Master Thesis

Business Intelligence Solutions For Supporting Management Activities In Small And Medium Enterprises

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Thesis Supervisors:	Ing. Athanasios Podaras, Ph.D.
	Department of Informatics

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Master Thesis Assignment Form

Business Intelligence Solutions For Supporting Management Activities In Small And Medium Enterprises

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3. Applied business intelligence solutions to the food industry.
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- GROSSMANN, Wilfried and Stefanie RINDERLE-MA, 2015. *Fundamentals of Business Intelligence. Data-Centric Systems and Applications.* Berlin Heidelberg: Springer-Verlag. ISBN 978-3-662-4653-1-8.
- SHERMAN, Rick, 2014. *Business Intelligence Guidebook: From Data Integration to Analytics.* USA: Elsevier. ISBN 978-0-12-411461-6.
- KOHTÄMAKI, Marko, 2017. *Real-time Strategy and Business Intelligence.* Cham: Palgrave Macmillan. ISBN 978-3-319-54845-6.
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Anotace

Tato práce se zabývá využitím nástrojů business inteligence pro podporu manažerských činností v malých a středních podnicích. S růstem dat v takových společnostech se potřeba účinných a efektivních nástrojů pro správu dat stala kritičtější. Zahrnuje zkoumání využití MS Access jako nástroje business inteligence a toho, jak jej lze využít k podpoře manažerských činností, jako je analýza dat, reporting a tak dále.

Studie se zaměřuje na konkrétní malý a středně velký potravinářský průmysl v Indii, protože tento podnik má omezené zdroje a může vyžadovat nízkonákladová řešení. Tato práce se zaměřuje na zefektivnění skladových operací společnosti, jako je manipulace se skladovými zásobami, a také upozorňuje na potenciální výhody lepší správy dat a zvýšení efektivity v rozhodovacích procesech.

V úvodní části práce jsou vysvětleny klíčové pojmy a myšlenky týkající se systémů business inteligence. Krátká vysvětlení jsou uvedena v oblasti architektury BI, atributů dat a dat, datového skladu a dalších témat. Navíc jsou zde popisy struktur datového modelování. V následující části práce, která popisuje, jak je systém BI skutečně implementován, jsou využity všechny poučné poznatky. Pomocí mnoha tabulek v MS Access je analyzován firemní sběr dat. Navíc ukazuje, jak byly vytvořeny vztahy mezi tabulkami pomocí přístupů datového modelování. Pro analýzu dat a vytváření sestav bylo vytvořeno několik dotazů. Součástí je také rychlý přehled budoucích studií souvisejících s aktuální prací.

Klíčová slova

Architektura business intelligence, Zefektivnění procesů, Model datového skladu, Systém správy databází, Řízení zásob.

Annotation

This thesis explores the usage of business intelligence tools to support management activities in small and medium-sized enterprises. With the growth of data in such companies, the need for efficient and effective data management tools has become more critical. It involves in examining the usage of MS Access as a business intelligence tool and how it can be used to support management activities, such as data analysis, reporting and so on.

The study focuses on an particular small and medium-sized food industry in India, as this business have limited resources and may require low-cost solutions. This thesis concentrates on streamlining the warehouse operations of the company like inventory handling and also highlights the potential benefits of improved data management and increased efficiency in decision-making processes.

The initial part of the thesis explains the key terms and ideas related to business intelligence systems are explained. Brief explanations are given on the BI Architecture, Data and Data attributes, Data Warehouse, and other topics. Additionally, there are descriptions of the data modelling structures. The following section of the thesis, which describes how the BI system is really implemented, makes use of all the instructive knowledge. With the aid of many tables in MS Access, the company's data collection is analysed. Additionally, it demonstrates how relationships between tables were created using data modelling approaches. Few queries have been constructed for data analysis and reporting. A quick summary of future studies connected to the current thesis is also included.

Keywords

Business intelligence architecture, Process streamlining, Data warehouse model, Database management system, Inventory management.

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List of Abbreviations

BI – Business Intelligence

BPMN – Business Process Modelling Notation

BIMP – Batch Image Processor

CRM – Customer Relationship Management

DBMS – Database Management System

ERP – Enterprise Resource Planning

ER- Entity Relationship

ETL – Extract Transform Loading

MDDB – Multidimensional Databases

MS – Microsoft

OLAP – Online Analytical Processing

ODS – Operational Data Stores

SME – Small and Medium Enterprises

SQL – Structured Query Language

UML – Unified Modelling Language

1NF – First Normal Form

2NF – Second Normal Form

3NF – Third Normal Form

1. Introduction

According to the type of business or organization being managed, it may generally seem like a straightforward procedure that entails a limited number of tasks to get the desired results. But as we approach closer to the action, we see that there are many smaller tasks, firms and many people engaged. Business intelligence fills the requirement for process analysis and simplification as well as aiding in employee organization and productivity.

There is a growing interest in implementing business intelligence systems in enterprises due to the developments in the field of business intelligence. Although the notion of business intelligence and its ability to provide corporate value is widely held, it is not always evident how investments in business intelligence systems are economically justified. Due to a lack of measurement techniques and resources, business intelligence value measurement is frequently neglected in practice. Even while the perceived advantages of business intelligence systems in terms of improved information quality or the accomplishment of goals for information quality improvement are not at all underrated, they are merely side effects of the systems commercial worth. Business intelligence systems economic worth lies in streamlining operations, which boosts productivity (Turk et al. 2010, s. 5).

Creating proper current information is crucial for operational and strategic company decision making. Business intelligence plays a significant part in this process, even though business choices are made at several organizational levels, they are still dependent on business politics and regulations in everyday operations. On the other hand, it also supports analytically focused decision-making process (Turk et al. 2010, s. 6).

This diploma thesis is focused on using business intelligence techniques to assist a food industry's crucial management activity. It involves in streamlining the evaluation and recording information about inventory specifics, the time of entry and exit of the inventory, stock data of the inventory and so on. It is challenging to extract and analyze this massive quantity of data since it is stored in an inefficient manner in typical spreadsheet. Consequently, a business intelligence solution is employed to streamline and enhance the process.

2. Goal and purpose statement

The primary purpose of the thesis is to enhance a food industry's internal data management and recording procedures. In keeping with this, an attempt is being made to employ business intelligence technologies to simplify and accelerate this process in its real-time implementation. Additionally, it seeks to arrange the data structure. In this thesis, MS Access And MS Excel spreadsheets are used to record and analyze inventory information. Combining the above-mentioned software makes it easier to give ideal solution for the firm.

- Identifying the company's current procedures and techniques together with any shortcomings that affect the effectiveness of the processes.
- To improve the activities employing business intelligence system technologies, some research to be done to provide alternatives.
- Finding and implementing a solution to improve the process.
- Creating the logical and conceptual model for the suitable data warehouse solution.
- Initiating the necessary data structure through a database management system program for seeing, updating, and reporting the information.

3. Business intelligence

Business Intelligence (BI) is a phrase used in business management to refer to software and other tools that gather, make available, and analyze information about an organization in order to help decision-makers make more educated choices (Kharade et al. 2022, s. 2).

According to the technology perspective, Business Intelligence (BI) is a set of technologies that facilitates data storage and analysis. The technology that enables the recording, retrieving, manipulating, and analysis of data are the major emphasis, not the method itself but rather on the technology that make it possible to capture, retrieve, manipulate, and analyze data (Kharade et al. 2022, s. 2).

The deployment of BI systems is expensive, requiring a complex project that takes a lot of time and requires the right resources and infrastructure. Examining the important variables that businesses should pay close attention to when starting a project is therefore justified, especially in the context of developing nations where there is limited information available (Kharade et al. 2022, s. 2).

Business intelligence is the most crucial tool for analyzing, managing, and making decisions for any business or organization size. They can use the information to work or study data and come to the best decisions for their growth and development (Kharade et al. 2022, s. 3).

To assist businesses in making more data driven decisions, **Business Intelligence (BI)** blends business perception, data quarry, data envision, data tools and architecture, and best practices (Shankar Bhosale 2021, s. 80).

Effective decision- making requires the timely and integrated use of information systems in this age of globalization and constantly shifting competitive trends of the market. Since the development of information technology, numerous big data businesses, factories, and even public organizations have begun to gather, analyze, and use electronic data from many sources to make significant choices (Kharade et al. 2022, s. 2).

3.1 Improved business functions with Business Intelligence

Business Intelligence aids in the detection of activities, people, or operations that are not adequately aligned with the key business goals. In turn, this facilitates management's ability to act quickly and enhance procedures. Business Intelligence is used in a wide range of applications. It may be a rummage sale for visual analysis, which used data to explain both the pat and the present (Shankar Bhosale 2021, s. 80).

3.1.1 Critical role of Business intelligence in businesses

There are several justifications for why businesses use business intelligence solutions. If you are considering purchasing business intelligence software, you might be wondering if it will be worth the time, effort, and the money to integrate it to the existing software suite. Business presentation organization, sales pipeline analysis, expenditure analysis, and sales compensation analysis are a few examples of the specific uses for Business Intelligence solutions may focus (Shankar Bhosale 2021, s. 82).

3.1.2 How Business intelligence aids in different parameters of business functions

Rapid examination

Business Intelligence systems are designed to do labor intensive information processing in the cloud or on the servers of your company. Business intelligence tools gather data from a variety of sources into an information storeroom. They then analyze the data before displaying it on consoles, slog-and droplet reports, and operator queries (Shankar Bhosale 2021, s. 83).

Improved management planning

Business Intelligence platforms for departmental collaboration, models created to improve better traceability, and swifter, more efficient methods of carrying productions. When

business invest a few hours in information examination and merging information (Shankar Bhosale 2021, s. 83).

Information influenced commercial decisions

Making better business decisions made possible by accurate information and quick reporting capabilities. They may firmly approach customers or merchants and also provide the most recent information projections (Shankar Bhosale 2021, s. 83).

Enhanced customer experience

Consumer satisfaction and experience may be directly influenced by commercial intelligence (Shankar Bhosale 2021, s. 83).

Increased employee satisfaction

Department of information technology and inspection spend less time responding to demands made by business employers. Departments that previously lacked the power to check their own information without consulting an inspector or an IT specialist can now do so with no training (Shankar Bhosale 2021, s. 83).

3.2 Business Intelligence (BI) Architecture

Exemplar BI architecture
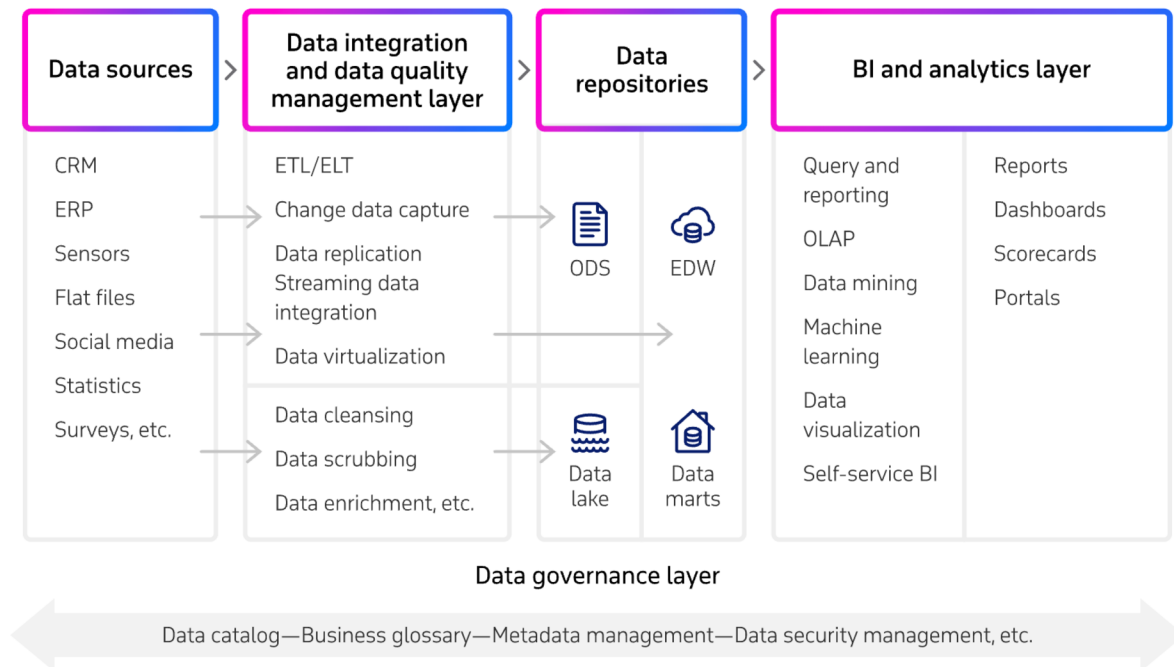
Figure 1: Modern BI architecture

Source: (Korobeyko [b.r.])

The following are the main components, as depicted in the business intelligence architecture diagram that is included.

3.2.1 Data source systems

All these systems such as **(ERP) Enterprise Resource Planning**, **(CRM) Customer Relationship Management,** financial, manufacturing, and supply chain management systems capture and store the transactional and operational data that has been highlighted as being crucial for the enterprise BI program. Secondary sources from outside data providers, such as market information and customer databases, can also be considered. As a result, A BI design frequently includes both internal and external data sources (Pratt [b.r.]).

Data relevance, data currency, data quality, and the amount of information in the accessible data sets are crucial factors in the selection of a data source. Executives and other

business users may also need a blend of structured, semi structured, and unstructured data formats to suit their data analysis and decision-making needs (Pratt [b.r.]).

3.2.2 Data integration and data quality management layer

An enterprise must combine and integrate many data sets to provide unified perspectives of them in order to evaluate the data gathered for a BI program successfully. **ETL (Extract Transform Load)** software, which extracts data from sources systems in batch operations, is the most popular data integration tool for BI applications. ETL is a variation in which data is extracted, loaded, and converted subsequently for certain BI needs. Other approaches include data virtualization, which virtually integrates data from several source systems, and real time data integration, such as change data capture enable and streaming integration to enable real time analytics applications (Pratt [b.r.]).

Tools for data profiling and data purification are frequently included in BI architectures and are used to detect and address problems with data quality. They assist data management a BI team in producing clean, consistent data that is appropriate for BI applications (Pratt [b.r.]).

3.2.3 Data Repositories

This includes all the locations where BI data is maintained and kept. The most important is a data warehouse, which typically maintains structured data in a relational, columnar, or multidimensional database and makes it accessible for analysis and querying. Additionally, an enterprise data warehouse may be connected to smaller data marts created for individual departments and business units and filled with information tailored to those individual BI requirements (Pratt [b.r.]).

Additionally, **Operational Data Stores (ODS)**, which serve as a temporary storage location for data before it is transferred to a data warehouse, are frequently included in BI systems. An ODS may also be utilized to execute analytical queries on recent transactional data. A data warehouse, data marts, and an ODS can all be implemented on a single database server or on several systems, depending on the scale of BI environment (Pratt [b.r.]).

A BI architecture may also make use of a data lake that is powered by a Hadoop cluster or another big data platform as a repository for different sorts of raw data. The data may either be filtered and transferred into a data warehouse for analysis, or it can be studied directly in the data lake. The data storage which is ideal for certain BI needs should be specified in a well-planned architecture (Pratt [b.r.]).

3.2.4 BI and analytics layer

Ad hoc query, data mining, and online analytical processing, or **OLAP (Online Analytical Processing)**, software is one of the few technologies that may be included into a BI architecture and are used to analyze data and display information to business users. Additionally, business analysts and managers may now run their own queries without the assistance of a Bi team because of the rising popularity of self-service BI technologies (Pratt [b.r.]).

Data visualization tools are also a part of BI software and may be used to produce graphical representations of the data in the form of charts, graphs, and other visualizations that highlight trends, patterns, and outer aspects in data sets (Pratt [b.r.]).

3.2.5 Dashboards, portals, and reports

With built-in data visualizations and frequently self-service options to perform additional data analysis, these information delivery platforms provide business users with visibility into the outcomes of BI and analytics applications (Pratt [b.r.]).

3.2.6 Data Governance layer

This component's primary function is to oversee and manage the whole BI process, which makes it closely related to the other four. When a corporation has data governance rules and policies in place, it can regulate who has access to the information, how it is accessed, if the data is of good quality and is properly protected etc., (Korobeyko [b.r.])

3.3 Business Process Modelling

By providing data-driven visual representations of the most important business processes, business process modeling provides businesses with an easy approach to comprehend and enhance workflows (Anon. [b.r.]).

A business process or workflow and the associated sub-processes are graphically represented in a business process model. Process modeling produces detailed, quantitative activity diagrams and flowcharts with important insights into how a particular process works, such as the following: (Anon. [b.r.])

- Activities and Events that take place inside a process.
- Who is responsible for those activities and events?
- Decision points and the alternate directions processes might go depending on their results.
- Equipment used in the procedure.
- Timelines for both the entire procedure and each individual phase.
- Positive and negative outcomes of the process.

