Regular Article

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Architectural modeling of data warehouse and analytic business intelligence for Bedstead manufacturers

https://doi.org/10.1515/eng-2022-0508
received July 11, 2022; accepted August 28, 2023

Abstract: Proper decision-making in a company requires a company to make decisions quickly, precisely, and relevant to the problem at hand. The ability to examine problems encountered necessitates the use of data from all areas of an organization. These data will be the basis for decision-making. Due to the significance of these data, data warehouse (DW) and analytics and business Intelligence (ABI) are necessary form of information technology. The DW and business intelligence requirements for each organization differ based on the industry. As a result, this case study of the Bedstead manufacturers intends to build a blueprint of the DW and ABI that can be used as the basis and reference in the future by this company and similar companies in creating DWs and business intelligence.

Keywords: blueprint, data warehouse, analytic business intelligence

1 Introduction

This study looks into a specific company in Indonesia that specializes in Bedstead. This corporation is currently using a simplistic system that is not connected and interacted in every section of the organization, causing management to struggle with market demands, production planning, and inventory control [1].

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The scale of a company's leaders' and management's decision-making responsibilities influence the company's direction and operation. To achieve these tasks, management must make judgments that are timely, precise, and relevant to the issues at hand. This decision making requires information technology (IT) support in the form of data warehouse (DW) and analytics and business intelligence (ABI) to be fast, precise, and relevant. According to Chen, Chiang, and Storey, business data analysis is critical for helping firms better understand their businesses, markets, and make the right decisions [2].

With the current IT advances, this manufacturer intends to leverage ABI and DWs as supports for accurate and timely decision making. ABI and data warehousing are distinct but nearly inseparable concepts. The DW is more concerned with how large and diverse data are stored in a single repository (DW) and structured in a way that allows for search, whereas business intelligence is one of the technologies used to present these data so that analysis and decision making can be based on accurate information from data sources, namely, DW [3].

Every manufacturing organization that uses IT has and uses enterprise resource planning (ERP) in addition to business intelligence and DW. ERP is a computer-based system designed to handle multiple organizational transaction procedures from various business operations in real-time using various integrated capabilities [4]. The availability of correct data and information has become a basic prerequisite for a firm in order to understand its position and development in relation to competitors. With reliable data, it may be molded into information or a report that can be beneficial in decision-making and also support the company's business plan in attaining its objective. Since 2016, this Bedstead manufacturer has been integrating ERP [5].

It is expected that with the availability of IT in the form of DW and business intelligence, data can be collected and processed well into information that is relevant to the needs of this Bedstead manufacturer, which can then be analyzed by executives and management of the company to aid in strategic decision making quickly and correctly [6].

The executives and management decide to explore more on planning and needs when developing a DW and business intelligence. On that premise, the aim of this study is to provide a blueprint for DWs and business intelligence that will one day be able to fulfill the needs of Bedstead manufacturers and similar companies in the creation or early development of the company's DW and business intelligence [7]. This design will serve as the foundation for corporate DW and business intelligence investment and implementation strategy, development, and manufacturing. Furthermore, this blueprint can serve as an excellent control and parameter tool for assessing the performance of DW and business intelligence development and implementation [8].

The research in this study was limited to data warehouse, creating a design for data warehousing and business intelligence based on the Bedstead manufacturer's ERP system.

2 Literature review

2.1 Blue print

Where a corporation has a strategic plan, a blueprint is a derivative of that strategy (generally made 5 years, 10 years, 15 years, and some even up to 25 years). When a company grows and gets more complicated, management requires access to data whenever and wherever they are needed, in an accurate, easy-to-read format that is standard throughout the firm, and most crucially, in a timely manner. To meet these demands, the corporation will file more applications without further consideration of the company's overall situation [9].

According to Oracle Corporation, a blueprint is a system design that contains and explains various components that can be interconnected and interact, such as the process of input (data) from various sources into the system, how the system processes, how the system groups data, and how the system can produce reports required by the company. The blueprint serves as a basis, foundation, or rule for firm management in the construction of information systems (ISs), allowing it to become a way of constructing an adequate and appropriate IS in accordance with the company's vision and goal [10].

2.2 ERP

ERP systems are business management software that can connect and link all organizational units and activities across enterprises into a single system unit, even if the organizations are not geographically separated. The goal of ERP is to improve company processes, create efficient workflows, and generate, process, and access information and knowledge in real time. The ERP architecture integrates human resource activities, data analysis, sales, services, supply chain management, finance, and manufacturing [3].

All information about procedures within the company's limits is combined in a single system. Because an ERP system involves computer hardware, software, Database Management Systems (DBMSs), trained users, and, most significantly, the dedication of managers who utilize this system, its adoption is expensive, complex, and challenging [9].

2.3 DW

2.3.1 Definition of DW

A DW is an integrated and historized collection of data generally used to make strategic decisions by means of online analytical processing (OLAP) techniques. It integrates data that come from independent heterogeneous operational data-sources and creates a single view about the organization. Once in the DW, these data are turned into structured information that can easily be handled by decision making processes [6]. Data and analytics have become indispensable to businesses to stay competitive. Businesses use reports, dashboards, and analytic tools to extract insights from their data, monitor business performance, and support decision making [11].

Basically, the DW is a database and also acts as a data center created based on the unification and processing of data from various data sources. In general, the DW is used for data reporting and analysis purposes.

2.3.2 Extract, transform, and load (ETL)

In a simple sense, ETL is a process that aims to extract and process data from one or many sources into new sources. The process of ETL enables the conversion of an online transaction processing (OLTP) database into an OLAP database. But ETL is not that simple, because data sources processed by ETL can be from various data sources, not only from OLTP databases, but also from websites, text files, spreadsheets, databases, e-mails, and so on.

