouse toolkit: The definitive guide to dimensional modeling (Third edition)*. John Wiley & Sons, Inc.
- McHugh, J. (2017, March 8). Data Warehouse Design Techniques—Ragged Hierarchical Dimensions. <a href="https://www.nuwavesolutions.com/ragged-hierarchical-dimensions/">https://www.nuwavesolutions.com/ragged-hierarchical-dimensions/</a>
- McHugh, J. (2017, May 24). Loading Hierarchical Bridge Tables.

https://www.nuwavesolutions.com/loading-hierarchical-bridge-tables/