3.3.1 Business Process Modelling Notation (BPMN)
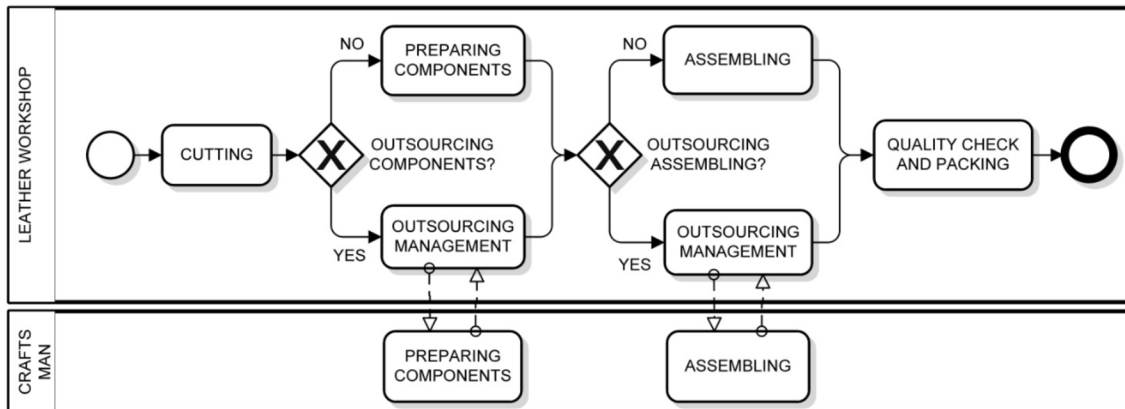
Figure 2: An example of a leather bag manufacturing workshop BPMN model

Source: (Cimino a Vaglini 2014, s. 325)

(BPMN) Business Process Modelling Notation is a popular graphical language for modeling business processes. A **Business Process Diagram (BPD)**, a flow-chart-based model that enables the explicit recording of activities, control flows, data, and auxiliary information about the process, is used in BPMN to define a business process (Rospocher et al. 2014, s. 135).

The (Figure 2) depicts the large-scale procedures involved in making bags at a leather business. The leather workshop pool start event, more particularly, shows where the process begins. The next step involves cutting a leather sheet. There are now two options: either the bag components are prepared externally through outsourcing or inside through a component preparation operation. In the latter scenario, an outsourcing management activity is in responsibility of assigning a third party to the job, which will be done by a skilled worker. As with the prior activity, an assembly activity can then be carried out either internally or externally. Finally, final items are created after the quality check and packing operations. The process termination is indicated by the end event (Cimino a Vaglini 2014, s. 325).

The **(BP) Business Process** diagram is provided by BPMN to represent business processes. The **(BIMP) Batch Image Processor** simulator supports the following core BP diagram components: event, gateway (split node), merging node, task, and activity. The following (Figure 3) provides a succinct definition of key ideas (Cimino a Vaglini 2014, s. 324).
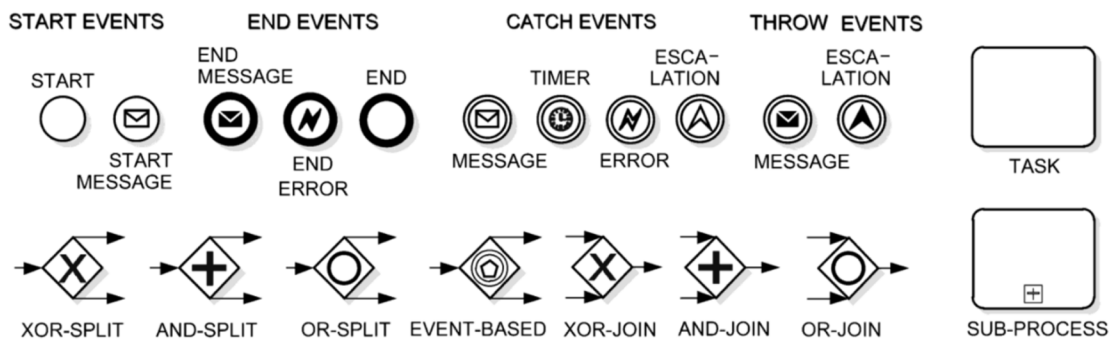
Figure 3: Business process model and BPMN elements supported by the BIMP simulator

Source: (Cimino a Vaglini 2014, s. 324)

Events serve as metaphors for potential BP outcomes and a start event initiates a business flow, which can continue with an end event, and intermediate events can take place anywhere in between. Gateways serve as decision points to regulate the flow of business activities. Business activities can be present as tasks or processes, sub-processes and also serve as a linking of tasks. The order in which the actions in the BP are carried out is shown by the sequence flow, which is depicted by solid arrows (Cimino a Vaglini 2014, s. 324).

We use the idea of a token traversing the sequence flow and passing through the process parts to build the BPMN process model. A theoretical idea known as a token is used to describe how a process will behave while it is being carried out. Any BPMN element which is present in the process model has a unique state for each process instance during the simulation (Cimino a Vaglini 2014, s. 324).
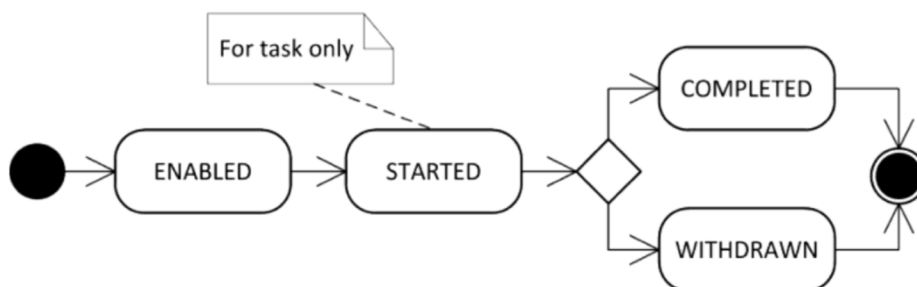
Figure 4: A UML state diagram showing the lifespan of a BPMN component that the BIMP simulator supports

Source: (Cimino a Vaglini 2014, s. 325)

(Figure 4) illustrates the lifetime of a BPMN element supported by the BIMP simulator using a **UML (Unified Modelling Language)** state diagram. An element explicitly gets enabled when the simulation engine chooses it as an element to be handled. A job is considered to have begun when a resource is assigned to it. Due to the fact that resources may only be given to tasks, elements other than tasks do not have the state "started". The element is considered complete if it is finished without any delays. If not, it becomes withdrawn (Cimino a Vaglini 2014, s. 324–325).

A BP diagram is often structured according to interacting pools (partners), which are depicted as named rectangular containers. To indicate a thorough classification of activities, a pool can be split into lanes, represented as internal labelled rectangular containers. Last but not least, communication flows, shown as a dashed white arrow, express messages transmitted between commercial companies (Cimino a Vaglini 2014, s. 325).

3.4 Database management system (DBMS)

A **database management system (DBMS)** is a cluster of software applications that maintains the organization of databases and oversees user access to the data they contain. A database resembles an extremely well-organized electronic file cabinet where the contents are managed by sophisticated software called a database management system (Coronel et al. 2011, s. 7).

3.4.1 Functions of the database management system

- The DBMS acts as a go-between between the user and the database.
- The database structure itself is kept as a group of files, and the DBMS is the sole mechanism to retrieve the data in those files.
- All application requests are received by the DBMS, which then converts them into the intricate processes necessary to fulfil them.
- The application software and users are mostly unaware of the internal intricacy of the database thanks to the DBMS.

- The application software may be produced using a DBMS utility tool or by a programmer using a programming language like Visual Basic.NET, Java, or C#.

Source: (Coronel et al. 2011, s. 7)
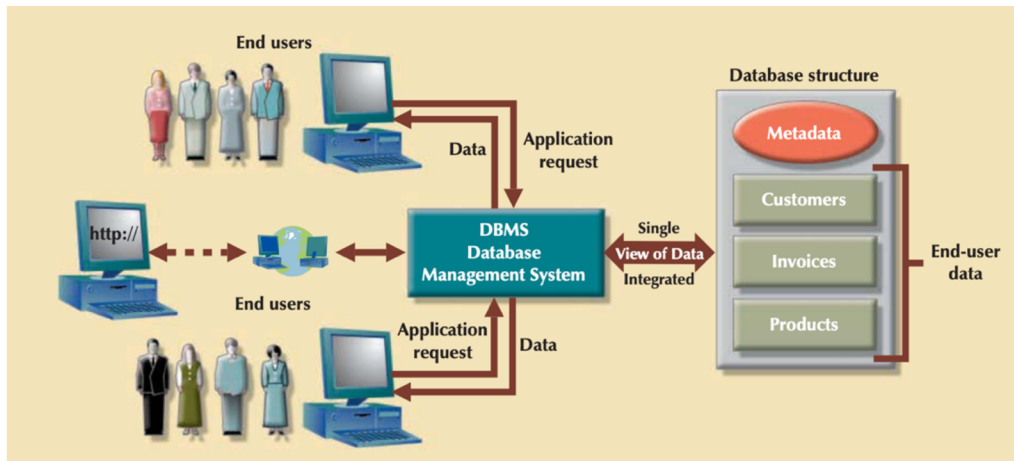
Figure 5: Roles of database management system

Source: (Coronel et al. 2011, s. 8)

3.4.2 Advantages of the database management system

- **Enhanced data exchange** - End users benefit from improved access to more and better managed data thanks to the DBMS environment. End users may react swiftly to changes in their environment thanks to this access (Coronel et al. 2011, s. 8).

- **Enhanced data protection** - The hazards of data security breaches increase as more individuals access the data. Businesses spend a plenty of time, effort, and money resources making sure that their data is used effectively. A DBMS offers a framework for better upholding data security and privacy rules (Coronel et al. 2011, s. 8).

- **Improved data integration** - An integrated perspective of the activities of the company and a stronger understanding of the broad picture are encouraged by greater access to well-managed data. It becomes much simpler to see how decisions made in one area of the business influence areas in other areas (Coronel et al. 2011, s. 8).

- **Increased output from users** - Informed judgments may be the difference between success and failure in the global economy, and the tools that turn data into useable information make it possible for end users to take advantage of this capacity (Coronel et al. 2011, s. 9).

3.5 Database management system architecture

The 3-tier DBMS architecture is the most popular one. A 3-tier DBMS divides its tiers based on the number of users. This is how it is explained:-
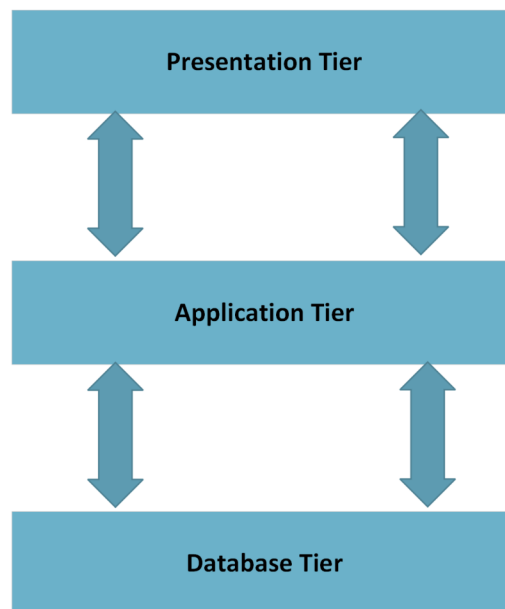
Figure 6: 3-tier DBMS architecture

Source: Own contribution

- **Database (data) tier** - There is simply a database here. The third layer of a three-tier architecture houses the database and the languages used to perform its queries. All relations and their restrictions are also included (Tutorials Point [b.r.], s. 10).

- **Application (middle) tier** - The application server and software that accesses the database are located at this layer. This application tier serves as a user's abstracted view of the database. Users are unaware that databases exist outside of applications. The application tier uses the database-tier. Beyond application tier, no further users are

known to the database tier. Between the two, this stratum serves as a mediator (Tutorials Point [b.r.], s. 10).

- **User (presentation) tier -** On this layer, an end user is seated. This layer is crucial from the perspective of the user. Beyond this layer, he or she is unaware of any databases in existence or in use. The program can offer many database views at this tier. Applications which are found in the application tier give all views (Tutorials Point [b.r.], s. 10).

Given that practically all of its components are independent of one another and may be altered individually, multiple layer database design is very flexible (Tutorials Point [b.r.], s. 10).

3.6 Relational database management system

In addition to a slew of other tasks that make the relational data model simpler to comprehend and use, the **Relational Database Management System (RDBMS)** fulfills the same fundamental tasks as the Hierarchical and Network DBMS systems (Coronel et al. 2011, s. 36).

3.6.1 Advantages of relational database management system

- Its capability to shield the user from the relational model's complexity.
- While the user views the relational database as a set of tables in which data are kept, the RDBMS maintains all of the technical aspects.
- The user may query and alter the data in a way that looks reasonable and straightforward.

Source: (Coronel et al. 2011, s. 36)

3.6.2 Concept development for an RDBMS

Before the database itself is developed, an **(ER) Entity Relationship Diagram** is created to set up the database idea. This provides an overview of the individual elements and their relations recorded in the database by displaying the entities and their relationships in a diagram. A user can gain valuable insight into an existing database by using an ER diagram. The following ER diagrams both (Figure 7) and (Figure 8) below has the components listed below: (Reid a Adams 2002, s. 3)
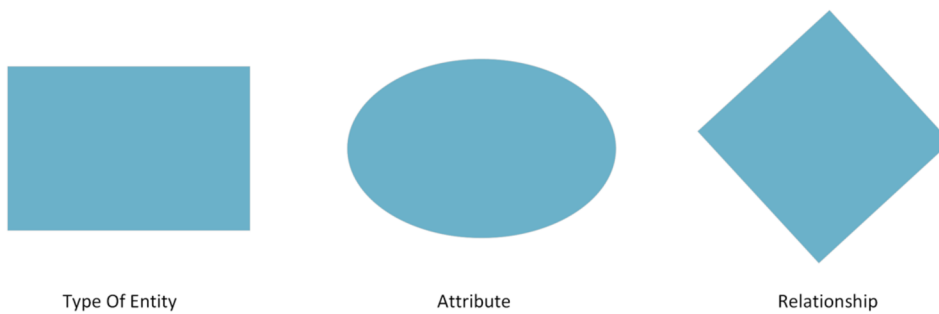
Figure 7: Elements of an RDBMS ER Diagram

Source: Own contribution
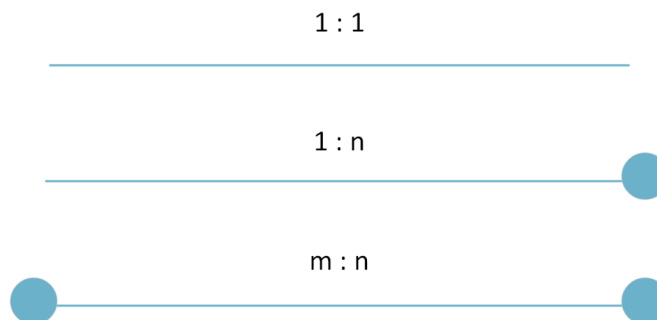
Figure 8: Relations of an RDBMS ER Diagram

Source: Own contribution

3.7 Entity relationship model

The concept of real-world entities and their relationships is the foundation of the entity relationship model. The entity set, relationship set, generic characteristics, and constraints are

created by the ER Model when it transforms real world scenarios into database models (Tutorials Point [b.r.], s. 11).
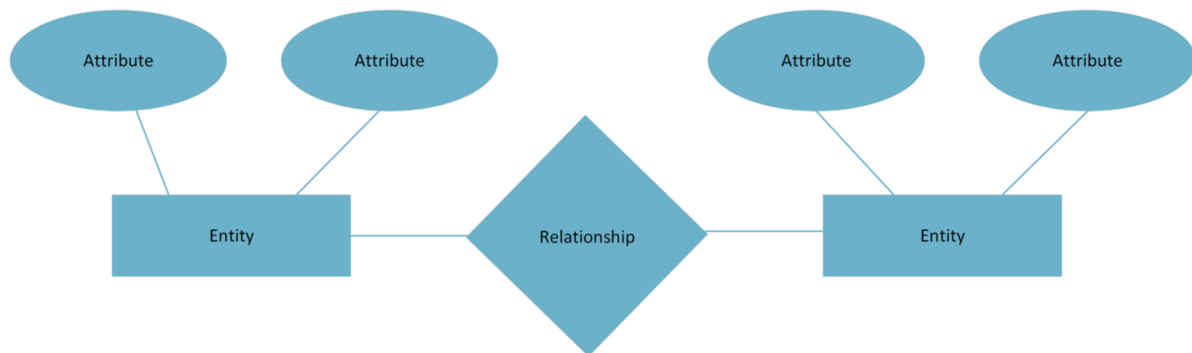
Figure 9: Basic ER model Diagram

Source: Own contribution

3.7.1 Conceptual database design of ER model

Entities and their attributes are the foundation of the ER Model. Relationships between the entities are explained below:

- **Entity -** A tangible object that is immediately recognizable and distinguished in the actual world, whether it is living or inanimate. For instance, in a university database, entities may include students, professors, classes, and courses offered. All entities have a few traits or characteristics that define who they are. A group of related sorts of entities is known as an entity set. Entities in an entity collection may have attributes with similar values (Tutorials Point [b.r.], s. 17). Rectangles are used to represent entities. The entity set that a rectangle represents is included in its name (Tutorials Point [b.r.], s. 21).

  For instance, a student's set would include every student in a university, while a teacher's set might include every instructor in a university across all faculties. Disjoint entity sets are not required.

Source: Own contribution

- **Attributes -** Attributes are the qualities that serve as representations for entities. Every attribute has a value. For instance, a student object may include properties like name, class, and age. A domain or a range of values are available for attributes to be assigned. A student's name, for instance, cannot be a number. It must follow the alphabet. The age of a student must not be negative, etc (Tutorials Point [b.r.], s. 17).