According to Kimball & Ross, ETL process is a mandatory process in the development and construction of a DW.

Each has a definition or meaning, namely, 1) Extract, data extraction is a process when data are taken from various sources of ISs or IT. The first step in the ETL process is to extract data from data sources. The extraction process is a decomposition process, cleaning of extracted data to obtain the expected structure or pattern of data [12]. 2) Transform, data transformation is the process when extracted data are then filtered and changed according to the format needed. This section refers to any function that converts the incoming data into the desired data. 3) Load, loading data is the last process of ETL, at this stage there is a process of loading data that has been transformed into the DW. ETL can read data from a data source, then change the form of data, and save in another data store. Data store that is read by ETL is called data source. The process of changing data is used so that the data matches the format and desired criteria [1].

2.3.3 Star schema

In OLTP systems a data modeling technique is called an Entity-Relationship (E-R). Whereas in the DW, a data modeling technique called a dimensional modeling technique is used. Dimensional modeling is a call-based model that supports high-volume query access. Star schema is a tool where dimensional modeling is applied and contains a central fact table. The fact table contains descriptive attributes that are used for query and foreign key processes to connect to dimension tables. The decision analysis attributes consist of performance, metric, operational, aggregate size, and all other metrics needed to analyze performance. The fact table shows what the DW supports in decision analysis. Dimension tables surround the central fact table. The dimension table contains attributes that describe the data entered in the fact table. The dimension table points to how the data will be analyzed.

2.3.4 OLTP

ISs are a set of functions that work together in managing, collecting, storing, processing, and distributing information [13].

OLTP is a technology used to manage transaction-oriented ISs. This technology is related to DW, each database associated with OLTP is called an OLTP database.

OLTP databases are commonly used in transaction-oriented ISs, meaning that ISs tend to insert, update, and delete the database in real-time. In general, it is intended for ISs that have criteria for mission critical applications, i.e., if a problem or disruption occurs in the IS, it will cause the business process to be disrupted.

OLTP exhibits distinct features, including the presence of a substantial user base engaged in concurrent data processing and data insertion activities. In this scenario, the application may become overloaded if a large number of users engage in data processing and addition. As the complexity of the database increases, the reaction time will decrease as a result of the accumulation of accessible resources, necessitating a significant amount of time.

2.3.5 OLAP

OLAP is a technology to meet needs in terms of analytics or analysis. Like OLTP, OLAP also deals with databases. Just like OLTP, every database related to OLAP is also called an OLAP database. OLAP database is a database that is maximized for speed in reading (select query). OLAP is not intended for the use of mission critical applications. One data source for forming OLAP is the OLTP database. OLAP must be formed through the ETL process.

OLAP can be considered as a computer-based process that allows users to view the latest data from various perspectives or perceptions easily and quickly. To enable analysis, OLAP data are stored in a multidimensional database.

OLAP is basically a special method for analyzing data contained in data storage media in the form of databases and then proceeds with making analysis reports in accordance with the requests of user or users. For this purpose, the data in the form of information are made into a special format by giving group or groups to these data [12].

OLAP contains two basic data types, namely, measures and dimensions. Measures are measured number data, for example quantity, price, average value of certain values, number of certain values, and so forth. While dimension refers to the category used to regulate measures.

Most common DBMSs such as Oracle, Microsoft Structured Query Language (SQL) Server, IBM DB2, PostgreSQL, MySQL, and others can be used for OLTP and OLAP databases. Both are distinguished in the schema table that will be formed. The OLTP database table scheme is generally in the form of normalization, while the OLAP database applies a star or snowflake scheme.

In OLTP, the query language used is SQL, while in OLAP, the query language used is Multidimensional Expressions.

2.4 ABI

According to Carlo Vercellis, ABI refers to a collection of mathematical models and analysis approaches that systematically employ and generate data to facilitate the production of information and knowledge. These outputs are intended to aid in the support of intricate decision-making processes. In the current era of IT, ABI is needed because of the rapid changes in globalization, innovation, and competition in making the right and effective decisions [1]. In addition, ABI can be interpreted as the emotionally coherent use of a skillset in different domains and in different accomplishments for objectives diversity to conceptualize and pass on to the materially realizable process of interpreting, analyzing, modifying, and innovating intentionally extracted business data in order to support decision support systems, generating and sharing knowledge [14].

The ABI architecture has six main components, namely, 1) data source, 2) DW and data mart, 3) data exploration, 4) data mining, 5) optimization, and 6) decisions [1]. Figure 1 shows the ABI architecture.

The benefits of implementing the ABI system as shown in Figure 2 are as follows [15]:

1. Receive many alternatives that can be taken in decision making.
2. Conclusions produced are more accurate Every decision that will be taken can have different meanings and knowledge.
3. Based on the results of effective and timely decisions, companies can take the right steps and be quick in facing the market competition.

There are four main steps in the process of making ABI, namely, 1) analysis, 2) design, 3) planning, and 4) implementation and control as shown in Figure 3 [15].

2.5 Zachman framework

Zachman's framework was first published by John Zachman in 1987 in his article "A Framework for Information Systems Architecture" in IBM Systems Journal. The Zachman Framework summarizes a set of perspectives based on architecture. The perspective is depicted in a two-dimensional matrix. The column matrix represents questions about the enterprise, namely, What (data), How (function), Where (network), Who (people), When (time), and Why (motivation) [5].

Figure 2: Benefits of ABI [15].

The development framework model and IT blueprint formulation has a number of input and output elements. Each perspective from Zachman's framework can be briefly stated as follows.

