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Design of Visibility for Order Lifecycle using Datawarehouse

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Abstract *Data warehouse, shortly called DW, a repository to store historical data was widely used across organizations for analyzing the data for any business decisions to be decided. It acts as a decision support system, which will help the decision makers to provide any conclusion based on the analyzed data. DW can be used across any particular fields in the public domain. Some of them would include Retail, Insurance, Finance, Sales, Services, Health Care, Education, etc.*
This paper analyses and proposes the datawarehouse design considerations for the supply chain. The design was explained with a detailed case study on understanding the visibility of sales order at various stages.

Keywords--- Bottom-Up Approach, Business Intelligence, Data Mart, Data Mining, Data Visualization, DW, Supply Chain, Order Visibility, Dimension, Fact Star Schema, OLAP, Top-down Approach

I. INTRODUCTION

Different people have provided their own way of defining a data warehouse. The most popular definition came from Bill Inmon (Father of the Data warehouse), which would be: "A data warehouse is an integrated subject oriented data, time-variant and has non-volatile data collection to support for management's decision making process". Let us see what would be the meaning of the individual attributes of Data warehouse.

Subject Oriented: Data in any data warehouse can be analyzed in specific to any of the subject area. In a product-based company, data can be analyzed/measured against Sales/Service/Time/Product etc.

Integrated: In a data warehouse environment, data from multiple sources will be integrated, and stored in a common place. For example, for a particular product, basic information (Product name, description, etc.) can come from Product manufacturing department, sale details of the product day-wise can come from the Sales department, details on users (user name, location etc.) who have purchased the product can come from the user domain department. However, all these data sources will be integrated and stored at a single place in the Data warehouse.

Time-Variant: Data warehouse loads and maintains historical data. Data can be retrieved from 3 months to 10 years or even more depending on the retrieval limit specific to each company.

Non-volatile: A datawarehouse data is constant once it is loaded. Hence, historical data in a data warehouse should never be altered.

This paper represents as a referential comprehensive guide to any retail domain or sales domain, in the design their Data warehouse. An overview of the ETL Process (Extraction, Transformation and Loading) of data from several data sources into a DW is demonstrated. In addition to that, as a case study, the paper gives the steps to be followed for the DW design in a supply chain . Datawarehouse is the key repository from which the proposed visibility of order in a lifecycle can be designed and the analysis of the information stored in it provides a practical way to identify the different stages of order and its behavior against the various phases can be determined.

After introducing the research problem and the introduction to the datawarehouse in this section, the structure of the paper is as follows: Section 2 represents the datawarehouse historical architecture, literature survey and theoretical background, Section 3 describes the DW design considerations for implementation in a supply chain domain; Section 4 explains the design with a case study.

II. BACKGROUND

In ths paper, the design considerations for implementing a datawarehouse solution for visibility in order lifecycle for a supply chain environment will be discussed in detail. In this section, the state of the art of the topic along with the technologies and components that are needed for the design of the DW are described.

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A. HISTORY OF DATAWAREHOUSE

Data warehouse started its journey in 1970s by Bill Inmon and Ralph Kimball, and in later 1980s, relational databases like Oracle, DB2, etc. were used to load data warehouse. It was discovered, that the modeled databases were not efficient at complex analytical reporting needs whereas they were efficient in transactional data processing. Business organizations require more analysis on the data to take effective business decisions. For which, the historical storage of data was necessary.

Hence, RDMS is used in place for some time to do historical analysis. However, there was no proper integration methodology that was available to represent the data required for business organizations. Every organization had a wide amount of historical data but was not aligned and integrated in a proper fashion. This provided the way for the emergence of Datawarehouse. Inmon and Kimball did a detailed research on the decision support system and data warehouse, and came up with their relative approaches in creating the warehouse.

After this, the progress of Datawarehouse was drastic. All organizations, specifically want to analyze their historical data, started maintain their own warehouses and started implementing the reporting environment from which the meaningful reports will be generated.