- **Type of attributes:-**

- **Simple attribute -** Properties of entities include attributes. Eclipses serve as a representation of attributes. Every eclipse exemplifies a certain quality and is associated with the entity it belongs to (rectangle) (Tutorials Point [b.r.], s. 21). Simple characteristics are atomic values that cannot be further subdivided. The phone number of a student, for instance, has an atomic value of 10 digits.
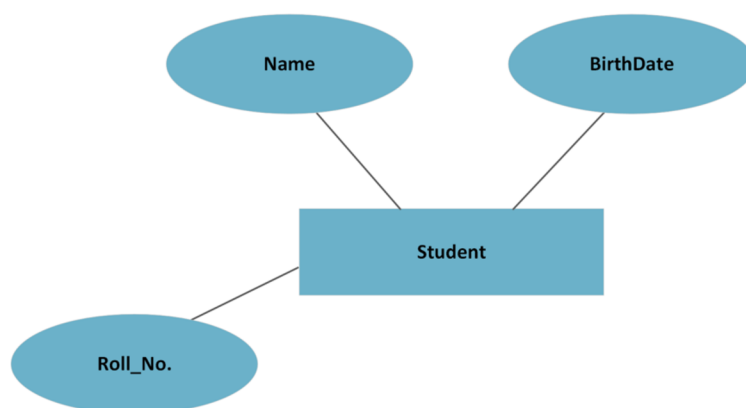
Figure 11: Simple attribute ER diagram

Source: Own contribution

29

- **Composite attribute -** In a tree-like structure, the traits are further broken down if they are composite. Then, each node is linked to its associated attribute. Eclipses that are associated with an eclipse indicate those composite features (Tutorials Point [b.r.], s. 21). Multiple simple qualities combine to form composite attributes (Tutorials Point [b.r.], s. 17).

For instance, a student's full name can consist of both their first and last names.
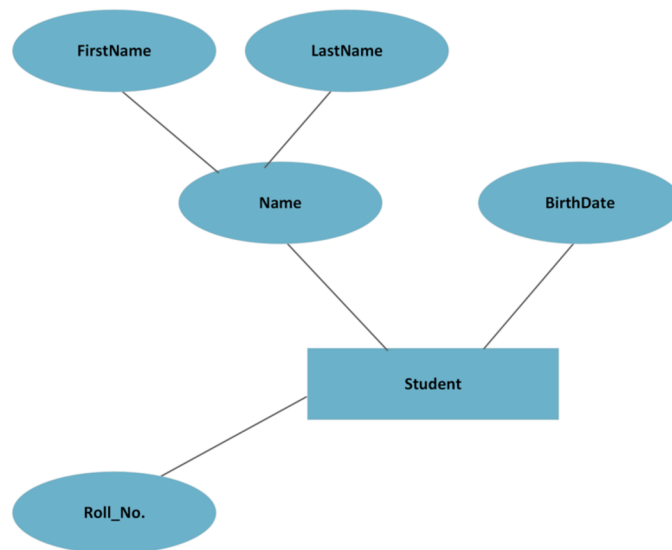
Figure 12: Composite attribute ER diagram

Source: Own contribution

- **Derived attributes -** Derived attributes are those whose values are derived from other attributes shown in the database but which do not physically reside there (Tutorials Point [b.r.], s. 17). Dashed eclipses represent derived properties (Tutorials Point [b.r.], s. 22).
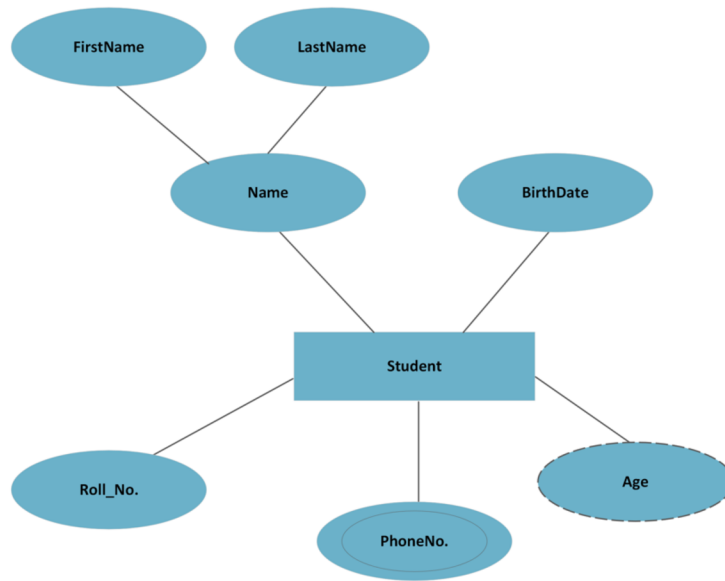
Figure 13: Derived attribute ER diagram

Source: Own contribution

- **Multi valued attributes -** A multi-value attribute is one that can have several values. For instance, a student could have many phone numbers (Tutorials Point [b.r.], s. 17). Double eclipses represent multi valued attributes (Tutorials Point [b.r.], s. 22).
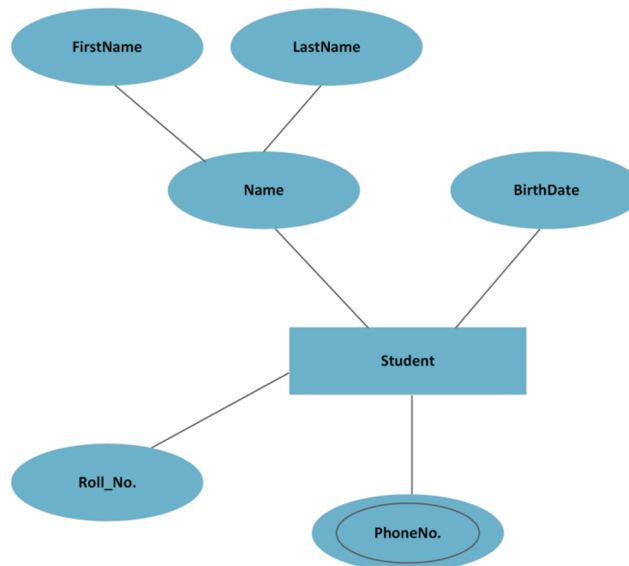
Figure 14: Multi valued attribute ER diagram

Source: Own contribution

- **Entity set and keys -** One attribute, or group of attributes, known as a "key," uniquely identifies an entity inside a set of other entities. For instance, student can be recognized among other students by using their roll number (Tutorials Point [b.r.], s. 18).

- **Super key -** An entity in an entity set is identified by a collection of (one or more) attributes (Tutorials Point [b.r.], s. 18).

- **Candidate key -** Candidate keys are minimal super keys, which are super keys for which no valid subset is a super key. More than one candidate key may exist for an entity collection (Tutorials Point [b.r.], s. 18).

- **Primary key -** The database designer selected this as one of the potential keys to specifically identify the entity collection (Tutorials Point [b.r.], s. 18).

- **Relationship -** Relationships are symbolized as a box with a diamond shape. The diamond-box has the relationship's name embedded on it. Each entity (rectangle) involved in the relationship is joined to it by a line (Tutorials Point [b.r.], s. 23).

o **Binary relationship and cardinality -** Binary relationships involve two entities and are defined as such. The number of instances of an entity from a connection that may be linked to the relation is measured by its cardinality (Tutorials Point [b.r.], s. 23).

- **One-to-one -** It is represented as "1" when there is only one instance of an entity linked to the relationship. The (Figure 15) below shows that there should only be one instance of each entity linked to the relationship. This is referred to as one-to-one relationship (Tutorials Point [b.r.], s. 23).
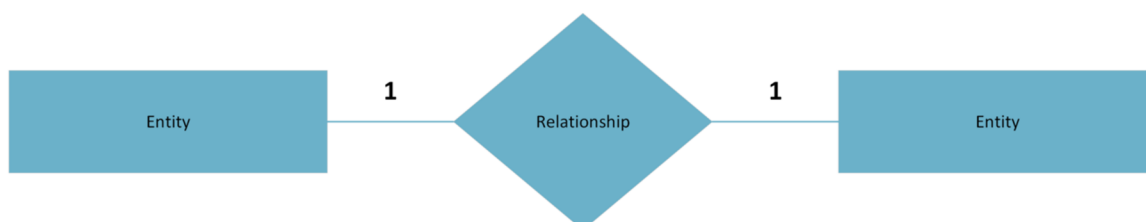
Figure 15: One-to-one ER diagram

- **One-to-many -** The relationship is denoted as "N" when there are several instances of an entity linked to it. According to the (Figure 16) below, the relationship can only be represented by one instance of each entity on the left and several instances of each entity on the right where one-to-many relationships are illustrated (Tutorials Point [b.r.], s. 24).
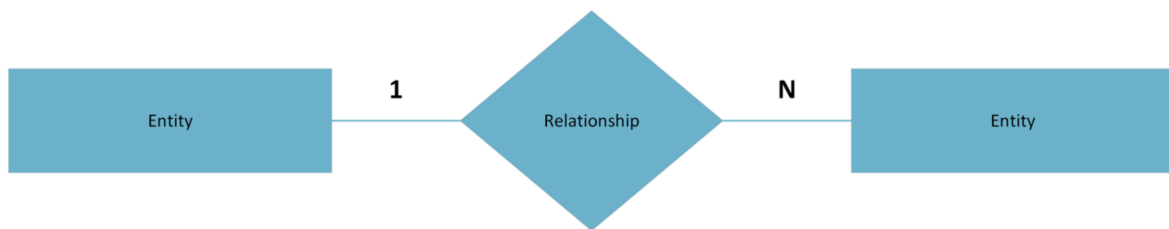
Figure 16: One-to-many ER diagram

- **Many-to-one -** The relationship is denoted as "N" when there are several instances of an entity linked to it. According to the (Figure 17) below, the relationship can be connected to more than one occurrence of the entity on the left side and only one occurrence of the entity on the right side. It illustrates a many-to-one relationship (Tutorials Point [b.r.], s. 24).
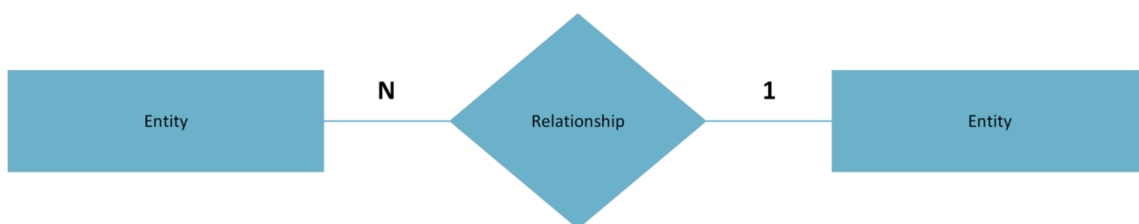
Figure 17: Many-to-one ER diagram

- **Many- to-many -** The (Figure 18) below shows how more than one instance of each entity on the left and the right can be connected to the relationship. The many-to-many relationship is portrayed (Tutorials Point [b.r.], s. 24).
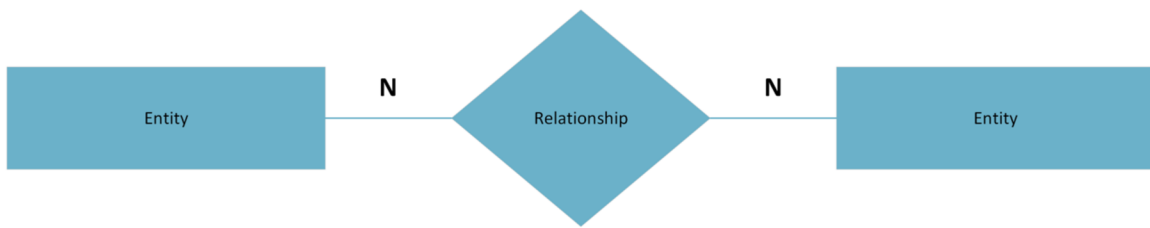
Figure 18: Many-to-many ER diagram

Source: Own contribution

○ **Participation Constraints:-**

• **Total Participation -** The relationship involves every entity in the entity. Double lines signify the total participation (Tutorials Point [b.r.], s. 24).

• **Partial Participation -** The relationship does not include all entities. A single line is used to signify partial participation (Tutorials Point [b.r.], s. 25).
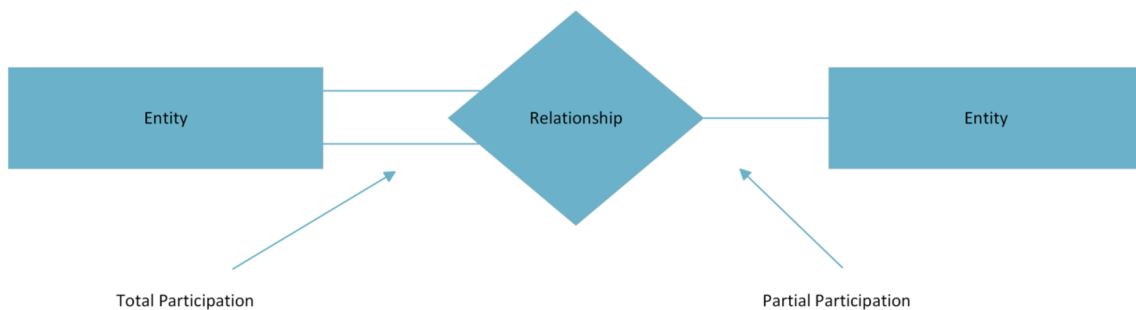
Figure 19: Participation constraints ER diagram

Source: Own contribution

• **Generalization -** It is known as the generalization process when entities are made to have the attributes of all other generalized entities. In generalization, many entities are combined into a single generalized entity based on their shared traits (Tutorials Point [b.r.], s. 26).

For example, Mercedes Benz, BMW, Audi can be generalized as cars.
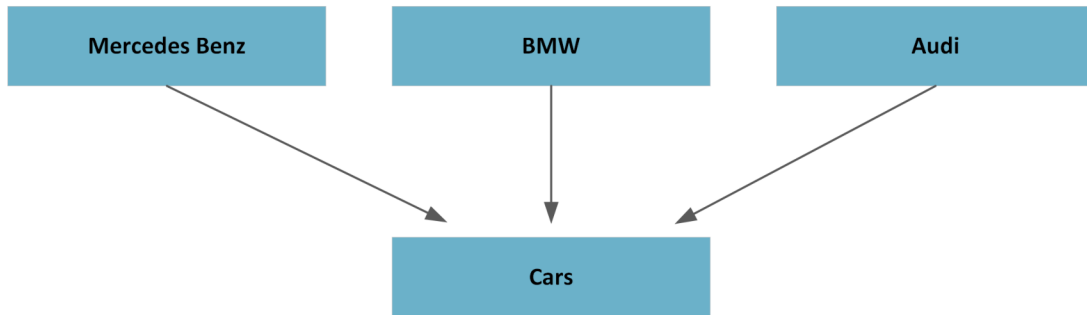
Figure 20: Generalization ER diagram

Source: Own contribution

- **Specialization -** As was already mentioned, specialization is a process that runs counter to generalization. In specialization, a collection of things is broken down into smaller groups according to their traits (Tutorials Point [b.r.], s. 26).

For example, In a university database, a person may be specialized as a staff member, student, or instructor depending on their position within the institution.
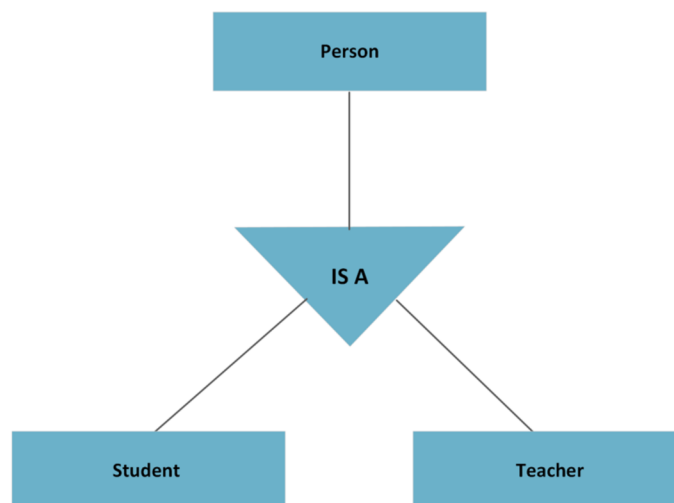
Figure 21: Specialization ER diagram

Source: Own contribution

- **Inheritance -** Inheritance, or the fact that lower-level things take on the characteristics of higher-level entities, is one of the key aspects of generalization and specialization (Tutorials Point [b.r.], s. 27).

For example, lower level entities like students, teachers, and others can inherit personal attributes like a person's name, age, and gender.
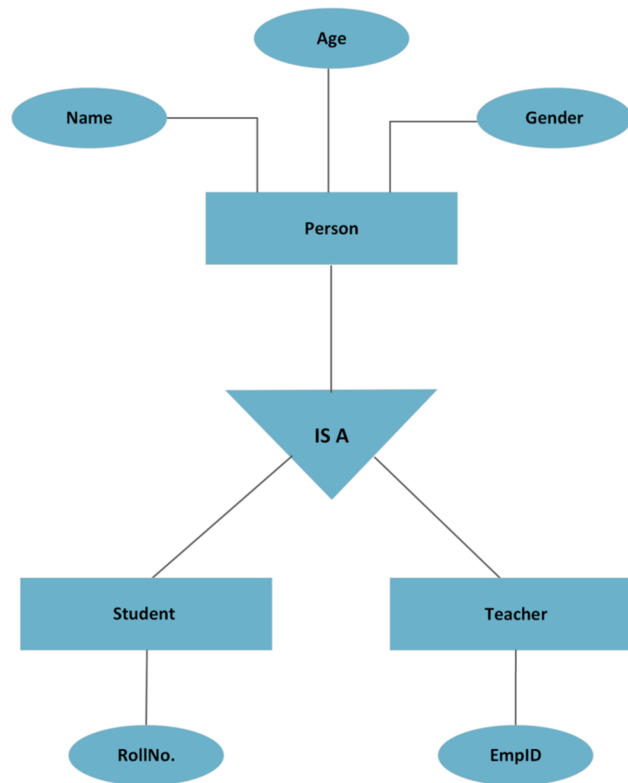
Figure 22: Inheritance ER diagram

Source: Own contribution

3.8 DBMS data schemas

3.8.1 Database schema

It represents the logical picture of the whole database and is the skeleton of the database schema. It describes the arrangement of the data and the relationships that exist between them. It outlines every database restriction that would be applied on data in relations that is stored in a database (Tutorials Point [b.r.], s. 13).