1. Planner will deal with an overview of ISs and position ISs in the context of the organization's internal and external business environment. Planning not only identifies the main components of ISs, but also talks about finance (including losses and profits), limitations, scope (what will be the IS and what is not).
2. Owner, in general, is very interested in the products produced by the business, enterprise model functionality, and how the enterprise model can be used. In a plan that is made, the owner usually determines the boundaries and specific needs of the system, such as organizational policies, data search requirements are flexible so response time is needed.
3. Designers work with the IS specifications provided by planners and owners to produce designs that will meet the owner's functional satisfaction and can be technically realized by the developer. A design is not only able to correctly interpret the boundaries and needs of the owner correctly, but he also needs to know the technical

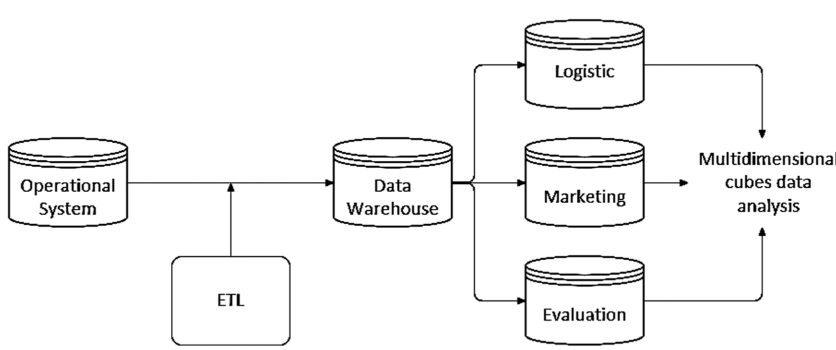

Figure 1: ABI architecture [15].

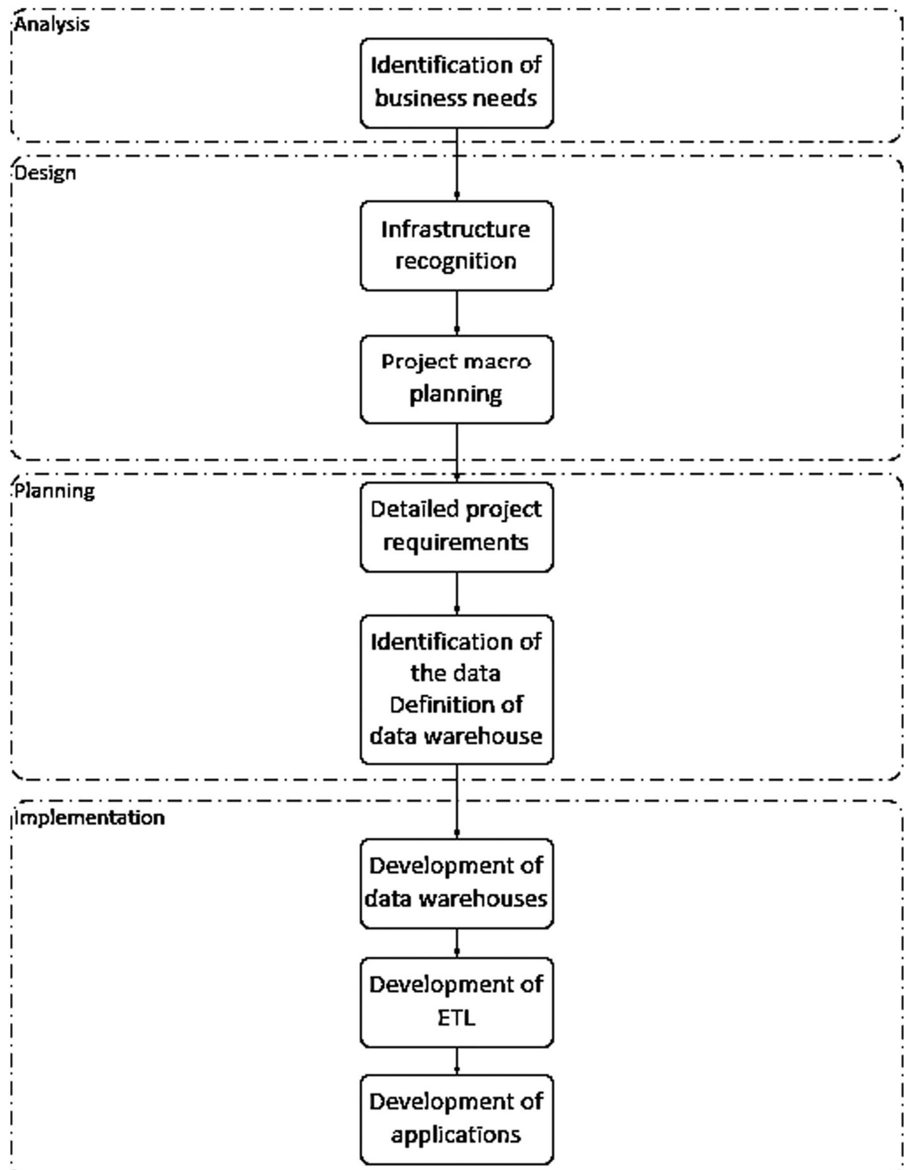

Figure 3: ABI development stage [15].

possibilities and limitations of the IS development platform needed.

4. The developer manages the process for making IS components, this requires careful understanding of the architect's specifications for the system. In addition, a developer must know the material to work with databases, programming languages, operating systems, and so on.
5. Subcontractors build specific parts of the product. The responsibility of the subcontractor is to produce components in accordance with the specifications provided. Subcontractors may be outside the organization (third party) or in the organization, their views can also be useful to communicate product specifications in the ISs division of an organization.
6. The user perspective is the interface and functionality of the final product. The user perspective is a culmination of the preceding planning, design, and development endeavors.