B. DATA WAREHOUSE ARCHITECTURE

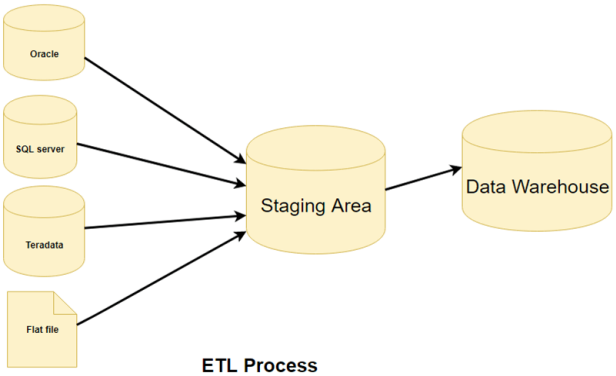
DW Architecture comprises of the ETL (Extraction, Transformation and Loading) procedure to capture and load data. It extracts its source information from several data sources like flat files, web pages, databases, etc. The extracted source data will be placed in the intermediate staging layer wherein the data will be cleansed and scrubbed to remove any data abnormalities (Duplicate data, Special characters, etc.). The business transformation rules will be applied on the cleansed data and it will be taken for loading into the target datawarehouse. End user using any OLAP tool for further analysis will use this final data.

Extraction Transformation and Loading: ETL is said to be a process that extracts the data from different RDBMS source systems, then transforms the data (like applying calculations, concatenations, etc.) and finally loads the data into the Data Warehouse system. ETL full-form is Extract, Transform and Load.To align with the required business changes, Data warehouse should be capable enough to accustom with business changes. As part of it, ETL will have to be present as the recurring activity (daily, weekly, monthly) for any Data warehouse system, which needs to be automated, agile and documented well.

ETL is widely adopted in many organizations because of its tangible benefits of which some of them are given below:

- ETL can answer complex business questions for which Transactional databases cannot answer.
- Data Warehouse provide a reusable and common data sharing repository
- ETL provide a specially designed way to move the data from various sources into a data warehouse.
- DW can automatically update any change (Update/Insert/Remove) when any given data sources changes.
- ETL allows comparison of data samples against the source and the target system.

ETL Process



ETL Process

Step 1: Extraction

In this first step, external data from different source systems extracted into a stage area. Transformations carried out in staging area to make sure that source system performance is not degraded. Staging layer provides the opportunity to do complete validation on the data extracted from source before it gets loaded in the Data warehouse. This is critical, as doing the rollback of DW data, which was loaded from corrupted data at source, will be a big challenge.

As part of the ETL process, DW has to do integration among systems having different Hardware, DBMS, Communication Protocols and Operating Systems. Sources comprises of some of the legacy applications like customized applications, Mainframes, Point of contact devices like Call ATM, text files, switches, spreadsheets, data from vendors, ERP, partners amongst others. There needs to be a logical mapping of data before it is extracted and physically loaded. The data mapping defines the relationships among source and target data.

Types of Data Extraction methods:

- Full load Extraction
- Partial load Extraction- not having update notification.
- Partial load Extraction- having notification

Validations in Data Extraction:

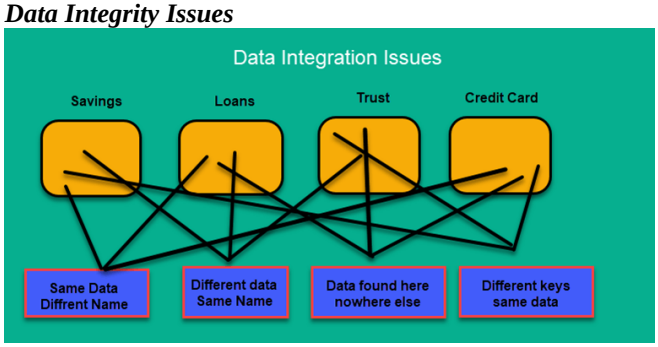
- Data reconciliation between source and target records
- Removal of unwanted data
- Validity of Data types
- Removal of Data duplicates and Fragmented data

Step 2. Transformation

Extracted data in DW from the source layer will be raw and are not usable with its original form. It should get cleansed, to be mapped and to be transformed.