A database schema identifies the relationships between its entities. Schema diagrams may be used to represent database schema, which is a descriptive aspect of the database.

Database designers perform all of these tasks to assist programmers and make it easier for them to grasp all aspects of databases (Tutorials Point [b.r.], s. 13).
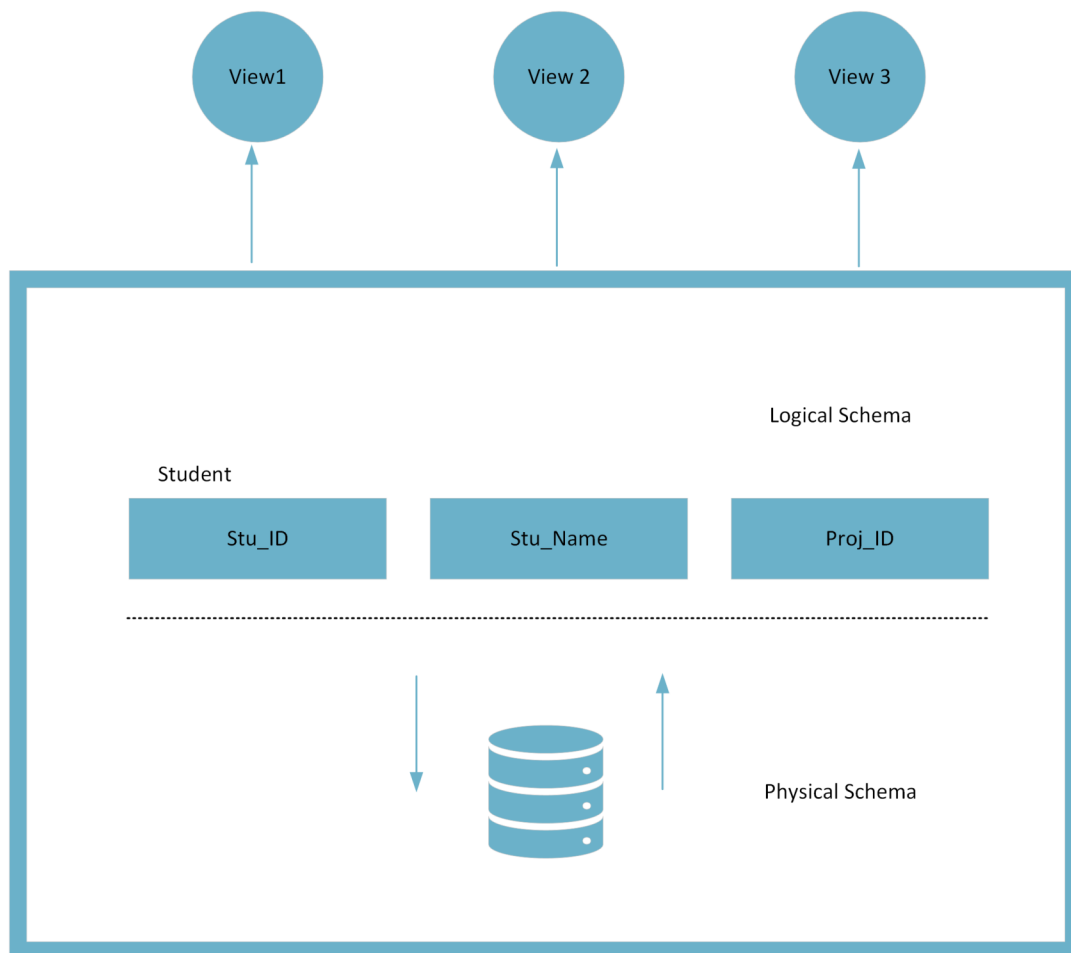
Figure 23: Structure of database schemas

Source: Own contribution

Database schema may be roughly classified into two types:

- **Physical database schema -** This schema relates to the actual data storage and the many types of storage, such as files, indices, etc. It specifies, among other things, how data will be kept in secondary storage (Tutorials Point [b.r.], s. 14).

- **Logical database schema -** This outlines any logical restrictions that must be applied to stored data. Tables, views, integrity restrictions, and other terms are defined (Tutorials Point [b.r.], s. 14).

3.8.2 Data independence

In addition to user data, the entire database management system contains a vast amount of data. Three different types of schemas are included in (DBMS) Database Management System, which are themselves data about data (Meta-Data). Along with the database, meta-data is also kept, and once it is, it is difficult to change. However, as DBMS grows, changes must be made over time to meet user needs. However, if all of the data were highly dependent, it would be laborious and extremely complicated (Tutorials Point [b.r.], s. 15).
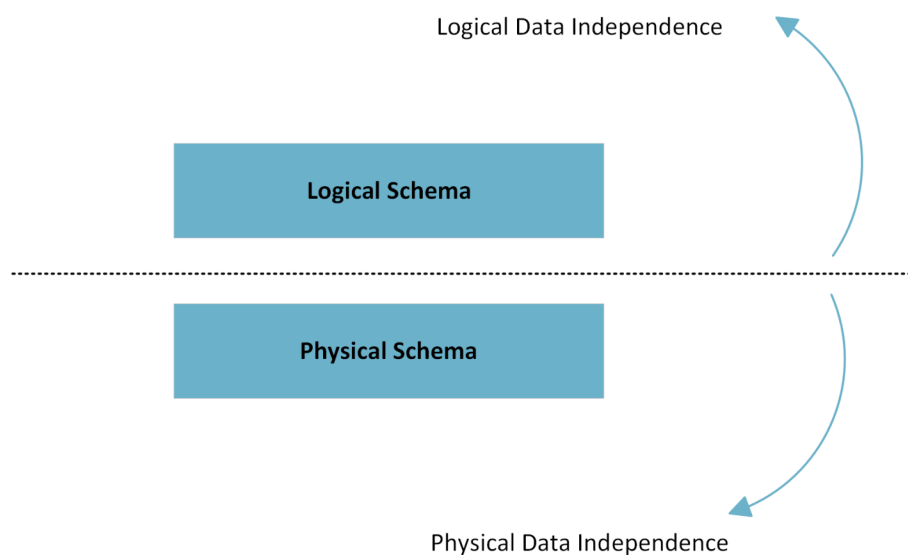
Figure 24: Data independence

Source: Own contribution

The data itself is split into layered architecture as seen in the above mentioned (Figure 22) so that changing data at one layer would not affect data layered at higher levels. Despite being separate, these data are mapped on one another (Tutorials Point [b.r.], s. 15).

3.8.3 Logical data independence

A form of mechanism known as logical data independence liberates itself from the actual data that is kept on the disk. The data stored on disk shouldn't be altered if we make certain modifications to the table format (Tutorials Point [b.r.], s. 15).

3.8.4 Physical data independence

All schemas are logical, and the real data is kept on the disk in bit format. The ability to alter physical data without having an influence on the schema or logical data is known as physical data independence (Tutorials Point [b.r.], s. 16).

3.9 Database normalization

A database design approach for arranging data in an orderly and consistent manner is called database normalization. By doing so, you may keep the database's integrity and prevent redundancy. Additionally, it aids in getting rid of unfavourable traits connected to insertion, deletion, and updating (Chris 2022).

3.9.1 Purpose of normalization

Database normalization's primary goals are to reduce complexity, get rid of duplicates, and arrange data consistently. The data is split up into several tables during normalization, and these tables are connected by relationships. *"These relationships may be created by database administrators using primary keys, foreign keys, and composite keys"* (Chris 2022).

3.9.2 Rules of normalization

Database normalization includes three rules. Databases may be categorized according on how many rules they adhere to. The first rule states that the database is in normal form when applied. Your database has attained second normal form using rule number one and rule number two. Third normal form is reached once rule number three has been added to your

database in the third normal form. The highest typical level of normalization that a database has attained is third normal form (Anon. [b.r.]).

The three rules are given below:

Rule 1 (First normal form) (1NF) :-

- Remove redundant groups from each table.
- For each group of connected data, make a distinct table.
- Use a primary key to identify each group of linked data.
- To contain comparable data, avoid using many fields in a single table.

Source: (Anon. [b.r.])

Construction of the restaurant management application is shown in (Figure 25) which begins with the creation of the following table of employees, which will be used to hold information on the company's employees (Chris 2022):-

EMPLOYEE_ID	NAME	JOB_CODE	JOB	STATE_CODE	HOME_STATE
E001	Alice	J01	Chef	26	Michigan
E001	Alice	J02	Waiter	26	Michigan
E002	Bob	J02	Waiter	56	Wyoming
E002	Bob	J03	Bartender	56	Wyoming
E003	Alice	J01	Chef	56	Wyoming

Figure 25: An example of Rule 1 (First normal form)

Source: (Chris 2022)

The table in the figure fulfils the Rule 1 (First normal form) since all the entries are atomic and there is a primary key (employee_id, job_code).

Rule 2 (Second normal form) (2NF) :-

- For collections of values that apply to numerous records, use distinct tables.
- Create a foreign key to connect these tables.
- Records should only be reliant on the primary key in a table (a compound key can be used if necessary).

Source: (Anon. [b.r.])

EMPLOYEE_ID	JOB_CODE
E001	J01
E001	J02
E002	J02
E002	J03
E003	J01

EMPLOYEE_ID	NAME	STATE_CODE	HOME_STATE
E001	Alice	26	Michigan
E002	Bob	56	Wyoming
Wyoming	Wyoming	Wyoming	Wyoming

JOB_CODE	JOB
J01	Chef
J02	Waiter
J03	Bartender

Figure 26: An example of Rule 2 (Second normal form)

Source: (Chris 2022)

Rule 3 (Third normal form) (3NF) :-

- Remove any fields that are independent of the key.
- Records in the table should not contain values that are not a part of the key for that record.
- In general, think about establishing a collection of data in a different table whenever the information in those columns may apply to more than one item in the table.

Source: (Anon. [b.r.])

EMPLOYEE_ID	JOB_CODE	JOB
E001	J01	Chef
E001	J02	Waiter
E002	J02	Waiter
E002	J03	Bartender
E003	J01	Chef

EMPLOYEE_ID	NAME	STATE_CODE
E001	Alice	26
E002	Bob	56
E003	Alice	39

JOB_CODE	JOB
J01	Chef
J02	Waiter
J03	Bartender

STATE_CODE	HOME_STATE
26	Michigan
56	Wyoming

Figure 27: An example of Rule 3 (Third normal form)

Source: (Chris 2022)

3.10 Data modelling

The process of constructing a data model for the data that will be kept in a database is known as data modelling. This data model is a conceptual representation of the relationships between various data items, the rules, and the data objects themselves. Data modelling facilitates the visual delineation of data and ensures that it complies with legal requirements, corporate regulations, and governmental directives. Data models guarantee data quality while guaranteeing uniformity in naming standards, default values, semantics, and security (Taylor [b.r.]).
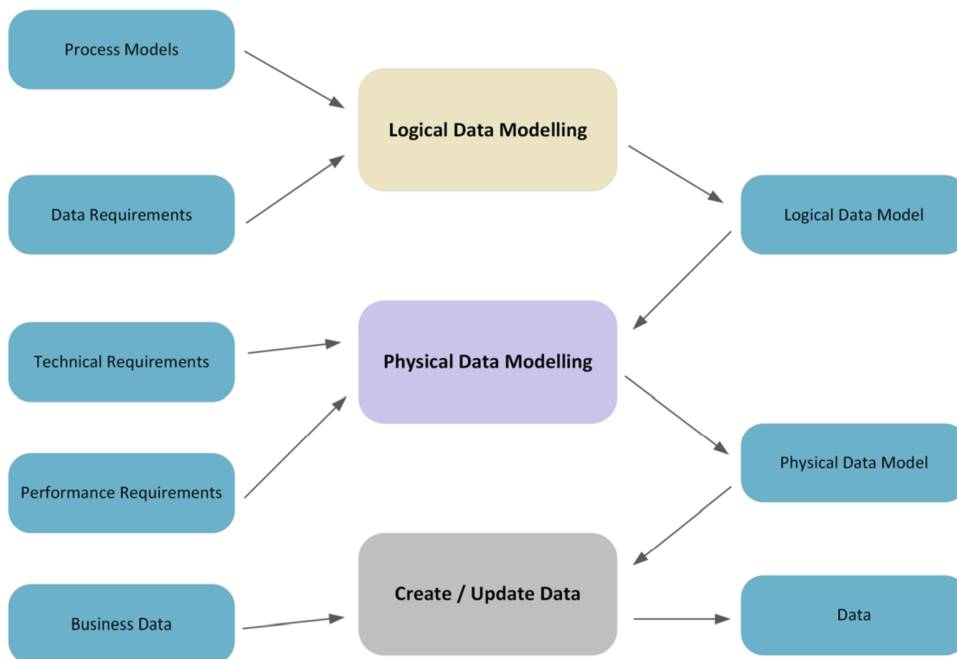
Figure 28: Types of data model

3.10.1 Conceptual data model

This model is known as the "big picture" model depicts the overall structure and substance of the data plan but not its specifics. Identifying the different data types and data flow inside the company, it serves as the conventional beginning point for data modelling. The conceptual model serves as a high-level guide for creating the logical and physical models and is a crucial component of the documentation for the data architecture (Anon. [b.r.]).
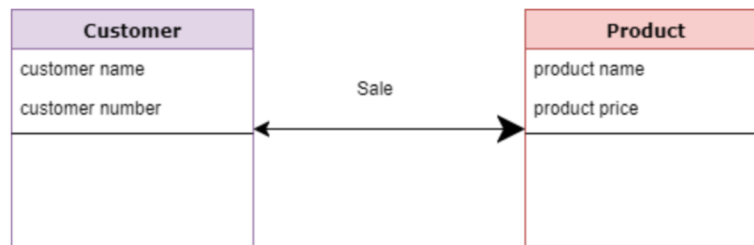
Figure 29: An example of conceptual data model

Source: (Taylor [b.r.])

The above example (Figure 29) depicts that the product and the customer are separate legal entities. The customer entity characteristics include the customer number and name. Price and product name are characteristics of the product entity. The relationship between the consumer and the product is called a sale (Taylor [b.r.]).

3.10.2 Logical data model

The structure of data items and the relationships between them are determined using the logical data model. The conceptual data model pieces are supplemented by the logical data model with additional data. The benefit of utilizing a logical data model is that it serves as a basis for the physical model. The modelling framework is still general in nature (Taylor [b.r.]).
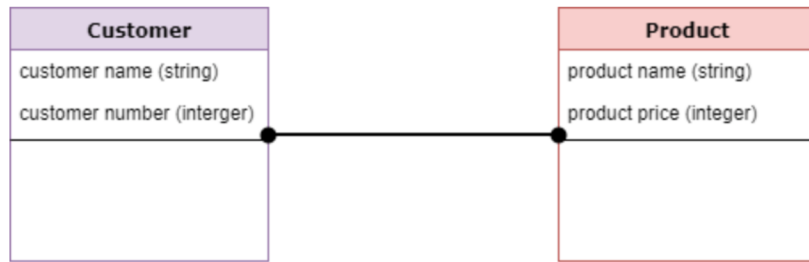
Figure 30: An example of logical data model

Source: (Taylor [b.r.])

The above example (Figure 30) shows that there are no stated primary or secondary keys. We must check and modify the connection details that were previously established for relationships at this level of data modelling (Taylor [b.r.]).

3.10.3 Physical data model

A database-specific implementation of the data model is described in a physical data model. It helps to create the schema and provide database abstraction. This is act as a result of the depth of meta-data which a physical data model provides (Taylor [b.r.]).
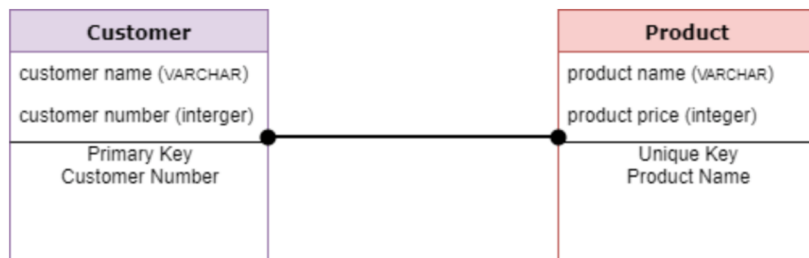
Figure 31: An example of physical data model

Source: (Taylor [b.r.])

The above example (Figure 31) is a physical data model which replicates database column keys, constraints, indexes, triggers, and other (RDBMS) Relational Database Management System characteristics to aid in visualizing database structure (Taylor [b.r.]).

3.11 Data warehouse

A precise form of data management system called a "data warehouse" is deliberated to clear the way for assisting business intelligence (BI) operations, particularly analytics. Data warehouses routinely have a lot of archival data and are only meant to be used for queries and analysis purpos. A data warehouse often uses a variety of sources, including transaction programs and application log files (Anon. [b.r.]). Its goal is to assist regulatory requirements, business intelligence (BI), reporting, and analytics so that businesses can transform their data into knowledge and make informed decisions (Anon. [b.r.]).
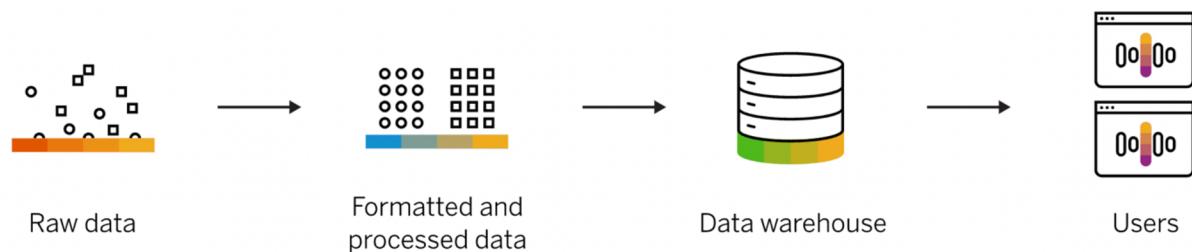
Figure 32: Data warehouse

Source: (Anon. [b.r.])