3 Research method

3.1 Overview of the company

This manufacturing company concentrates in the field of Bedstead. This company successfully implemented assets in the form of ERP systems for modules used such as asset, accounting, bill of materials, inventory, procurement, sales, and production modules.

This corporation originated in Indonesia and China. The company manufactures beds, mattresses, box spring beds, and motorized adjustable beds. Clients include service sectors, hotels, furniture and bedstead retailers, interior architects, hotel planning firms, and hotel interior design firms. There are no minimum order amounts because the company is completely flexible.

Since mid-1921, the company has been making bedstead products in the third generation as a family business. This company provides unique products and sleep solutions to hotels as well as other consumers. The goods are designed and manufactured for the unique needs of hotels. They are tailored to the needs of hotel cleaning as well as the required long-life quality. Because of this, bedstead products are also desirable and desired by everyone for use in their own house.

To manufacture the products, the company employed only the best certified and controlled materials. The organization has had a long-term relationship with overseas clients for over 40 years. This is founded on history, trust, and collaboration.

The goods offer solutions that have been specifically designed to fulfill the needs of hotels and individual consumers. Comfort, hygiene, and handling are all unified, and the external design may be tailored to the needs of different hoteliers. The ideas are based on an understanding of what is important in a hotel and service industry bed. The principles are formed through an understanding of the fundamental components of a bed in the hotel and hospitality industry. This statement contains multiple facets pertaining to beds, encompassing their fundamental construction, level of comfort and hygiene, concerns for design, and potential for cost-saving functionality. The company expertise is founded on the company's history and brand.

In terms of the quality of room interiors, sleeping comfort, and personnel efficiency, these items place the hotel and other service industries in the lead.

Guests and consumers will be better satisfied, and the items may lower expenses in a particularly labor-intensive location, thereby supporting the company's and their client's investment decision. The adaptable and best-educated staff accommodate the needs of international customers in a flexible manner, utilizing their superior understanding of bedstead items.

3.2 Data analysis

The method used is qualitative. The steps that will be carried out analyze the company's internal data to support the creation of a DW and ABI blueprint for the Bedstead manufacturer. The internal data analysis activities of the company include 1) the ERP system of the Bedstead manufacturer and 2) the database structure of the ERP system of the Bedstead manufacturer.

The data collected through the methods of observation and interviews with various stakeholders of the Bedstead manufacturing company serves as a foundational resource for the development of ABI blueprints and DWs.

3.3 Determining target of ISs/IT

The aim of this stage is to identify the problems and opportunities for the use of IS/IT that have occurred in meeting the needs of the Bedstead manufacturer's business strategy both internally and externally. What is needed at this stage is the organization's future business needs, identification of IS/IT utilization opportunities, and current IS/IT needs. The processes that will be carried out at this stage are 1) identifying information about IT strategies and strategies both before or in progress and 2) gathering information about the company's IT section and the process.

3.4 Design method

The design method that will be used for the DW is the method by Kimball and Caserta where there are four stages that must be passed in designing a DW, namely, selecting the business process, declaring the grain, identifying the dimensions, and identifying the facts [16].

3.5 Database design

The work plan for database design is to analyze and review data requirement, determine the needs of aggregation functions and summarization, and design target DW databases. In designing a target DW database from predetermined needs, attention must be paid to the E-R scheme and design scheme. The final stage is designing the physical database. After all the designs needed are complete, a data definition language and data manipulation language scheme is developed, the authority for the database will also be created.

3.6 Data collection

1. Conducting studies or learning through scientific books and writings relating to the making of blueprints, DWs and ABI.

2. The study involved the utilization and acquisition of internal data from the ERP database of the Bedstead maker through the implementation of observations and interviews.

4 Results and discussion

4.1 Data collection

At this stage, the collection of data requirement for designing a DW blueprint and ABI was carried out using the interview method at the Syspro System Review meeting which discussed all aspects of business processes and the use of the Syspro ERP system.

The following is the response of each leader of each division based on each suggestion and input from users in each division section especially in the use of the Syspro ERP system at this Bedstead manufacturers. Table 1 is the result of interviews conducted in meeting data need aimed at the leaders of each division in the Bedstead manufacturer.

Herewith the details of questions of interviews ask about:
1. The duration of payable account to create the report.
2. The duration of a receivable account to create the report.
3. The duration of a trial balance to create the report.
4. The duration of an inventory movement to create the report.
5. The duration of a sales report to create the report.
6. The duration of a comparison report on sales of goods to create the report.
7. The duration of an inventory movement to create the report.
8. The duration of production to create the report.
9. The duration of an inspection to create the report.
10. The duration of the use of raw materials, finished goods, and scrap goods. to create the report.
11. The duration of labor to create the report.

4.2 Data source analysis

ETL process is the process of transferring data from the OLTP operational database, namely, the ERP system transaction database on the Bedstead manufacturer into the DW that will be designed. In the ETL process, the data are transferred from the database named “SysproCompanyBNIS” to the “BNISDataWarehouse” database. Before the ETL process is carried out, it is necessary to define the relation between each table from the database “SysproCompanyBNIS” to find out the flow that occurs in each transaction process. From here, there are five kinds of relations that occur in this process, which are as follows:
1. Relationship between the account payable module table and *ApInvoice* as the transaction center.
2. Relationship between the account receivable module table and ArInvoice as the transaction center.
3. Relation between the inventory module table and InvMovements as the transaction center.
4. Relationship between Sales module tables with SorDetail as the transaction center.
5. Relationship between the Work in Progress module table and WipMaster as the transaction center.

Figure 4 shows one of the relations that occurred in this process.