In this second step, a set of rules or functions applied on extracted data. Data, which do not need transformations, are defined as direct move data or pass-through data.
Customized operations performed on data during the transformation step For example, if the end user needs sum-of-sales revenue that is unavailable in database.
If both the first and last names in a table are in the different columns. It is possible to do concatenation of names before loading.

Data Integrity Issues



1. Same name spelled in different ways like John, Jon etc.
2. A company denoted in several ways. E.g.. Google Inc., Google, etc.
3. Same customer, obtaining different accounting numbers generated via various applications.
4. Some of the required data missing in source files

Validations performed during this stage
- Handling of Encoding and Conversion of Character Sets
- Filtering – Selection of specific attributes for loading
- UOM (Units of Measurement) Conversions- Conversion of currencies, mathematical conversions and Date/Time Conversions, etc.
- Threshold and Data Limit Validation- Adultery age limit restriction to two digits.
- Validation of Data Income and Outcome flow- From stage tables to intermediate temporary tables.
- Not Null Field Validation.
- Data Cleansing - Gender Mapping ("M" to Male, "F" to Female), NULL to zero mapping, etc.

Step 3. Loading

Data Load to the target DW database schema is the final step in ETL. In a Data warehouse, enormous data volume should be loaded in a short span of time (nightly load). The load process hence should have better optimization techniques for improving performance.
In any failure of Data load, required recovery mechanisms should configured to restart the load from the failure point without any loss on data integrity.
Different Types of Data Load:
- Initial or First Load — Data Load in all DW tables
- Incremental Load — On-going changes applied whenever required on a periodic manner.
- Full Refresh — Remove the contents of required tables and reload with new data.

Load verification
- Verification of Data in one or more key fields are not missing.
- Data check Validation in dimension table and history tables.
- Verification of Data population (Fact and Dimension) in BI reports.

The DW architecture from data source extraction to end user reporting is explained in detail in Fig 1. Data Mart is likely to be the copy or subset of any datawarehouse, which has the dimensionally modeled data customized for any specific subject area or business function

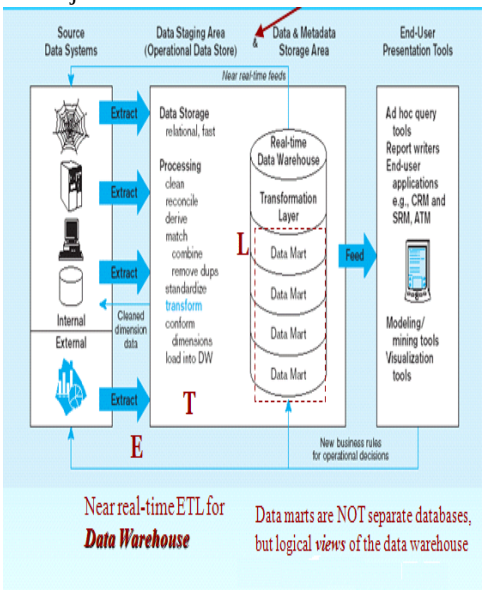


Fig 1. Datawarehouse Architecture

C. *APPLICATION OF DATAWAREHOUSE*

Data warehouse techniques used in several fields for its effective Extraction, Loading and Transformation methodology. Any industry/institution needs to perform analysis on their data to strive for growth and DW was being used widely for this reason across many fields. Fig. 2 explains in detail, the different sectors using DW.