3.11.1 ETL Process

The data integration process known as (ETL) Extract, Transform, and Load, brings together data from several data sources into a sole, accordant data store that is then put into a data warehouse or other destination system (Anon. [b.r.]).
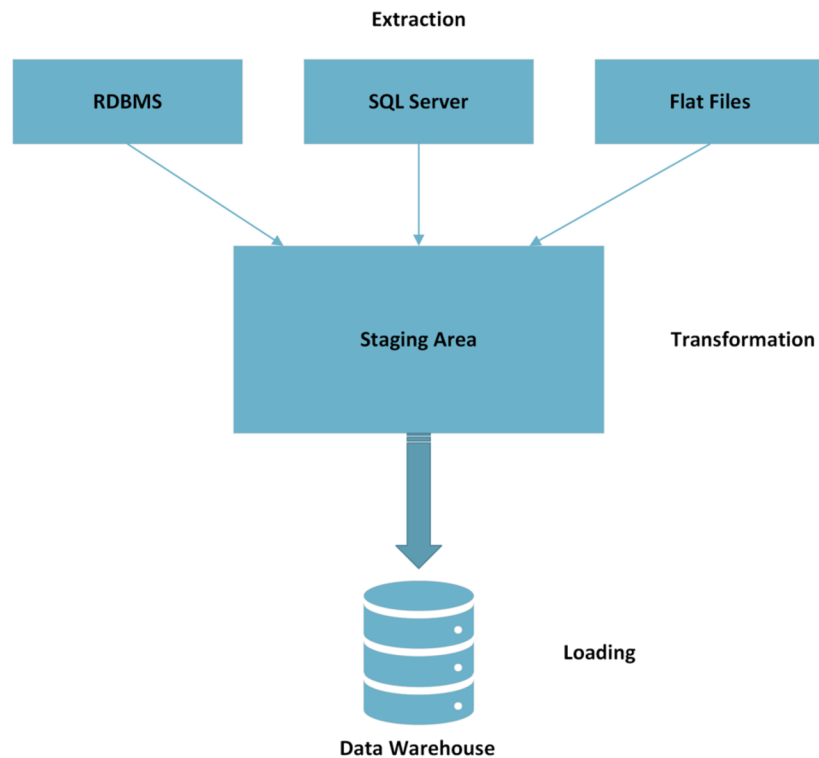
Figure 33: ETL process

Source: Own contribution

3.11.2 Extract

The first stage in bringing data into a data warehouse environment is extraction. To extract means to read, comprehend, and copy the source data into the ETL system for further modification. The data is currently the property of the data warehouse (Kimball a Ross 2013, s. 19).

3.11.3 Transformation

There are many possible transformations that can be made to the data after it has been extracted using the ETL system, including cleaning the data (fixing typos, resolving domain issues, taking care of missing elements, or changing into standard formats), combining data from different sources, and de-duplicating data. With these duties of cleaning and conforming, the ETL system changes and improves the data, adding value to it. Additionally, these activities may be designed to generate diagnostic metadata, which may eventually result in the

reengineering of business processes to enhance the quality of the data in the source systems (Kimball a Ross 2013, s. 20).

3.11.4 Loading

The actual organizing and loading of data into the target dimensional models for the presentation area is the last phase of the ETL procedure. These subsystems are crucial since the delivery step dimension and fact tables are the main tasks of the ETL system. Many of these specified subsystems concentrate on processing dimension tables, such as surrogate key assignments, code lookups to provide suitable descriptions, splitting or joining columns to present suitable data values into flattened denormalized dimensions. Contrarily, fact tables are often huge and time-consuming to load, but they are typically simple to prepare for the presentation area. The business community is informed that new data has been released after the dimension and fact tables in a dimensional model have been updated, indexed, and given with proper aggregates, and further quality guaranteed (Kimball a Ross 2013, s. 21).

3.12 OLAP

Online analytical processing (OLAP) is a class of decision support tools that enables quick, consistent, and interactive access to data that has been reformatted, summarized, and extracted from relational datasets, primarily from data warehouses, into **Multi-Dimensional Databases (MDDB)**, which facilitates trend analysis and allows for the best possible data retrieval. For the examination of strategic databases, OLAP is a suitable idea. OLAP has the capacity to analyse vast amounts of data and derive useful information from it. Business, education, or the medical fields may all benefit from analytical development. This capability is supported by data warehouse, OLAP, and analysis tool technologies (Anon. [b.r.]).

By simultaneously requesting a large amount of data from several database source systems, OLAP enables the discovery of patterns and relationships present in business activity. An OLAP server was necessary to organize, modify, and create MDDB in order to process database information using OLAP. After that, cubes are used to divide the MDDB so that client

OLAP tools may analyse the data and find new patterns in the relationships between the cubes (Anon. [b.r.]).

3.12.1 Techniques involved in OLAP operations

- **Roll-up -** Rolling up is like enlarging the data cube's view. Roll-up is a tool for giving users details at an abstract level. It accomplishes further data aggregation either by moving up a concept ranking for a dimension or by reducing the dimension (Bhatia 2019, s. 433).

- **Drill-down -** This process is straight opposite to roll-up. Drill-down is used to give the user detailed info and is similar to zooming in on the data. By adding a new dimension or descending a concept hierarchy for an existing dimension, it gives extensive information. It switches between less and more precise data (Bhatia 2019, s. 433).

- **Slice & Dice -** Slice and dice illustrate how information may be seen from several angles. By choosing a certain dimension from a predetermined cube, the slice operation creates a new sub-cube. Consequently, a slice is a subset of the cube that represents a single value for one or more dimension members. It causes a decrease in size. In order to choose one dimension from a three-dimensional cube and create a two-dimensional slice and the user performs a slice operation (Bhatia 2019, s. 435).

  Without a decrease in the number of dimensions, the dice operation is comparable to the slice procedure. By choosing two or more dimensions from a predetermined cube, the dice operation creates a new sub-cube (Bhatia 2019, s. 437).

- **Pivot -** Rotation is another name for the pivot process. To provide a different data presentation, this action rotates the data axes in view. It could include switching the columns and rows (Bhatia 2019, s. 438).

3.12.2 Benefits of OLAP operations

- It is possible to drill down into further depth by gradually increasing parts of levels within a dimension, but only to the degree of information required to identify a pattern or a problem.
- By starting with a single piece of data and breaking it down into a number of layers, OLAP tools also enable you to search through the data for intriguing patterns.
- OLAP's adaptability makes it useful. Once the facts and dimensions have been created in the OLAP server, OLAP tools offer a simple approach to analyse data by allowing users to drag and drop facts and dimensions into the proper positions.

Source: (Bogue 2005)

3.13 Schemas

Schemas are logical descriptions of databases. It serves as the database overall design plan. It explains how the data are set up and how the relationships between them are connected. The name and description of entries, together with any associated data items and aggregates, are included in the data warehouse schema. A data warehouse employs the star, snowflake, and fact constellation kinds of schema whereas a database uses relational models (Bhatia 2019, s. 405).

3.13.1 Star schema

One of the simplest data warehouse architectures is the star schema. Because of the way its points extend outward from a central point as it is known as a star. A one-dimensional table and a collection of attributes make up the dimension table for each dimension in a star schema. Comparatively speaking, dimension tables have fewer entries than fact tables, but each record may have many characteristics that characterize the fact data. Foreign keys to dimensions data are typically included in fact tables along with numerical facts (Bhatia 2019, s. 408).

In a star schema, fact tables are often in third normal form (3NF), whereas dimensional tables are typically in de-normalized form. Although it is one of the simplest forms, the star schema is still widely used today and is advised by Oracle (Bhatia 2019, s. 408).
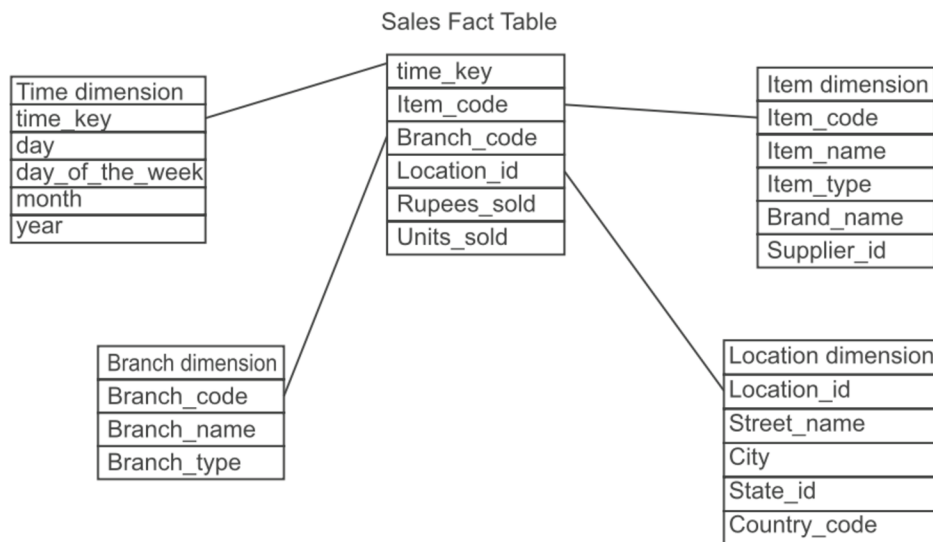
Figure 34: Star schema of a company for analysis of sales

Source: (Bhatia 2019, s. 409)

3.13.2 Snowflake schema

The main distinction between the snowflake and star schemas is that whereas the star schema always has de-normalized dimensions, the snowflake schema may also have normalized dimensions. Because it supports the normalizing of dimension tables, the snowflake schema is an alternate variant of the star schema. In the snowflake schema, some dimension tables are normalized which separates the data into additional tables. In a star schema, normalizing the dimension tables is the procedure known as "snowflaking." When the entire dimension tables are fully normalized, the resulting structure resembles a snowflake with a fact table at the centre (Bhatia 2019, s. 410).
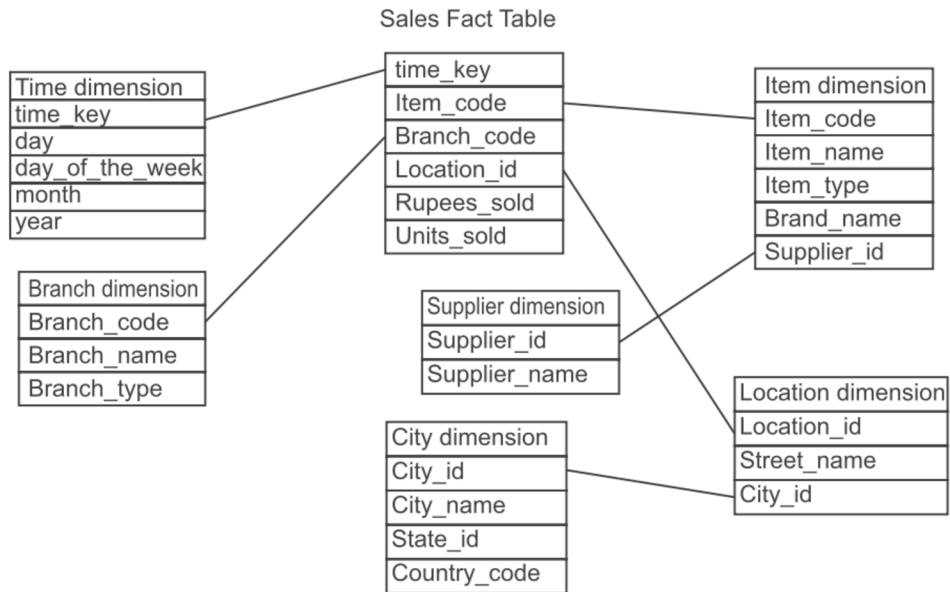
Figure 35: Snowflake schema of a company for analysis of sales

Source: (Bhatia 2019, s. 410)

3.14 Data Mining

Understanding data involves cleaning up raw data, looking for patterns, developing models, and testing those models. This process is known as data mining. It encompasses database systems, statistics, and machine learning. It's simple to mistake data mining for analytics, data governance, and other data processes since it frequently involves several data projects. Data mining was generally used to be a labour-intensive manual coding operation, and today's findings still need to be cleaned, processed, and interpreted by experts who have coding skills. For data professionals to successfully finish data mining processes, they also require some programming language expertise (Anon. [b.r.]).

3.14.1 Data mining process
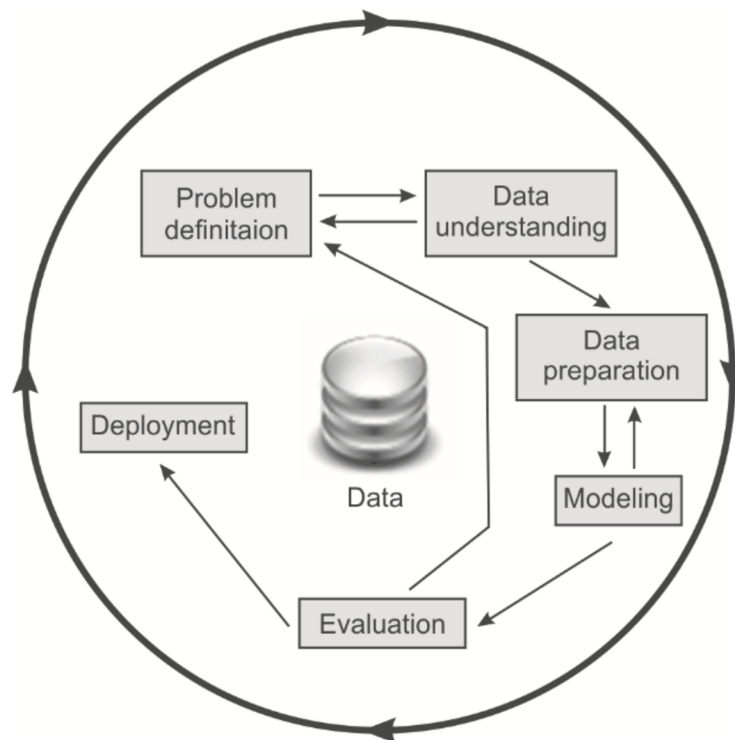
Figure 36: Data mining process

Source: (Bhatia 2019, s. 22)

- **Problem definition stage -** Understanding the needs and goals of a project are the primary emphasis of the first stage of a data mining process. The project may be written down as a data mining challenge after it has been defined. After that, a draft implementation strategy may be created (Bhatia 2019, s. 22).

- **Data understanding stage -** Data collecting begins the next stage of the data mining process. Data is gathered from the various sources during this phase, and certain crucial tasks like data loading and data integration are completed to ensure proper data collecting. The data is then carefully examined to ascertain if it will answer all the business related issue. Therefore, to properly solve the problem, extra data might be added or eliminated. Missing data is also found at this point (Bhatia 2019, s. 22).

- **Data preparation stage -** Typically, a project spends 90% of its time in this phase. Once the sources of the data are known, they must be chosen, prepared, created, and structured as needed for further processing (Bhatia 2019, s. 23).

- **Modelling stage -** Various data mining methods are used in this step to create models. In order to accomplish the goals of the suggested solution, appropriate data mining methods are chosen and implemented on the provided data (Bhatia 2019, s. 23).

- **Evaluation stage -** The model findings are assessed in the assessment step to see if they satisfy the initially stated the business aim or not. The provided data is split into training and testing datasets for this purpose. The models are tested using test data after being trained on training data. One returns to the earlier steps to make any necessary adjustments if the model accuracy on test data is found to be insufficient. When accuracy is at a reasonable level, the procedure moves on to the deployment step (Bhatia 2019, s. 23).

- **Deployment stage -** Insights and useful information obtained from data must be offered in the deployment phase in a way that stakeholders may utilize it whenever they want. The deployment step might be simple (simply generating a report) or complicated depending on the project requirements (requiring further improving data mining processing). Dashboards or graphical user interfaces are created at this phase to address all stakeholder needs (Bhatia 2019, s. 23).

4. Practical section

Village Foods is a food processing company headquartered in Salem, India which was established in 2015. It is a **Small and Medium Enterprise (SME)** company which is involved in food and agriculture sector. The major food product that is manufactured is vacuum packed sweetcorn cobs when compared to other consumer food products produced within the company. The following thesis is based on the inventory data acquired from one of the department of the company. The present system uses only manual physical documentation for collecting and recording data of the inventory in the company warehouse. This type of data is also used to move inventory to different warehouse bin locations. The usage of a data warehouse and relational database management system which helps in improving the efficient analysis of the given large volume of data.

4.1 Pilot data

The dataset incorporated into the database was made specifically to test its characteristics. Although the database which is used is based on actual transactions undergone in the company and it was built to meet the demands of the present thesis. The dataset establishes a context in which the tools indicated in the thesis may be utilized which in turn provide a set of data to solve the needs of the industry.