The details of terms that are used in Figure 4 are as follows:
1. ApBranch is the module table for branch.
2. ApBank is the module table for bank.

Table 1: Results of interviews with the leaders of each division

Division	Response
Accounting	Requires a payable account report that is not limited to only 3 months
	Requires a receivable account report that is not limited to only 3 months
	Requires comparison of financial statements from time to time
	Requires a trial balance report that is not limited to only 3 months
Marketing	Requires an inventory movement report that is not only limited to 3 months
	Requires a sales report that is not limited to only 3 months
	Requires a comparison report on sales of goods from time to time
Production	Requires an inventory movement report that is not only limited to 3 months
	Requires production reports from time to time
	Requires an inspection report from time to time
	Requires reports on the use of raw materials, finished goods, and scrap goods
	Requires labor reports

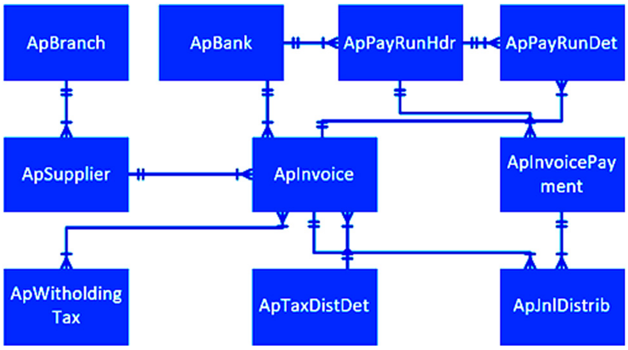

Figure 4: Relations between the account payable module table with App Invoice as the transaction center.

3. ApSupplier is the module table for supplier.
4. ApWitholdingTax is the module table for withholding tax.
5. ApInvoice is the module table for invoice.
6. ApTaxDistDet is the module table for tax distribution.
7. ApPayRunHdr is the module table for paying the payment.
8. ApPayRunDet is the module table for paying the rest debt.
9. ApInvoicePayment is the module table for payment of the invoice.
10. ApInDistrib is the module table for App Invoice

4.3 Designing DW

4.3.1 Designing a star schema

Star Schema is a means to organize a DW or DWs using a relational database. The scheme uses dimension tables to describe the data contained in the fact table.

The main characteristic of star schema is that the dimension table is not normalized. The fact table contains data extracted from the operational database (OLTP). The fact table will be connected with tables that describe the dimensions for the measure (dimension table). From this scheme, we can easily see why this scheme is called a "star scheme," because the model looks like a star, with a dimension table that surrounds the fact table.

Time dimensions are almost always present in every ABI, so all ABI solutions usually have pre-defined tables of this dimension. On one of the tables in an OLTP database, for example, once a column type is date, it is automatically recognized as a complete time dimension with other attributes such as month, quarter, semester, year, etc. With this pre-defined dimension of time, we hardly need to create our own dimension tables, but for this case we will create a table of its own time dimension.

Herewith the details of questions of interviews ask about: At this stage, five types of star schemes are produced from each module, namely,

1. The star scheme of payable account module
2. The star scheme of receivable account module
3. The star scheme of inventory module
4. The star scheme of sales module
5. The star scheme of the work in progress module

Figure 5 is one example of the star schema that was produced in this study.

The details of abbreviations in Figure 5 are as follows:

1. The module of dim_supplier is the module of supplier.
2. The module of dim_tax is the module of tax.
3. The module dim_appayment is the module of payment.
4. The Module dim_apjournal is the module of journal transaction.
5. The module dim_time is the module of work in progress module.
6. The module fact_apinvoice is the module of payable account.

In the star scheme module, account payable the *fact_apinvoice* table contains measurable data, such as the amount of debt, taxes, and so on to the supplier. Fact table *fact_apinvoice* is surrounded by five-dimension tables including *dim_supplier* which contains supplier data, *dim_tax* which contains tax data, *dim_time* which contains time data, *dim_apjournal* containing accountant journal data that occurs, and *dim_appayment* which contains debt payment data. The tables contain more complete data that can explain the contents of the fact table and the dimension table can be used as a key to search data.

4.3.2 ETL design

In this study, there are several stages in ETL design, which include the following:

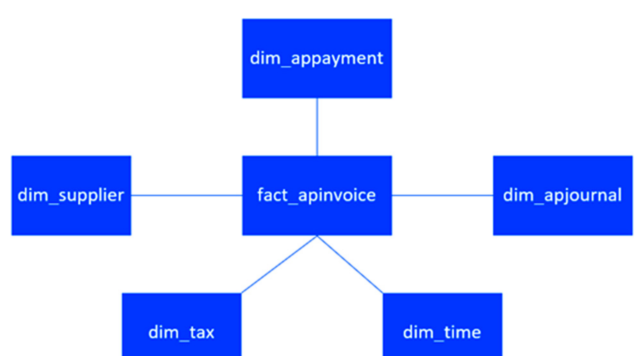

Figure 5: The star scheme of payable account module.

1) Data cleaning/cleansing and reducing several columns in certain tables contained in database transactions or OLTP databases and then reducing certain tables because information needs can be accessed through other tables.

2) Create a new table that functions as a relation or connection between one table and another table and brings together several fields from the table that have been reduced to a new table in meeting the measure needs.

3) Perform ETL processes using SQL Server Integration Service (SSIS) tools. The ETL mechanism in SQL Server SSIS 2012 is divided into two parts, namely, data flow and control flow. Data flow is used for ETL processes in which there are process control components where the components are source, transformation, and destination. While control flow is used to regulate the activity of data flow processes and other processes in a package. Figure 6 shows the control flow and data flow in the ETL mechanism.