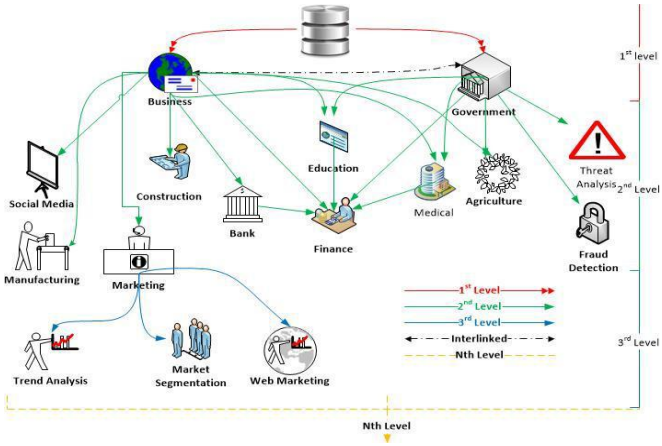


Fig 2. Applications of DW

A generic layout with several levels defined was suggested which interlinks data warehouse application fields. Each level was associated with a hierarchy.Level1, the core component, was always been a central DW.

Level2 associated with the top domains (Root, business and Government). All sublevels populated from Level2 and serves as the pillar to support other domains. Level3 domains are the more general. The Nth level was defined to be the most generic level holding all domains (minor/major).

D. *REVIEW OF DATA WAREHOUSE IN RESEARCH*

There were many researches were happened previously in the field of both Data warehouse focusing primarily on the education sector. Analysis of the Data warehouse data can be effectively done through the use of Business Intelligence Applications. These applications will be customized to fetch data from datawarehouse for any analytical purpose.

Pranjal Muley described the scope of Data warehouse and Business Intelligence applications in Education. The architecture of the Data warehouse (Eg. Different tiers involved in the architecture) along with the major application, areas of the Data warehouse were explained.**[2]** The paper concluded that for Education sector, Data warehouse can get develop as an enterprise wide physical warehouse or DataMart or virtual datawarehouse depending on the customer requirements.

Zina A.S. Abdullah and Taleb Obaid explained the difference between Educational Intelligence (EI) and Business Intelligence (BI). The need of creating an Educational Data warehouse was discussed. The paper proposed the creation of Educational Data warehouse by sampling the data from the University of Basra and AL_IRAW University

Manjunath T.N., Ravindra S Hegadi, Umesh I.M. and Ravikumar G.K., illustrated the key design principles required for creating the Data warehousing environment for R V College of Engineering, Bangalore, India.

Qaisar Javaid explained in detail, the application of Data warehouse in Real life with examples.**[5]** The paper laid out a generic layout illustrating the interlinked applications used in data warehouse. The relevant case studies explained against several domains and a utilization percentage of the application of DW in both Business and Government functional areas was arrived.

Srinath Doss and Panacea Makela discussed the approach to be followed for building the Data warehouse structure for any organizational requirement, which includes the **Top Down Approach** and the **Bottom up Approach**. Both the approaches have their related Pros and Cons and it is up to the educational institution to decide and finalize the approach to be followed based on their requirement needs as both the approaches seems to be good in the way they are required to process.

Emil BURTESCU discussed in detail whether the investment on Data warehouse / Data Mining technologies would be useful or useless. He explained the advantages as well as the list of steps involved in both the technologies (Data warehouse / Data Mining) and listed down their benefits as well.

Samiya Khan Kashish A. and Shakil, Mansaf Alam, discussed in detail the need for Educational intelligence and the ways to apply cloud-based analytics using big data focusing on the Education sector of India. Learning analytics, data analytics on big scholar and academic analytics can be incorporated a single umbrella called "Educational Intelligence" recommends the use of Big data based analytics in a cloud network can improve the education sector and also enhances the research productivity.

III. DESIGN CONSIDIERATIONS FOR VISIBILITY FOR ORDER LIFECYCLE

In this Section, a deep analysis on the significance of the order lifecycle and its travel in a Supply chain environment is performed. The proposed design for a datawarehouse structure for is outlined based on the deep dive analysis.