5. Data warehouse model

5.1 Conceptual data model

Identifying and creating the conceptual model is one of the core basic initiative step to develop a suitable data warehouse model for any use case. The fact and dimension tables which are utilized, are generally used to collect and calculate the data which in turn portrays the conceptual data model in the form of entity relationship diagram as illustrated in the (Figure 37). This model is exclusively built and tailor made to meet the needs of the user. Subsequently, this data model can also have restrictions to information where only authorised users can view the full information and other secondary user can just view the information which they have access to. Various dimension tables are attached to a single fact table in the form of one-to-many relation. Therefore, this particular model poses structure like star schema.
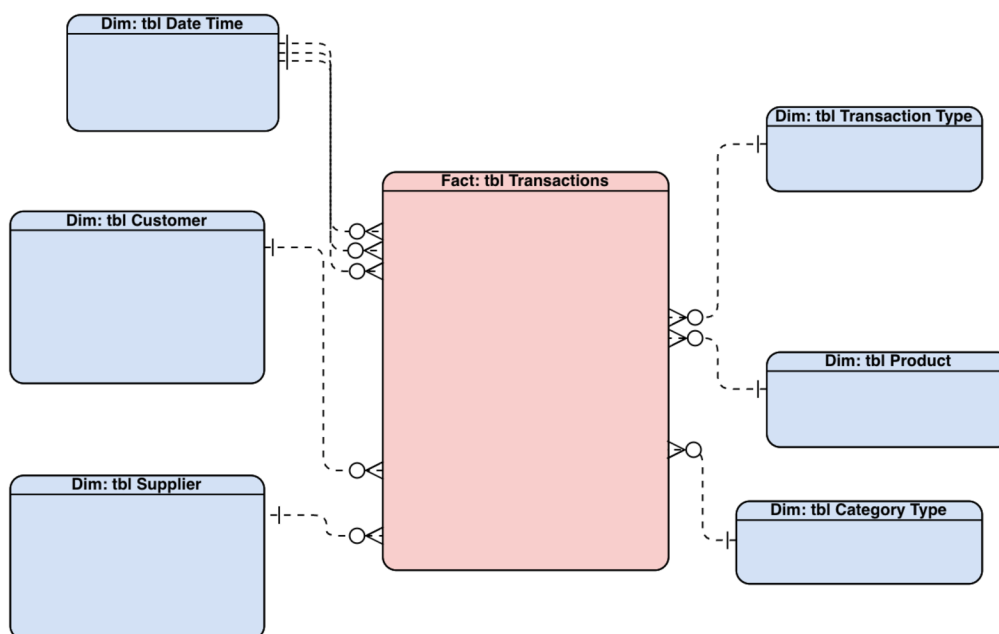
Figure 37: Conceptual model for the proposed inventory management system

Source: Own contribution

5.2 Logical data model

The next crucial step succeeding the conceptual data model is the logical data model. The main difference between the conceptual and logical data model is that the logical data model displays the primary key and columns of the database. The final model which is constructed includes various dimension tables like "tbl Customer", "tbl Supplier", "tbl Category Type", "tbl Transaction Type" and "tbl Product" connected to a single fact table "tbl Transactions" subjected to one-to-many relationship with the mentioned fact table. The fact table "tbl Transactions" contains different attributes like "Transaction ID" which acts as a primary key which is then followed by "Year", "Month", "Week", "Date", "Transaction Type", "Product Name", "Batch Number", "Quantity", "Price", "Total Amount", "Category", "Customer Name", "Invoice No", "Purchase Order No", "Supplier Name" and "Supplier Invoice No".
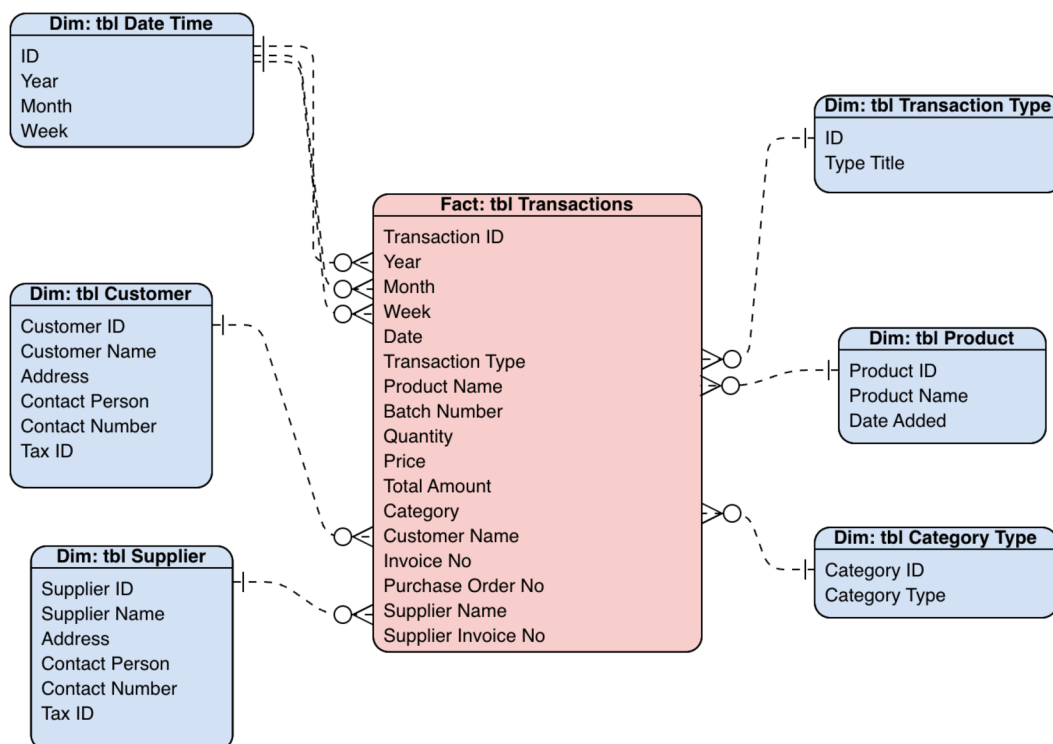
Figure 38: Logical model for the proposed inventory management system

Source: Own contribution

The attributes of the above mentioned dimension tables are also explained in the following. The two dimension tables "tbl Customer" and "tbl Supplier" consist of unbalanced

hierarchy information respectively which is responsible for making several required transactions in the system. The other corresponding dimension tables like "tbl Date Time", "tbl Category", "tbl Transaction Type" and "tbl Product" specifies the which category, time period, transaction type record was made for each and every product transaction happening in the data system. Overall, this current model was designed in order to give an idea to the management of the company about their actual inventory levels and their transactions happening within the company.

5.3 Physical data model
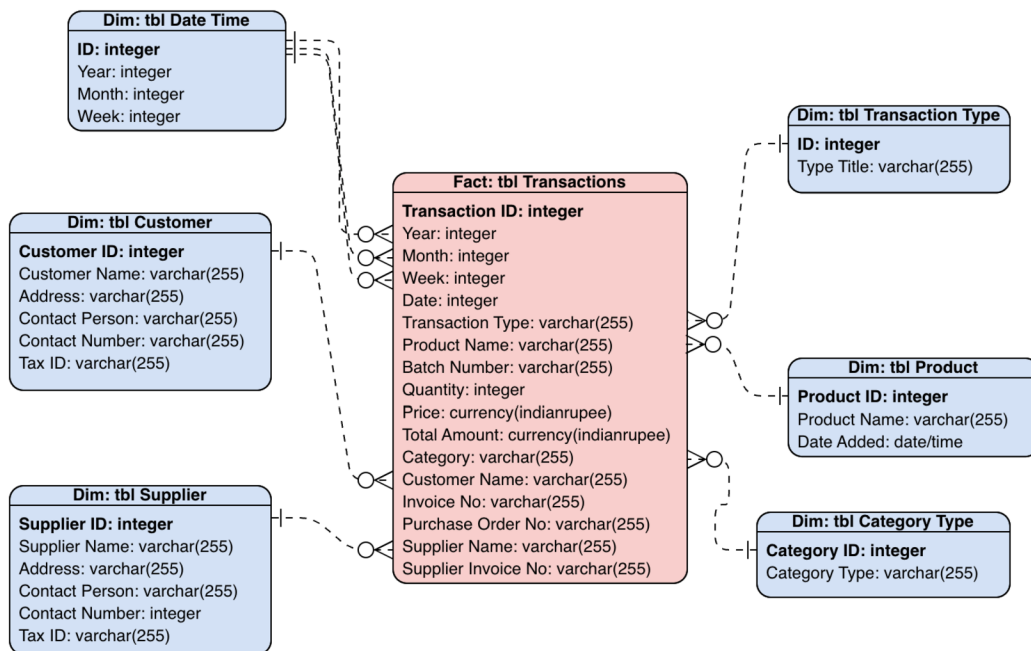
Figure 39: Physical model for the proposed inventory management system

Source: Own contribution

The physical model portrays the final interpretation of the data model for the target end users as it is the final step in the data model construction. The physical data model mainly represents the data types of every attribute involved in each table of the data model. The physical model incorporates all the data needs of the user in one place. As you can see in the above mentioned (Figure 39) some of the crucial and important data types and length allocated are the product name in which the transactions are done is in "variable character 255", quantity in "integer", price and total amount in "currency (Indian Rupee)" etc.,. After arriving the

model, this particular model is constructed into a relational database management system by using the software MS Access.

The decision to utilize this DBMS was taken due to the software's availability as a component of the MS Office suite and the simplicity with which both users and developers could construct databases and issue commands. Other DBMS, such as Microsoft Power BI, were also taken into consideration, but I ultimately chose to utilize MS Access due to its simplicity and ease of use.

6. Queries implemented

6.1 Query for analysing the stocks coming into the warehouse

Year	Month	Week	Date	Product Name	Batch Number	Quantity	Price	Total Amoun	Transaction	Supplier Nam	Supplier Inv
2023	3	1		5 Sippy Masala Noodles 400gm (₹ 60) (54 Pcs/ Box	FF1651	55	₹ 1,809.00	₹ 99,495.00	Stock In	RR Fresh Farms	DC-23/171201
2023	3	1		6 Sippy Bajra Noodles 400gm (₹ 75) (54 Pcs/ Box)	FF1652	162	₹ 2,000.00	₹ 3,24,000.00	Stock In	RR Fresh Farms	DC-23/171202
2023	3	1		6 Sippy Egg Noodles 400gm (₹ 65) (54 Pcs/ Box)	FF1653	83	₹ 2,200.00	₹ 1,82,600.00	Stock In	RR Fresh Farms	DC-23/171203
2023	3	1		6 Sippy Multigrain Noodles 400gm (₹ 75) (54 Pcs/ B	FF1655	95	₹ 2,500.00	₹ 2,37,500.00	Stock In	RR Fresh Farms	DC-23/171206
2023	3	1		6 Sippy Ragi Noodles 400gm (₹ 75) (54 Pcs/ Box)	FF1654	69	₹ 1,800.00	₹ 1,24,200.00	Stock In	RR Fresh Farms	DC-23/171203
2023	3	2		7 Sippy SC D.Cobs (500gm) (12pcs/Box)	VF410	500	₹ 500.00	₹ 2,50,000.00	Stock In	Village Foods	DC-23/16381
2023	3	2		7 Sippy SC D.Cobs (500gm) (12pcs/Box)	VF411	250	₹ 500.00	₹ 1,25,000.00	Stock In	Village Foods	DC-23/16382
2023	3	2		7 Sippy SC D.Cobs (500gm) (12pcs/Box)	VF412	750	₹ 500.00	₹ 3,75,000.00	Stock In	Village Foods	DC-23/16383
2023	3	2		8 Sippy Golden Dragon GDN Noodles (₹ 20) (170gm	FF1601	70	₹ 1,500.00	₹ 1,05,000.00	Stock In	RR Fresh Farms	DC-23/171204
2023	3	2		8 Sippy Golden Dragon GDN Noodles (₹ 20) (170gm	FF1602	558	₹ 1,500.00	₹ 8,37,000.00	Stock In	RR Fresh Farms	DC-23/171205
2023	3	2		9 Sippy SC D.Cobs (500gm) (12pcs/Box)	VF413	4500	₹ 500.00	₹ 22,50,000.00	Stock In	Village Foods	DC-23/16384

Figure 40: Design view of the query of stocks coming into warehouse

Source: Own contribution

This query was generated to let know the management of the company about the products coming into their warehouse. The information generated may examined later to discover facts that will help in promoting and developing the company. They also indicate the value of the stocks and also denote the type of entry into the warehouse. It can either be straight from the supplier or from the customer in the form of sales return.

The software MS Access is used while performing the query. The query which is performed is then later exported to MS Excel which eventually undergoes OLAP analysis to determine the average quantities of stocks entering into the warehouse. We need two separate programs since MS Access assists in data manipulation according to the required specifications. Whereas in other hand, MS Excel is used to execute pivot analysis to fulfil the exact specifications. One of the primary goals when calculating this particular query is to facilitate simple structured data entry and simple data retrieval. Normally, it is challenging to get the desired outcome when there is a large amount of data present. So, the firms should utilize the right queries constructed in a database management system to make it efficient and cost-effective.
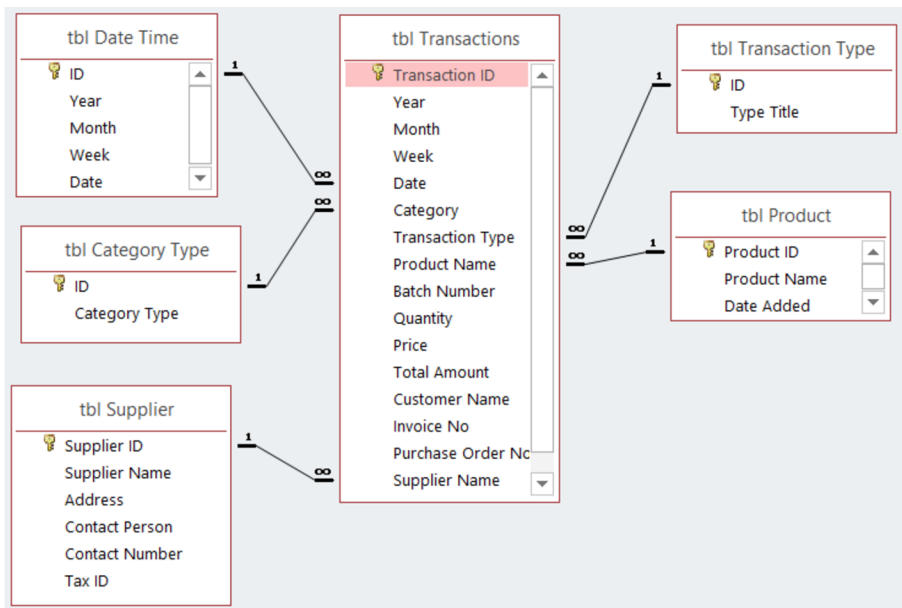
Figure 41: Relationship map of the query of stocks coming into the warehouse

Source: Own contribution

```
SELECT [tbl Transactions].Year, [tbl
Transactions].Month, [tbl Transactions].Week, [tbl
Transactions].Date, [tbl Transactions].[Product
Name], [tbl Transactions].[Batch Number], [tbl
Transactions].Quantity, [tbl Transactions].Price,
[tbl Transactions].[Total Amount], [tbl
Transactions].[Transaction Type], [tbl
Transactions].[Supplier Name], [tbl
Transactions].[Supplier Inv No]

FROM [tbl Transactions]

GROUP BY [tbl Transactions].Year, [tbl
Transactions].Month, [tbl Transactions].Week, [tbl
Transactions].Date, [tbl Transactions].[Product
Name], [tbl Transactions].[Batch Number], [tbl
Transactions].Quantity, [tbl Transactions].Price,
[tbl Transactions].[Total Amount], [tbl
Transactions].[Transaction Type], [tbl
Transactions].[Supplier Name], [tbl
Transactions].[Supplier Inv No]

HAVING ((([tbl Transactions].[Transaction Type])=1));
```

Figure 42: SQL code of the query of stocks coming into the warehouse

Source: Own contribution

This query also helps the operations department of the company to get better information and control of the finished goods produced by different divisions of the company. They also

60

help in cross checking with the production quantities and take necessary measures to improve the production efficiency.

Transaction Type	Stock In								
Sum of Quantity	Column Labels								
Row Labels	Sippy Bajra Noodles 400gm (₹ 75) (54 Pcs/ Box)	Sippy Egg Noodles 400gm (₹ 65) (54 Pcs/ Box)	Sippy Golden Dragon GDN Noodles (₹ 20) (170gm) (25pcs/Bag)	Sippy Masala Noodles 400gm (₹ 60) (54 Pcs/ Box)	Sippy Multigrain Noodles 400gm (₹ 75) (54 Pcs/ Box)	Sippy Ragi Noodles 400gm (₹ 75) (54 Pcs/ Box)	Sippy SC D.Cobs (500gm) (12pcs/Box)	Sippy Tomato Noodles 400gm (₹ 65) (54 Pcs/ Box)	Grand Total
				32			2000		2032
RR Fresh Farms	162	83	628	55	95	69		10	1102
Village Foods							18500		18500
Grand Total	162	83	628	87	95	69	20500	10	21634

Figure 43: Pivot Analysis for total quantities of different products coming into the warehouse

Source: Own contribution

The pivot analysis in the above (Figure 43) shows the total number of quantities of different products delivered by different divisions of the company. This analysis helps the sales department of the company in such a way to commit trade orders to the customers and it also gives a basic forecast of the upcoming sales.

Transaction Type	Stock In		
Row Labels	Total Deliveries	Total Value Of The Stocks	Average Value Of The Stocks
	3	₹10,57,888.00	₹3,52,629.33
RR Fresh Farms	8	₹19,30,795.00	₹2,41,349.38
Village Foods	6	₹92,50,000.00	₹15,41,666.67
Grand Total	17	₹1,22,38,683.00	₹7,19,922.53

Figure 44: Pivot Analysis to arrive the total counts of deliveries and total value of stocks coming into the warehouse

Source: Own contribution

Figure 45: Slicer operation to obtain average quantities of a product delivered from different divisions of a company

Source: Own contribution

The pivot analysis in the (Figure 44) helps the company to know the value of the stocks delivered each time to the warehouse. This helps the company to evaluate, reduce and match the logistics costs according to the value of the stocks of that particular delivery. The slicer operation performed as shown in (Figure 45) is helpful for the company to know which product and their quantity is consistently stored in the warehouse. They also help the company to allot bin location for the that particular product in the warehouse.