In Figure 6, it can be interpreted that the first process that must be run is SQL Server 2012 running the command contained in the Task 1 query, and then the next process is the data flow transfer that occurs from the original database to the destination database based on the command found in Task 1 query. This repeats until SQL Task *n* is executed and all data transfer processes or data flow task *n* are resolved.

In this study, there are five ETL data flow processes are occurring, namely:
1. ETL data flow process of account payable module
2. ETL data flow process of account receivable module
3. ETL data flow process of inventory module
4. ETL data flow process of sales module
5. ETL data flow process of work in progress module

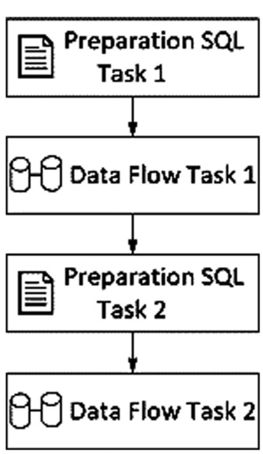

Figure 6: The control flow of ETL process.

4.4 Designing ABI

4.4.1 Decision tree algorithm

Decision tree is a prediction model that uses tree structures or hierarchical structures. Decision tree is used for pattern searching and includes statistical search patterns. Decision tree algorithms are frequently employed because to their ability to generate simply interpretable findings and models, while still exhibiting relatively quick computational performance.

The structure of decision tree is formed from three types of vertices, namely, root node, intermediate node, and leaf node. Each node can be interpreted as follows:
1. The root node is the starting point of the decision tree.
2. The intermediary node is related to a question or test.
3. The knot leaf contains a final decision or target from the decision tree.

To be able to further clarify how the decision tree compiles and determines the initial node, the example relating to the data contained in the fact table that is sourced from the DW will give a clear understanding [17].
1. From the fact table, fact_apinvoice and fact_invmovements contained in the DW, the category attribute is to determine whether the company needs to make purchases against suppliers or not based on company conditions defined as non-category attributes. The non-category attributes are supplier, item, price, quantity, due, and current ratio.
2. From the fact table, *fact_arinvoice*, *fact_invmovements*, and *fact_sales* found in the DW, the attribute category is to determine whether the company needs to provide promotion and whether the company needs to sell related customers based on company conditions defined as non-category attributes. The non-category attributes are customer, item, price, unit cost, quantity, due, and receivable turnover.
3. From the fact table, fact_invmovements, and fact_wip contained in the DW, the category attribute is to determine whether the company needs to carry out production of certain items based on company conditions defined as non-category attributes. The non-category attributes are item, bill of material, unit cost, quantity, and inventory turnover.
4. To determine the node selected as root, a calculation is performed to find the entropy value of each attribute. The attribute value with the smallest entropy is used as the root node. The formula used to find the entropy value is as follows:

$$\text{Average entropy} = \sum_{\mathrm{b}}\left(\frac{n_{\mathrm{b}}}{n_{\mathrm{t}}}\right) \times \left[\sum_{\mathrm{c}} -\left(\frac{n_{\mathrm{bc}}}{n_{\mathrm{b}}}\right)\log_2\left(\frac{n_{\mathrm{bc}}}{n_{\mathrm{b}}}\right)\right]. \quad (1)$$

where n_b is the number of positive and negative non-category attribute values, n_t is the total data, and n_{tx} is the number of non-category attribute values that are positive and negative.
5. After calculating each entropy value of each attribute, the smallest entropy value of each attribute is obtained and selected as the root node.
6. The subsequent leaf node may be chosen based on qualities that exhibit both positive and negative values. The calculation is performed in a manner such that all nodes transition into leaf nodes uniformly at points 4, 5, and 6, until the entropy value reaches 0.

4.4.2 ABI interface design

ABI interface prototype that can be easily understood and used is created and displayed in this stage, where the application of ABI will be used by top management within the company to analyze the condition of the company. With this ABI interface prototype and the DW, company leaders can see all the information that occurs in the company and then assist them in making appropriate and effective decisions. Some graphical interface displays that will appear here include 1) Line graphs, 2) Bar graphs, 3) Circle graphs, and 4) Summary graphs that contain the essence of existing data [18].

Figure 7 is an example of a Summary graph prototype that can be used as a reference.

4.5 Blue print

Discussion of the DW and ABI blueprint at the Bedstead manufacturer is focused on six perspectives.

4.5.1 Scope (contextual)/planner

Based on the company's vision and mission, the perspective of Zachman's framework can be briefly stated as follows:
1. Data (what)

   In alignment with the stated objective of the Bedstead producer to comprehend and uphold market demands, as well as enhance the company's competence. The company's activities need to be used through IT in analyzing data, information, and knowledge to provide value for the company in making decisions. Based on the perspective of Zachman's framework, we can present the flow of data that move across the company and with that align the Bedstead manufacturer. As stated in ref. [11], the use of IT holds potential benefits in the analysis of data, information, and knowledge, hence adding value to the decision-making processes inside the firm.
2. Function (how)

   At this stage, all Syspro ERP databases will be formulated and analyzed in the company which runs from 2016 to 2017 which are useful for designing DWs and prototype ABI. The functional results show that the implication with the implementation of the DW and ABI will be beneficial to enhance the bedstead manufacture. As shown by Aulia [1], the ERP database will provide significant impact to the enterprise. Since bedstead manufacture is in the areas of enterprise, the implication of DW and ABI will provide significant effect as well.
3. Network (where)

   The placement of the DW and ABI can be deployed on the primary server, enabling the utilization of ABI in a cloud environment. As mentioned by Brito et al. [14], the risk that we need to consider will be on areas of location as well as the issues that relate with risk mitigation.