A. SUPPLY CHAIN AND ORDER LIFECYCLE

In a Supply chain environment, visibility plays a major role since it helps to reduce the errors and make sure that a company can keep its reliability to customers. Visibility deals with inventory strategies, orchestration and allocation and several ways that any company can able to serve their customers when, where, they and how they want. The benefits of the Supply Chain Visibility realized primarily as the soft cost savings. It is difficult to produce a business case because of the visibility, with the given substantial resources, using which full visibility of end-to-end implemented with all the other involved, including OMS (Order Management System), TMS (Transportation Management System), ERP (Enterprise Resource Planning System) and WMS (Warehouse Management System). The challenge hence with visibility in supply chain related to where and how many resources allocated instead of deciding whether to provide the dedicated resources or not.

Improve Supply Chain Visibility across the Order Lifecycle

There are three major stages of visibility occurs during any life cycle of Shipment. The first stage is at the order-level (Request for a specified quantity of a product is placed). The second stage is at the in-transit-level (Representation of Items during Physical movement). The third stage is at the audit and invoice stage (Transactions being complete among sellers, buyers and LSPs. The visibility level within the stages is determined depending on the execution methodology of the task by the organization. Every stage is completed through the below ways

Manual - Through Emails, Phone calls and Spreadsheets
Automatic - Events generated from the system being triggered by the user
Integrated – Information and Messages exchanged via independent connected systems

Stage 1: Order Visibility: Item entered as an entry through "Order" before any product created.

Manual Execution - Lowest level of visibility. Manual matching of Purchase Order to Sales Order through spreadsheets

Automatic Execution: Implement using sales order or purchasing system
(In-house/Third-party).

Integrated Execution: Organized way of data collection and transmission. Greatly reducing the total touch-points and thereby creating an organized flow of work, which enables to carry out the significant tasks first. This approach is the method that sets an organization up for true end-to-end visibility.

Stage 2: In-Transit Visibility: The physical movement of the product from the warehouse floor is carry through rail, ocean, truck, air or through combined modes. Transportation seems to be highest cost hitting factor for a product and as well subject to changes in market, directly affecting the cost.

Manual Execution - Visibility based on operators exchanging emails and phone call with carriers, relaying information to relevant parties.

Automated Execution - Visibility through a TMS, which translates the information to reusable data. Organizations having access to historic data like data volume of moving freight, transit time, volume of freight moving, and transporting mode used. The data sets are used to arrive at decisions like staffing the warehouse resources, les with most challenges, decision on whether a switch mode is required or not.

Integrated Execution - At the center of an integrated approach is a fully implemented and integrated TMS, which exchanges information in real time with other systems within an organization and has electronic data interchange (EDI) with systems of other trading partners in the supply chain.

Stage 3: Visibility in the Payment and Invoice Audit Stage: Not having direct impact on the freight movement and ordering, this stage has a direct financial impact on a company's supply chain. Full visibility in this stage directly translates to hard dollar savings.

Manual Execution - A manual environment in this stage entails working entirely off spreadsheets. The exact precision of accounting necessitates multiple invoice audits to confirm the amount stated is the amount owed, and that the amount paid matches.

Automatic Execution - Automating the freight invoice and auditing phase is typically done through an on-premise or cloud-based program like QuickBooks.

Integrated Execution - A fully integrated software suite communicates with OMS, WMS, and TMS systems to provide true upstream visibility to the associated costs and spend in a supply chain.

IV CASE STUDY - DATAWAREHOUSE DESIGN FOR ORDER LIFECYCLE

The proposed design for the Order Lifecycle Visibility will provide the sales representatives, the visibility to their open sales orders using their hand held devices or through email using their existing email accounts. This will reduce the amount of time sales representatives spend to "pull" sales order information. As a result, this allows more time for them to sell and enables them to provide their customers with timely information on order shipments.