6.2 Query for analysing the stocks going out of the warehouse

Year	Month	Week	Date	Product Name	Batch Numbe	Quantity	Price	Total Amoun	Transaction	Customer Name
2023	3	3	12	Sippy Bajra Noodles 400gm (₹ 75) (54 Pcs/ Box)	VF1652	155	₹ 2,000.00	₹ 3,10,000.00	Stock Out	SpiceRich Seasonings Pvt Ltd
2023	3	3	12	Sippy Masala Noodles 400gm (₹ 60) (54 Pcs/ Box	VF1651	27	₹ 1,809.00	₹ 48,843.00	Stock Out	Rudhra Marketting
2023	3	3	13	Sippy Egg Noodles 400gm (₹ 65) (54 Pcs/ Box)	VF1653	83	₹ 2,200.00	₹ 1,82,600.00	Stock Out	Charu Foods And Cosmetics
2023	3	3	14	Sippy Golden Dragon GDN Noodles (₹ 20) (170gn	FF1601	30	₹ 1,500.00	₹ 45,000.00	Stock Out	Bluewaves Marketing
2023	3	3	14	Sippy Golden Dragon GDN Noodles (₹ 20) (170gn	FF1601	35	₹ 1,500.00	₹ 52,500.00	Stock Out	S2S Enterprises
2023	3	3	15	Sippy Golden Dragon GDN Noodles (₹ 20) (170gn	FF1602	500	₹ 1,500.00	₹ 7,50,000.00	Stock Out	Eagle Stone Impex
2023	3	3	15	Sippy SC D.Cobs (500gm) (12pcs/Box)	VF415	4000	₹ 500.00	₹ 20,00,000.00	Stock Out	Payagri Innovations Pvt. Ltd
2023	3	3	15	Sippy SC D.Cobs (500gm) (12pcs/Box)	VF415	4000	₹ 500.00	₹ 20,00,000.00	Stock Out	Symega Food Ingredients Ltd
2023	3	3	16	Sippy Bajra Noodles 400gm (₹ 75) (54 Pcs/ Box)	FF1652	15	₹ 2,000.00	₹ 30,000.00	Stock Out	Payagri Innovations Pvt. Ltd
2023	3	3	16	Sippy Bajra Noodles 400gm (₹ 75) (54 Pcs/ Box)	FF1652	75	₹ 2,000.00	₹ 1,50,000.00	Stock Out	S2S Enterprises
2023	3	4	17	Sippy Egg Noodles 400gm (₹ 65) (54 Pcs/ Box)	FF1653	71	₹ 2,200.00	₹ 1,56,200.00	Stock Out	Eagle Stone Impex
2023	3	4	18	Sippy Masala Noodles 400gm (₹ 60) (54 Pcs/ Box	FF1651	47	₹ 1,809.00	₹ 85,023.00	Stock Out	SpiceRich Seasonings Pvt Ltd

Figure 46: Design view of the query of the stocks going out of the warehouse

Source: Own contribution

This query was generated to mainly identify the total stocks dispatched to the customer. They also further help in knowing the value of the stocks billed to the customer. The information generated is useful for the company to take management decisions and this particular information also plays a vital role in business development areas of the company.
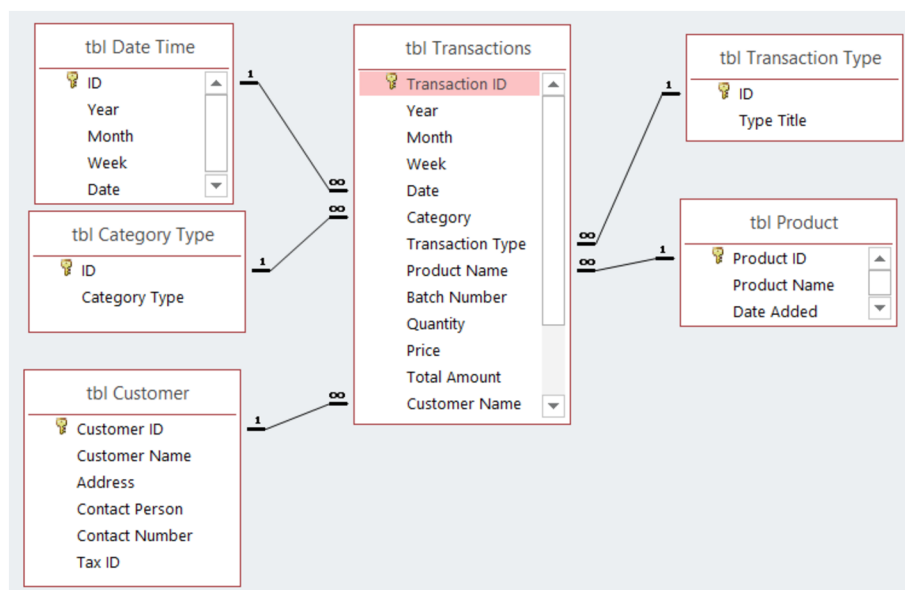
Figure 47: Relationship map for the query of stocks going out of warehouse

Source: Own contribution

```
SELECT [tbl Transactions].Year, [tbl
Transactions].Month, [tbl Transactions].Week, [tbl
Transactions].Date, [tbl Transactions].[Product
Name], [tbl Transactions].[Batch Number], [tbl
Transactions].Quantity, [tbl Transactions].Price,
[tbl Transactions].[Total Amount], [tbl
Transactions].[Transaction Type], [tbl
Transactions].[Customer Name], [tbl
Transactions].[Invoice No], [tbl
Transactions].[Purchase Order No]

FROM [tbl Transactions]

GROUP BY [tbl Transactions].Year, [tbl
Transactions].Month, [tbl Transactions].Week, [tbl
Transactions].Date, [tbl Transactions].[Product
Name], [tbl Transactions].[Batch Number], [tbl
Transactions].Quantity, [tbl Transactions].Price,
[tbl Transactions].[Total Amount], [tbl
Transactions].[Transaction Type], [tbl
Transactions].[Customer Name], [tbl
Transactions].[Invoice No], [tbl
Transactions].[Purchase Order No]

HAVING ((([tbl Transactions].[Transaction Type])=2));
```

Figure 48: SQL code for the query of stocks going out of warehouse

Source: Own contribution

Transaction Type	Stock Out							
Sum of Quantity	**Column Labels**							
Row Labels	**Sippy Bajra Noodles 400gm (₹ 75) (54 Pcs/ Box)**	**Sippy Egg Noodles 400gm (₹ 65) (54 Pcs/ Box)**	**Sippy Golden Dragon GDN Noodles (₹ 20) (170gm) (25pcs/Bag)**	**Sippy Masala Noodles 400gm (₹ 60) (54 Pcs/ Box)**	**Sippy Multigrain Noodles 400gm (₹ 75) (54 Pcs/ Box)**	**Sippy Ragi Noodles 400gm (₹ 75) (54 Pcs/ Box)**	**Sippy SC D.Cobs (500gm) (12pcs/Box)**	**Grand Total**
Bluewaves Marketing			30					30
Charu Foods And Cosmetics		83						83
Eagle Stone Impex		71	500					571
J.T.Syndicate						60		60
Payagri Innovations Pvt. Ltd	15						8440	8455
Rudhra Marketting				27				27
S2S Enterprises	75		35	20				130
Salem Food Products Pvt. Ltd.							490	490
SpiceRich Seasonings Pvt Ltd	155			47				202
Symega Food Ingredients Ltd.					69		8440	8509
Grand Total	**245**	**154**	**565**	**94**	**69**	**60**	**17370**	**18557**

Figure 49: Pivot Analysis for total quantity of stocks going out of warehouse

Source: Own contribution

The pivot analysis as shown in the (Figure 49) helps the sales department of the company to get information on the top selling product. This also gives the actual sales information data

and helps the management to take decision for improving sales and to allocate budget plan accordingly.

Transaction Type	Stock Out		
Row Labels	Count of Invoice No	Sum of Total Amount	Average of Invoices
Bluewaves Marketing	1	₹45,000.00	₹45,000.00
Charu Foods And Cosmetics	1	₹1,82,600.00	₹1,82,600.00
Eagle Stone Impex	2	₹9,06,200.00	₹4,53,100.00
J.T.Syndicate	1	₹1,08,000.00	₹1,08,000.00
Payagri Innovations Pvt. Ltd	3	₹42,50,000.00	₹14,16,666.67
Rudhra Marketting	1	₹48,843.00	₹48,843.00
S2S Enterprises	3	₹2,38,680.00	₹79,560.00
Salem Food Products Pvt. Ltd.	1	₹2,45,000.00	₹2,45,000.00
SpiceRich Seasonings Pvt Ltd	2	₹3,95,023.00	₹1,97,511.50
Symega Food Ingredients Ltd.	3	₹43,92,500.00	₹14,64,166.67
Grand Total	18	₹1,08,11,846.00	₹6,00,658.11

Figure 50: Pivot Analysis to arrive the value of invoices billed to customers for the stocks going out of warehouse

Source: Own contribution

Figure 51: Slicer operation for average quantities of a product billed to different customers of the company

Source: Own contribution

The pivot analysis shown in the (Figure 50) assists the company in planning the budget for the production, fix the order limit quantities to the customers and also prioritize their customers according to the business they have done. The slicer operation performed as shown in the (Figure 51) helps the company to plan the inventory levels for the most selling product for the upcoming period to optimize production process efficiently.

6.3 Query for indicating the stock remaining in the warehouse

Product Name	Batch Numbe	qry Stock in 1	qry Stock out	Balance
Sippy Bajra Noodles 400gm (₹ 75) (54 Pcs/ Box)	FF1652	162	90	72
Sippy Egg Noodles 400gm (₹ 65) (54 Pcs/ Box)	FF1653	83	71	12
Sippy Masala Noodles 400gm (₹ 60) (54 Pcs/ Box)	FF1650	32	20	12
Sippy Masala Noodles 400gm (₹ 60) (54 Pcs/ Box)	FF1651	55	47	8
Sippy Multigrain Noodles 400gm (₹ 75) (54 Pcs/ Box)	FF1655	95	69	26
Sippy Ragi Noodles 400gm (₹ 75) (54 Pcs/ Box)	FF1654	69	60	9
Sippy Tomato Noodles 400gm (₹ 65) (54 Pcs/ Box)	FF1649	10	0	10
Sippy Golden Dragon GDN Noodles (₹ 20) (170gm) (25pcs/Bag)	FF1601	70	65	5
Sippy Golden Dragon GDN Noodles (₹ 20) (170gm) (25pcs/Bag)	FF1602	558	500	58
Sippy SC D.Cobs (500gm) (12pcs/Box)	VF308	750	0	750
Sippy SC D.Cobs (500gm) (12pcs/Box)	VF309	1250	0	1250
Sippy SC D.Cobs (500gm) (12pcs/Box)	VF410	500	490	10
Sippy SC D.Cobs (500gm) (12pcs/Box)	VF411	250	0	250
Sippy SC D.Cobs (500gm) (12pcs/Box)	VF412	750	0	750
Sippy SC D.Cobs (500gm) (12pcs/Box)	VF413	4500	4440	60
Sippy SC D.Cobs (500gm) (12pcs/Box)	VF414	4450	4440	10
Sippy SC D.Cobs (500gm) (12pcs/Box)	VF415	8050	8000	50

Figure 52: Design view for the query of stocks remaining in the warehouse

Source: Own contribution

This query was generated to indicate the stocks remaining after deducting all the dispatched quantities of different available stocks in the warehouse. This query plays a crucial part in letting know the company about their present scenario of the stocks available in their inventory system. This query also helps the company to plan their production of goods efficiently, optimize production operations and reduce excess inventory costs.
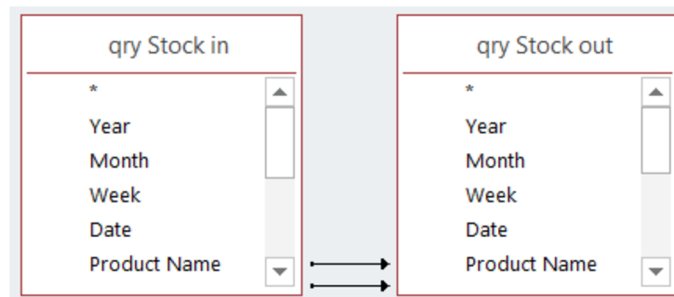
Figure 53: Relationship map for the query of stocks remaining in the warehouse

Source: Own contribution

```
SELECT [qry Stock in].[Product Name], [qry Stock
in].[Batch Number], Sum(Nz([qry Stock
in].[Quantity],0)) AS [qry Stock in T], Sum(Nz([qry
Stock out].[Quantity],0)) AS [qry Stock out T], [qry
Stock in T]-[qry Stock out T] AS Balance

FROM [qry Stock in] LEFT JOIN [qry Stock out] ON
([qry Stock in].[Product Name] = [qry Stock
out].[Product Name]) AND ([qry Stock in].[Batch
Number] = [qry Stock out].[Batch Number])

GROUP BY [qry Stock in].[Product Name], [qry Stock
in].[Batch Number], Nz([qry Stock in].[Quantity],0);
```

Figure 54: SQL code for the query of stocks remaining in the warehouse

Source: Own contribution

6.4 Query for indicating sales return stocks coming into warehouse

Category	Year	Month	Week	Date	Product Name	Batch Numbe	Price	Quantity	Total Amoun
Sales Return	2023	3	4	22	Sippy Masala Noodles 400gm (₹ 60) (54 Pcs/ Box)	FF1650	₹ 1,809.00	32	₹ 57,888.00
Sales Return	2023	3	4	22	Sippy SC D.Cobs (500gm) (12pcs/Box)	VF309	₹ 500.00	1250	₹ 6,25,000.00
Sales Return	2023	3	4	23	Sippy SC D.Cobs (500gm) (12pcs/Box)	VF308	₹ 500.00	750	₹ 3,75,000.00

Figure 55: Design view for the query of sales return stocks coming into warehouse

Source: Own contribution

This query was generated to indicate the sales return stocks coming into the warehouse. This assists the company in a better way of knowing the parameters like the product which they are selling is of good quality and also helps in knowing the root cause of the many other problems and issues arising which causes sales return.
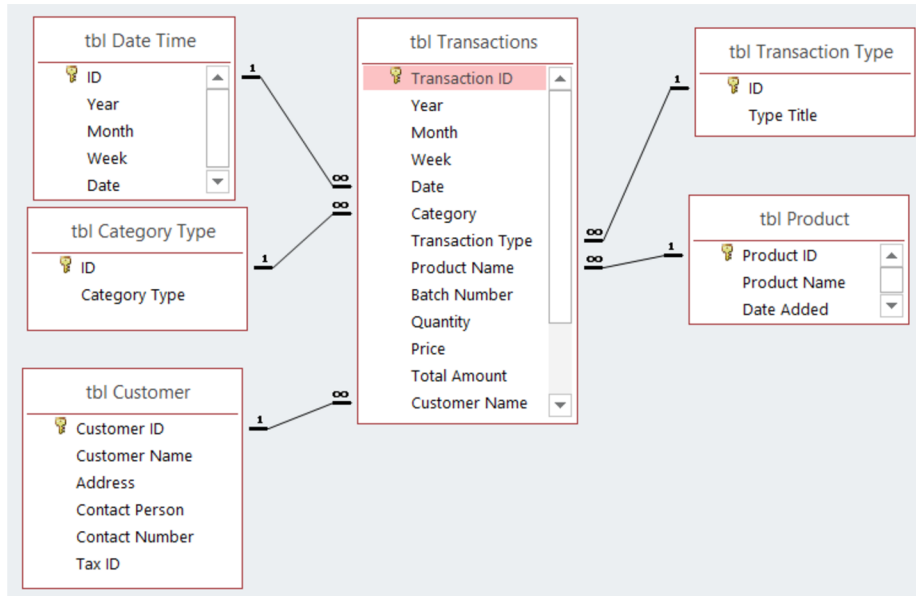
Figure 56: Relationship map for the query of sales return stocks coming into warehouse

Source: Own contribution

```
SELECT [tbl Transactions].Category, [tbl
Transactions].Year, [tbl Transactions].Month, [tbl
Transactions].Week, [tbl Transactions].Date, [tbl
Transactions].[Product Name], [tbl
Transactions].[Batch Number], [tbl
Transactions].Price, [tbl Transactions].Quantity,
[tbl Transactions].[Total Amount], [tbl
Transactions].[Customer Name], [tbl
Transactions].[Transaction Type]

FROM [tbl Transactions]

WHERE ((([tbl Transactions].Category)=2) AND (([tbl
Transactions].[Transaction Type])=1));
```

Figure 57: SQL code for the query of sales return stocks coming into warehouse

Source: Own contribution

Category	Sales Return			
Sum of Quantity	Column Labels			
Row Labels	Payagri Innovations Pvt. Ltd	Sri Ayyanar Traders	Symega Food Ingredients Ltd.	Grand Total
Sippy Masala Noodles 400gm (₹ 60) (54 Pcs/ Box)		32		32
Sippy SC D.Cobs (500gm) (12pcs/Box)	1250		750	2000
Grand Total	1250	32	750	2032

Figure 58: Pivot analysis to compute total sales return quantities of stocks returned by customers

Source: Own contribution

ansacti	Year	Month	Week	Date	Category	Transaction T	Product Name	Batch Numbe	Quantit	Price	Total Amoun	Customer Name
37	2023	3	4	22	Sales Return	Stock In	Sippy SC D.Cobs (500gm) (12pcs/Box)	VF309	1250	₹500.00	₹6,25,000.00	Payagri Innovations Pvt. Ltd
38	2023	3	4	23	Sales Return	Stock In	Sippy SC D.Cobs (500gm) (12pcs/Box)	VF308	750	₹500.00	₹3,75,000.00	Symega Food Ingredients Ltd.
									2000			

Year		Month		Week		Date		Category		Product Name	
2023		3		4		22		Sales Return		Sippy Masala Noodles...	
				1		23		(blank)		Sippy SC D.Cobs...	
				2		5		Sales		Sippy Bajra Noodles...	
				3		6				Sippy Egg Noodles...	
						7				Sippy Golden Dragon...	
						8				Sippy Multigrain...	
						9				Sippy Ragi Noodles...	
						10				Sippy Tomato Noodles...	