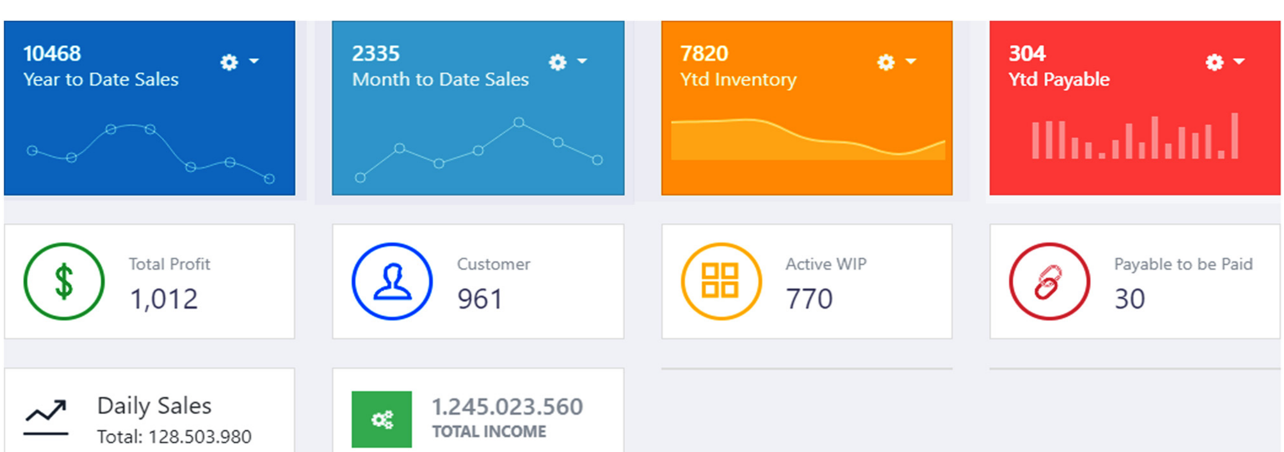

Figure 7: Prototype of ABI summary.

4. People (who)

   Directors, accounting managers, marketing managers, and production managers can utilize ABI. While IT managers can utilize this blueprint in the construction and implementation of DWs and ABI, the details of people accessing the blueprint of DW will depend on the flow of information in the organization. As mentioned by Ragulan and Subash [18], we can derive the general organization structure related with main process and supported by Finance, Human Resource, and Marketing.
5. Time (when)

   Activities related to compiling a blueprint will take 5 months. Table 2 is the timeline needed in preparing a blueprint.

   The above timeline for blueprint was aligned and matched with the results of the study by Hadhoud and Salameh [19] that shows the stages of analyzing, designing, prototyping, and final blueprint. Each stage will be measured based on the timeline as well as the output for each stage.
6. Motivation (why)

   Based on the vision and mission of Bedstead manufacturers and in the current era of IT, this blueprint is needed for the construction of DWs and ABI to be able to support the company's mission in analyzing the data already owned. As mentioned by Ragulan and Subash [18], the mission and vision of an enterprise will be very essential since the blueprint that will be released will be based on the vision and mission of the bedstead manufacturing.

4.5.2 Business model (conceptual)

It is the perspective of the top management of Bedstead manufacturer as the recipient or user of the final product/service from the blueprint.

1. Data (what)

   The Bedstead manufacturer has three main business processes, namely, purchasing business process, production business process, and sales business process. The three business processes have data from 2016 to the present that can be used as information and knowledge by utilizing the DW and ABI. The three main business processes: purchasing, production, and sales business processes are also mentioned by Brito et al. [14]. The most important output of those processes will enhance the knowledge of the Bedstead manufacturer.
2. Function (how)

   In the business process of purchasing or procuring goods, Bedstead manufacturer purchases raw materials to be produced into semi-finished goods until finished goods are ready for sale. In the purchasing business process, there are five main actors involved including supplier, warehouse staff, purchasing staff, purchasing manager, and finance staff. Production business process is a production activity that converts raw materials into semi-finished goods and then semi-finished goods are converted into finished goods that are ready for sale, in this process, there are five main actors involved: PPIC staff, PPIC supervisor, production staff, QC inspection staff, and warehouse staff.

   In the sales business process, the Bedstead manufacturer utilizes the roles of department stores and marketing staff of the company in marketing finished goods owned by the company. All company business processes have utilized the role of IT and ISs to support the company's business needs. With the existence of IT and ISs, the data can be utilized and processed to produce information and knowledge that can be used for decision making.

   The organization's functions will consist of the sales business process, procurement, and the IS department, which supplies data to all of these departments.

   As mentioned by Shmueli et al. [17], procurement and the logistic play significant roles in the manufacturing of the bedstead.
3. Network (where)

   In order to facilitate the integration and coordination of many divisions within a firm, as well as to meet the ERP requirements. Figure 8 is a description of the network topology owned by the Bedstead Manufacturer

   The Bedstead manufacturers placed the main server by utilizing co-location server services to avoid and minimize risks that can harm or delay the company's business processes. While the computer user or client is not directly connected to the main server, but uses the terminal server to run the ERP.
4. The topology of server shown in Figure 8 is aligned with the study by Shmueli et al. [17]. The flow of transactions and information will be reflected based on the network topology. The topology that is shown in Figure 8

Table 2: Timeline for designing blueprint

No.	Activities	Month				
		1	2	3	4	5
1	Analyzing data source	X	X			
2	Designing DW			X		
3	Designing prototype ABI				X	
4	Preparing blue print					X