There are four basic categories of sales order information that users need visibility to. The four basic categories of information to provide are:

- **Bookings***:* This includes orders entered and booked in Order Management.
- **Shipments**: This includes orders that have shipped from or one of party logistics centers as of a particular date.
- **Backlog**: This includes orders that are booked and not shipped. This backlog is further separated into two sub-categories as follows:
  - *Scheduled Orders:* This includes orders for which holds released and a scheduled ship date assigned.
  - *Orders on Hold:* This includes orders, which remain on either a header or line level hold, which is preventing them from being scheduled. Until the hold releases, these orders will not get schedule for shipment.
- **Cancellations**: This includes orders where all lines on the order were cancelled after the order had been booked

The first step is to identify the required dimensions and facts to be loaded into the datawarehouse. Here in the Order Lifecycle visibility, we will use Star schema wherein we will have one Fact table providing a consolidated view of all four categories (Booking/Shipment/Backlog/Cancellation) for an order along with the required dimensions.

We will also create some intermediate tables called Stage tables to perform ETL on the source data.

The jobs are hence classified into the below Categories based on their purpose.

1. Dimension Load jobs.
2. Lookup Table Load Jobs.
3. Staging Load Jobs.
4. Target Load Jobs.

Dimension Load Jobs:

- DimFieldAdmins: This Job will retrieve and loads the fields Field Admin details such as Field Admin Code, Field Admin Name and their email address.
- DimCustomer: This Job will retrieve and load the Customer details
- DimSalesRep: This Job will retrieve and load the Sales Rep details

Lookup Table Load Jobs:

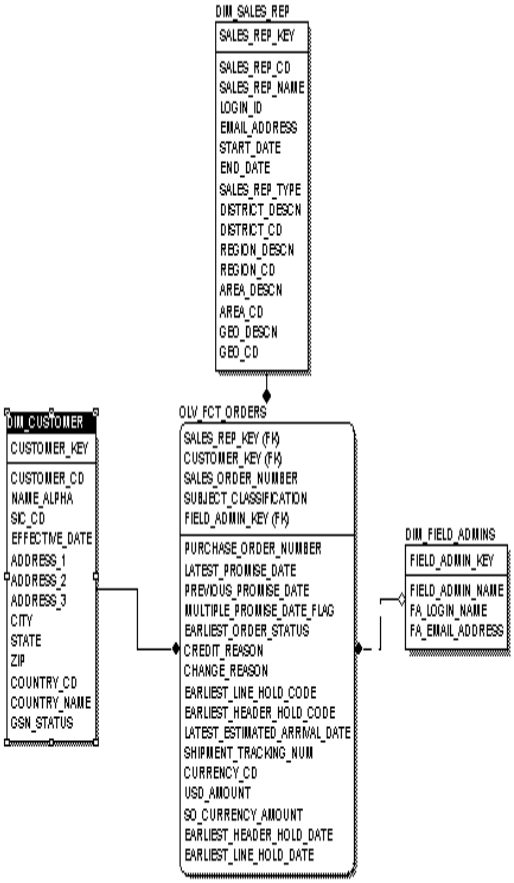
- LkpArrivalDateInfo: This Job will retrieve and load the arrival date information of the order and load in to the LKP_CUSTOMER_ARRIVAL_DATE_INFO table.
- LkpOrderStatus: This job will retrieve the status information of the order and store in to the LKP_ORDER_STATUS table.

Staging Load Jobs:

- StageOrderBacklogs: This jobs retrieves Hold code

information for the Orders and other measures from source system and load it in to the STG_BACKLOG_ORDERS table at the order level.