Figure 59: Slicer operation performed to compute the quantities of sales return stocks on period and product basis

Source: Own contribution

The analysis in the (Figure 58) and (Figure 59) was done to let know the company to correct or adjust the value of trade transactions done with customers and also take preventive management action to ensure the product they are selling is free of quality defects and shipping errors and provide excellent customer service.

7. Elaboration of results

The primary goal of this thesis was to use business intelligence to improve the process of capturing data in a corporation. This is mostly accomplished through the combination of Microsoft Access and Microsoft Excel applications, the simplification of data tables, the enablement of queries, and so on, as they will be briefly explained:

7.1 Collaboration of Microsoft access and excel

This method is one of the largest contributor to this thesis. The combination of MS Access with Excel results in efficient way for capturing and analysing huge amounts of information. Excel and Access both have their own set of perks and limitations. The utilization of both the software relies on the purpose of the project. Since integrating both was the optimal strategy for this task, associated operations were executed.
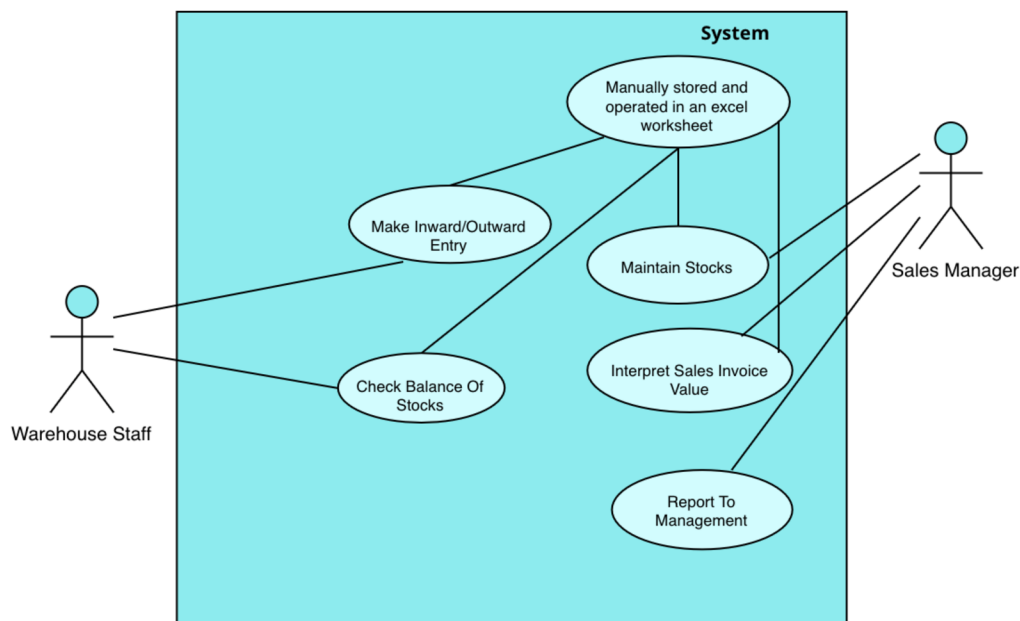

Figure 60: Previous use case model of stock management

Source: Own contribution

Some important capabilities of Excel are its ability to store massive amounts of data, its great flexibility, the ability to analyse and perform basic queries, the pivoting function for altering data rows and columns, and so on. Excel, however, has restrictions. When the task

develops to a greater degree of complexity, the flexibility, ease of calculation and analytical functions of Excel become more sophisticated and difficult to complete. With the gradual rise in the data amount, data manipulation becomes more difficult. The faults and flaws created result in superfluous or undesired outputs, which leads to poor analysis.
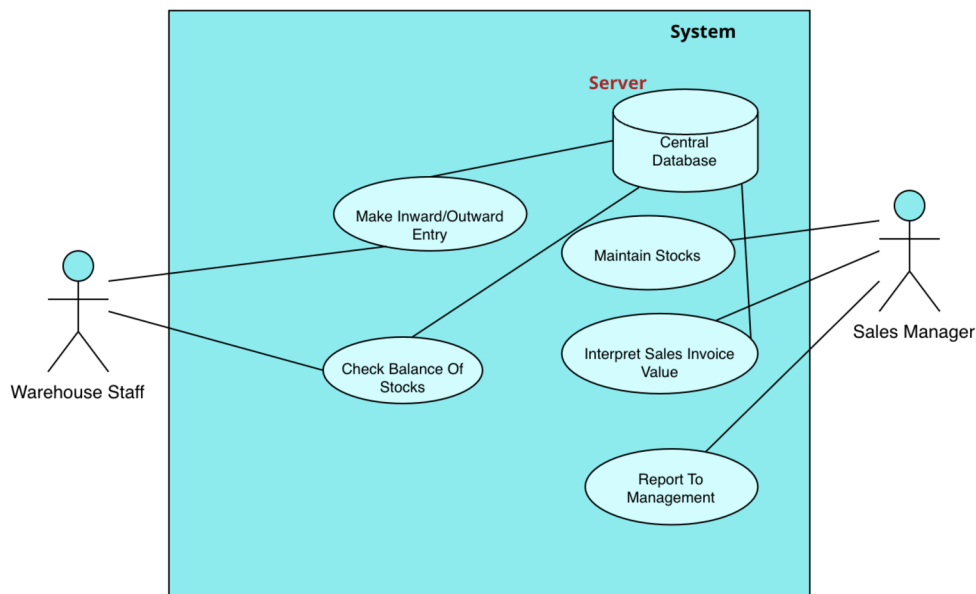

Figure 61: Stock management supported by the proposed database solution

Source: Own contribution

In contrast to Microsoft access, which is a relational database that stores numerous tables, Microsoft excel operates as a database stored in flat files where simple databases may be kept. Access is a simple database program used for gathering and arranging an organization's complicated data files, which are often kept in Excel. It is capable of storing data in tables and create associated relations, queries, and so on. This project makes use of both programs, optimizing the procedure as much as it is feasible. At first, the data in Microsoft excel is imported into an Microsoft Access file and examined in the "datasheet view" form. The benefit is that the data is replicated in the exact identical format as the original data type, with no modifications and thereby eliminating file transfer errors from one software application to another. The access database file is connected to the excel worksheets. This improves query and reporting performance. The query forms were created without manually inputting any SQL instructions, making them incredibly effective and simple.

The additional benefit is that the restriction of Microsoft access data manipulation difficulties is removed, since the linkage allows you to update data in access by altering it in the related excel worksheet. The organizing and filtering features of access are extremely similar, so there is no need to learn a new program from scratch.

7.2 The effectiveness of data analysis

It was discovered that Microsoft access is more suitable for data management in the current project. It primarily offers the user with simple sorting, filtering, and structuring of complicated data. Excel is a program that allows you to save just one table with various data fields for simple computation and analysis. However, because inventory information records comprise several tables and complicated data structures, a relational database management system in a version of Microsoft Access is required. The primary goal of transforming a single flat file into a relational database is to streamline data analysis and processing far more efficient and straightforward.

Some additional perks of MS Access when compared to MS Excel is its robust querying features where we can extract and analyse data in a more flexible and advanced manner than using Excel. **Structured Query Language (SQL)** allows you to build queries that link tables, aggregate data, and carry out sophisticated computations. Moreover, MS Excel is made for a single user to work on a spreadsheet at a time, whereas Access can handle many users accessing the same database concurrently.
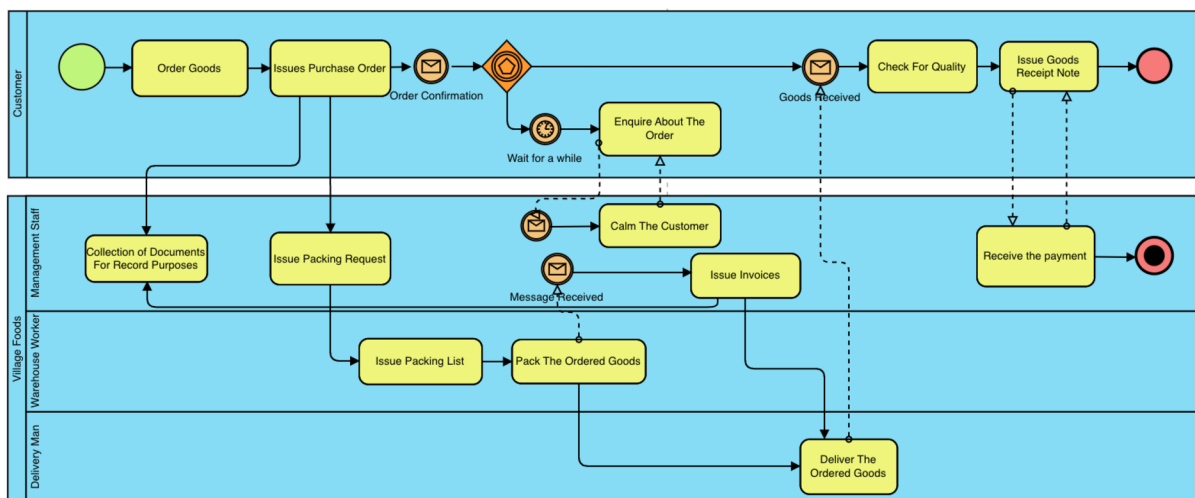

Figure 62: Diagram of previous dispatch process of the company

Source: Own contribution

The (Figure 62) and (Figure 63) gives us the comparison of previous dispatch process of the company and the changes made to dispatch process of the company respectively. The purpose of giving this business intelligence solution to the company is to increase efficiency, and accuracy. They also play a vital role in reducing the time, manual paperwork and collection of such documents for records purpose during the dispatch process which ultimately saves time and leads to some extent of cost savings.
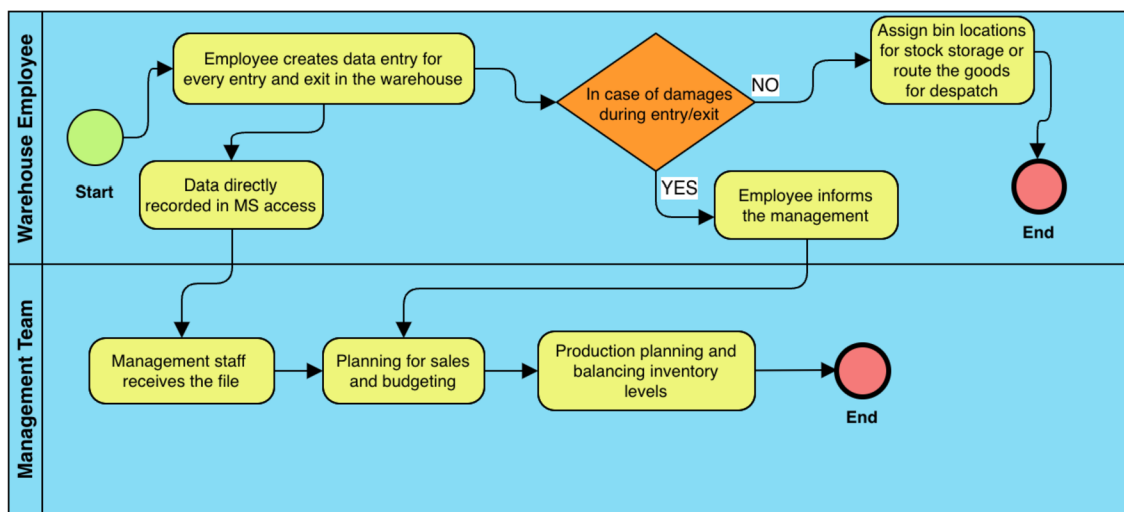

Figure 63: Business process diagram for streamlined stock management system

Source: Own contribution

The flat file is transformed into many multiple tables in this format, ensuring that each inventory data is kept in its own database. An effective structure without any repeating attributes is provided by several data tables. Changes to the data in one table affect all the associated tables as a result of data integrity. The database structure's data integrity requirements make sure that the appropriate data is entered in the appropriate data type field. For instance, the batch number must be entered in the batch number type field or attribute and avoiding to do so lead to an error notice. This feature makes sure there are no mistakes made while entering information into or modifying the relevant field. When necessary, this file can also give user access distinction to the database file for records and security in accordance with the firm guidelines.

7.3 Execution of queries

Both Microsoft access and excel are utilized in this project for carrying out various queries. The necessary queries are executed where the Microsoft access and excel are connected. With the help of queries, a user is able to quickly and effectively extract vast volumes of data and produce the desired result. This method assists in combining several tables to produce the pertinent information as needed by the individual using it. Excel displays the results of the query with graphs and other advanced analysis tools. Additionally, constructing customized code for the queries is not required, which streamlines the process and saves time. The pivot table tool is utilized to examine a number of data queries related to the inventory, including the total value of finished goods based on each delivery to the warehouse, the total value and count of the bills invoiced to the customer, and the total quantity of different types of stock available in the warehouse.

These queries primarily aid in internal administration of the business, which indirectly affects their financial standing as a whole. It gives the business the ability to assess and manage production performance. The organization uses this information to address its weaknesses and boost productivity. It also offers a solid foundation for decision-making for both managers and employees.

7.4 Data model for future implications

The logical data model constructed as shown in the below (Figure 64) is to enable the company to store many other inventory goods like raw material, packing material, utilities and so on. By doing this it helps the company to use its warehouse for multiple purposes. They help the company to reduce the transportation costs for transferring inventory items from multiple locations to production facility.
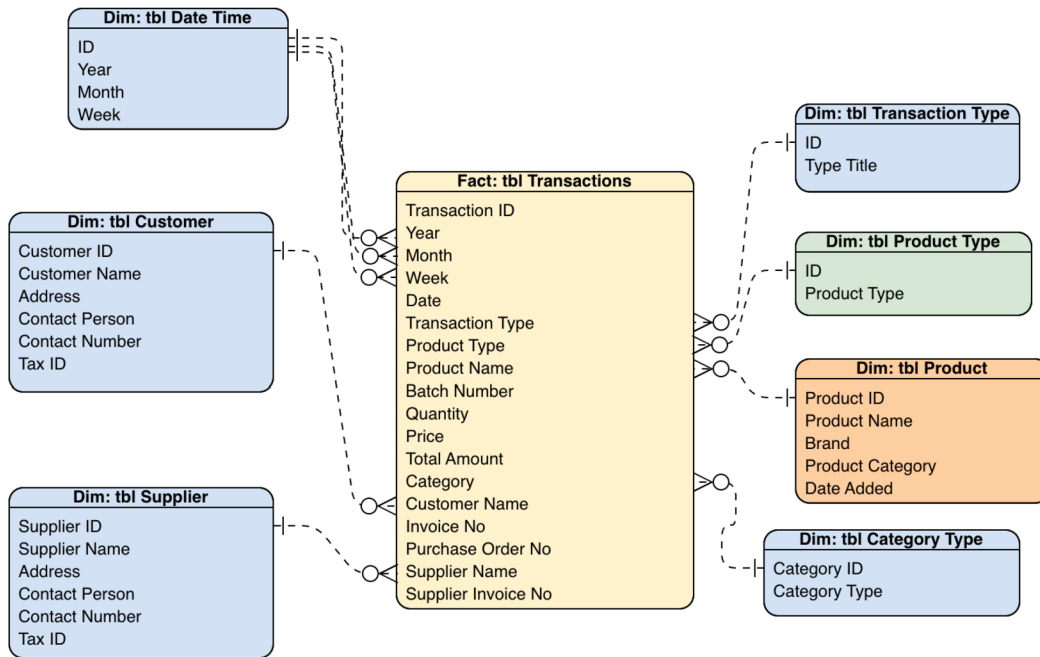
Figure 64: Logical data model for future implications

Source: Own contribution

When comparing it with the other logical data model as shown in (Figure 38) this logical data model in (Figure 64) has a new attribute "Product Type" which has to one-to-many relationship with "tbl Product Type". The purpose of this attribute and dimension table is to let know the company like what type of goods is stored in the warehouse. It comprises of finished goods, packing material, raw material and so on. On the other end, it has other dimension table "tbl Product" with new attributes like brand and category. This enables the company to store goods with multiple brands and categories in future if they start retail and trading activities.

8. Conclusion

This project is being carried out with the intention of using business intelligence to optimize the procedure for acquiring inventory movement and storage records. The use of a central database structure was the most effective, economical, and straightforward approach to carry out this procedure. The software applications such as MS Access and MS Excel were also integrated into this project. The process of building conceptual, logical, and physical models, as well as defining associated relationships between various entities, was used to gradually create the database structure. Concepts like the relational database management system, hierarchical structures, data schemas, data modelling methods, and business intelligence architecture were all explained in this thesis. Use case models, flowcharts, and BPMN process diagrams are employed to illustrate the structure and direction of the mentioned business process in this thesis. Additionally, queries were performed to analyse and compute the inventory data in accordance with the needs. This aids in assessing the company's production performance. Thus, consistently improving inventory records results in a firm that operates effectively and generates the highest possible financial outcomes.

There may be other innovations used in addition to the existing work being done to optimize the inventory records. It is possible to study and use business intelligence more sophisticatedly. More users can work together with the database file if the procedure is made mutually beneficial or cooperation friendly. The visual appearance of reports may also change which becomes more visually appealing or pictorial while presenting high-level data outcomes. Implementing a cloud-based storage solution is another option for data backup and recovery. Numerous businesses have also implemented web-based data application systems that provide employees real-time read-only access to stock reports, dispatch reports, and other information.

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