- StageOrderBookings: This Job retrieves Booking information for the orders, which are booked on the Current date and the corresponding cost, status and hold information from the summary and lookup tables and load into STG_ORDER_BOOKINGS table.
- StageOrderCancelled: This job retrieves Cancelled information from the dimension table and the corresponding cost, Field Admin information from the summary and hold tables and load the data's in to the STG_ORDERS_CANCELLED table.
- StageOrderScheduled: This Job retrieves the Orders Scheduled information from the dimension and summary tables and load it in to the STG_ORDERS_ SCHEDULED table.
- StageOrderNotInvoiced: This SQL retrieves the Order Lines and their associated attributes that have been shipped but not invoiced on a specific date from the dimension table and load it in to the STG_ORDERS_NOTINVOICED table.
- StageOrderInvoiced: This SQL retrieves the Order Lines and their associated attributes that have been shipped and invoiced on a specific date from the dimension table and load it in to the STG_ORDERS_INVOICED table.



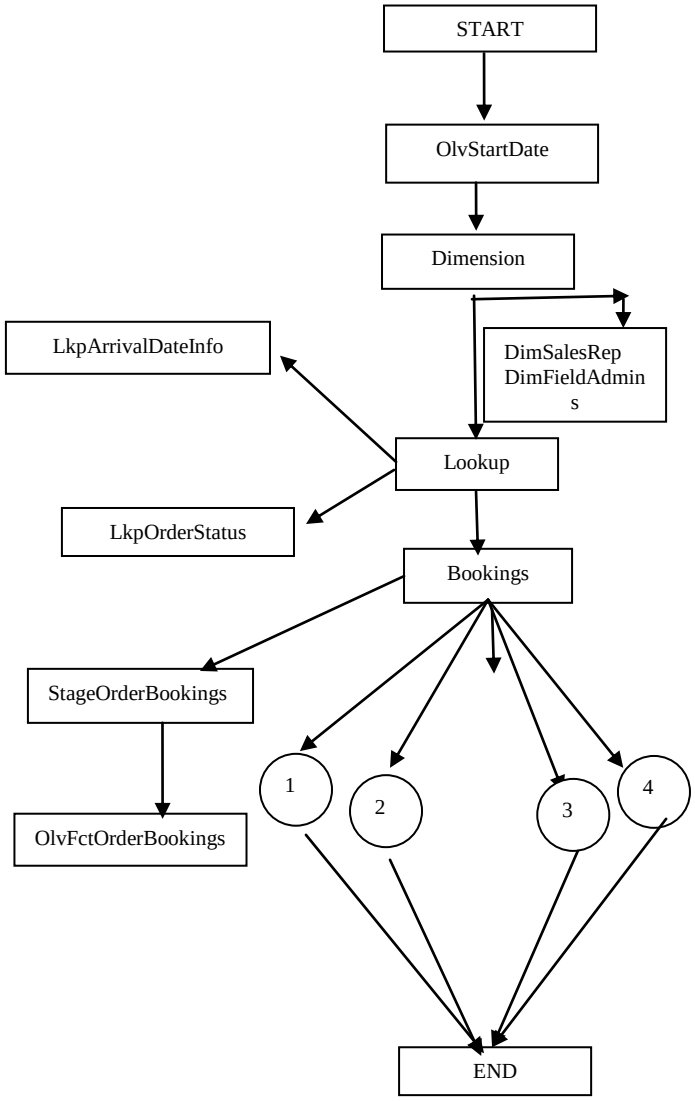
Target Load Jobs:

- OlvFctOrdersBooked: This Job populates the fact table OLV_FCT_ORDERS for the classification 'Booking'.
- OlvFctOrdersCancelled: This Job populates the fact table OLV_FCT_ORDERS for the classification 'CANCELLED'.
- OlvFctOrdersNotInvoiced: This Job populates the fact table OLV_FCT_ORDERS for the classification 'SHIPPED BUT NOT INVOICED'.
- OlvFctOrdersInvoiced: This Job populates the fact table OLV_FCT_ORDERS for the classification 'SHIPPED AND INVOICED'.
- OlvFctOrdersHold: This Job populates the fact table OLV_FCT_ORDERS for the classification 'HOLD'.
- OlvFctOrdersScheduled: This Job populates the fact table OLV_FCT_ORDERS for the classification 'SCHEDULED'.

The below diagram explains the high level Logical data model for the order lifecycle. The data model will not show the intermediate stage tables we use and will only display the high level data flow from Dimension, Lookup and Target.

ETL JOB FLOW:

ETL Job flow diagram gives the diagrammatic view of the Order of execution of jobs.



B. RESULTS AND FINDINGS

The data stored in the order visibility datawarehouse can be validated through the below use cases. The different test cases enables the developer to validate and confirm that the data has loaded correctly.

1. If multiple statuses are associated with an Order, then verify if the earliest status is displayed.

```
select distinct
sales_order_number,
earliest_status_orderlevel
from stg_order_bookings
where sales_order_number = 621600
minus
select distinct
sales_order_number,
b.reporting_status
from (select sales_order_number,
min(a.order_status)
reporting_status
from stg_order_bookings a,
lkp_order_status b
where a.order_status =
b.status_cd(+)
and sales_order_number = 621600
group by sales_order_number) a,
lkp_order_status b
where a.reporting_status =
b.status_cd(+)
```

2. If 'None' is displayed for 'Header Hold Code' column, verify if no header hold code has been defined with the Order.

```
select sales_order_number,
earliest_header_hold_code
from olv_fct_orders
where subject_classification = 'B'
and earliest_header_hold_code is
null
and sales_order_number = 621577

select * from iw_order_line_holds
where order_number = 621577
```

3. If multiple Line Hold Codes were defined for an Order, check if the earliest line hold is displayed for that order.

```
select distinct
sales_order_number,earliest_line_h
old_code from olv_fct_orders
where subject_classification = 'B'
and earliest_header_hold_code is
null and earliest_line_hold_code is
not null
and sales_order_number = 621614

SELECT
SALES_ORDER_NUMBER,EARLIEST_LINE_H
OLD_CODE FROM
STG_ORDER_BOOKINGS A
WHERE LINE_HOLD_CREATION_DATE=(
SELECT
MIN(LINE_HOLD_CREATION_DATE)
FROM STG_ORDER_BOOKINGS1 B
WHERE
A.SALES_ORDER_NUMBER=B.SALES_ORDER
_NUMBER
GROUP BY SALES_ORDER_NUMBER)
and a.sales_order_number = 621614
```

CONCLUSION AND FUTURE WORK

In the changing Information technology world, all technologies/tools will undergo changes during the course of time. The same holds for DW as well. Datawarehouse now offered as a service (DWaaS) instead of an individual data repository. The service provider who provides the DW service will manage the hardware/software resources and the customer pays for the managed service he is lending. From the era of Decision support systems to the Cloud-based environment, Data warehouse has undergone many changes. Latest technologies like Big data, Cloud services were expected to overcome the existence of Datawarehouse in the earlier days. There were even some debates / discussions happened across the technology area to assess the requirement of DW creation for business organizations as to check whether it is a valid investment or not.

However, the necessity of having a Data warehouse for any strategic business decisions still holds valid across organizations. With the advent of latest technologies, the cost of DW creation and maintenance has reduced largely.

In this paper, the detailed analysis on the Data warehouse historical trend and its architectural concepts discussed. The key design principles in designing a data warehouse explained with a help of a case study. The case study demonstrated the design architecture for an order visibility in the supply chain market. A systematic procedure on sequencing the ETL Jobs using the logical data models explained as well. This data will be in use across any Supply chain field or in any other fields, which involves order management processing. This provides the company a meaningful data specifically focused on sales order management, and is used for any strategic, decision purposes.

The research area can be extend to build the reporting environment based on the data warehouse created for order lifecycle. Using the various Business Intelligence tools, currently available in the market, one should be able to arrive and create a robust reporting environment from which meaningful reports (Canned / Dashboard / Adhoc) can be created.

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