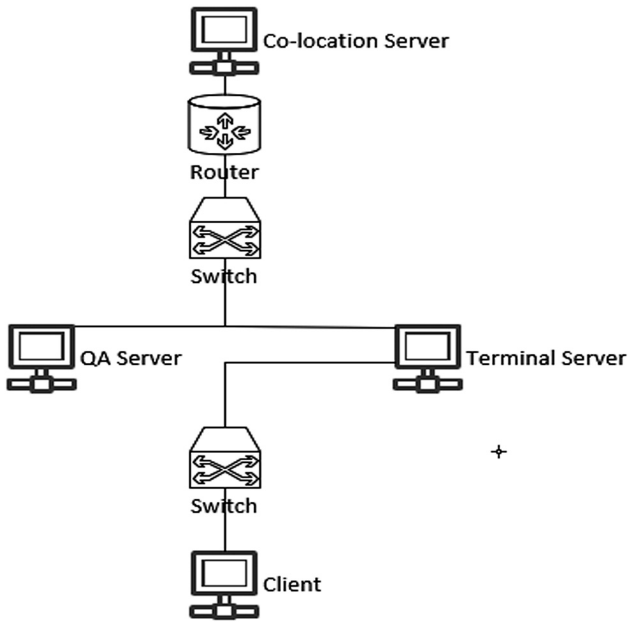

Figure 8: Network Topology of the Bedstead manufacturer.

provides more detail on the efficient monitoring of the transaction process. Overall, the topology that is proposed on the bedstead manufacture will be able to enhance the escalation as well as the dynamic access to the server.

5. People (who)

   Operational managers and staff members are responsible for utilizing IT and information systems IS to execute the various business activities of the company.

   Organization structure as well as the business process will depend on the personnel who interacts inside the organization. The above details are aligned with the results of the study by Ragulan and Subash [18], which shows that the operation will provide detail of responsibility for the use of IT and IS.

6. Time (when)

   Based on IT and ISs that are currently running, it can be determined that the working time for the construction of DWs and ABI can be started and worked at any time as long as the existing IT and ISs are working properly.

   The construction of DW and ABI will depend on the time management as well as time line of the project itself. According to Shmueli et al. [17], the design of the bedstead manufacturing process is highly influenced by the design of the timeline.

7. Motivation (why)

   Based on the vision and mission of this Bedstead manufacturer and in the current era of IT, this blueprint is needed for the construction of DWs and ABI to be able to support the company's mission in analyzing the data already owned. According to Brito et al. [14], the blueprint model necessitated assistance from both the rationale behind bedstead production and the design of the data warehouse itself.

4.5.3 System model (logical)/designer

The designer's perspective is informed by the blueprint's objectives and the technical and physical feasibility of what can be accomplished.

1. Data (what)

   In accordance with the ERP in Section 4.2 about data source analysis that describes the relationship of entities or objects from the Syspro ERP database at Bedstead manufacturer, the data system model as mentioned in Section 4.2 provides details of data relationship between each of the entities as well on the Bedstead Manufacturer. As shown in Amazon web service (AWS) [11], the logical model of the data proposed conceptual model already provided the efficient and effective structure.

2. Function (how)

   In accordance with the star scheme and ETL design in Section 4.3 of the DW design and prototype of ABI interfaces in Section 4.4 which describes the creation of DWs and ABI sourced from the Syspro ERP database of the Bedstead Manufacturer, the choice of star scheme and ETL were aligned with the results of the study by Shmueli [17], which provides better result on the implications of the creation of DW and ABI.

3. Network (where)

   Based on the network topology at the Bedstead Manufacturer, the DW and ABI can be realized and can be in the form of a cloud which is currently a trend in IT. The form of network in the cloud will provide better control and monitoring as well as reduce the cost of maintaining. This is aligned with the result of the study by Ragulan and Subash [18]. The challenges involved with cloud base is relate with the trust and continuation of services as shown by Hadhoud and Salameh [19]. However these issues have already been solved due to the improvement in technology and have provided the service level agreement as reported by Hadhoud and Salameh [19]

4. People (who)

   Based on the organizational structure of the company and concerning the overview of the company, IT managers are responsible for the construction of the DW and ABI. The issues related with people are critical due to the span of responsibility as well as the organization structure issue. As mentioned by Ragulan and Subash [18], the implementation of the analytic database and ABI for Bedstead manufacturers will be critical on the people and organization structure.

5. Time (when)

   Based on this work, no time is needed in the planning and design process of the DW and ABI. The timeline as well as the target for each specific design of the DW and ABI are critical. As mentioned by Hadhoud and Salameh [19], time is also critical on the perspective of resources usage. This suggests that the organization should engage in a more comprehensive adaptation over time.

6. Motivation (why)

   The strategies and policies applied to regulate the use of technology are based on the internal and external environment of IS/IT. The motivation will provide crucial support for the implementation and use of the technology. The results of the study by Brito et al. [14] provide insight to the implications of the technology itself on the bedstead manufacturing.

4.5.4 Technology model (physical)/builder

It is a technical and physical perspective used in overseeing technical and physical implementation.

1. Data (what)

   IT infrastructure in this company is good enough with several interconnected servers either locally or in cloud. Internet connections currently have 30 mbps upload speed and 50 mbps download speed over fiber optic network. The presence of networked servers, whether they are located locally or in the cloud, has led to improvements in the quality of internet connection via fiber optics, both in terms of upstream and downstream data transmission. The implementation of internet connections already provided the efficient and effective structure. The result was supported by the research by AWS [11]

2. Function (how)

   ISs and IT solutions can support the achievement of this company in realizing the vision, mission, and goals of the organization. Solutions are derived through the understanding of both internal and external requirements.

3. Network (where)

   ABI is a PHP web application that runs on Windows-based servers and DWs in SQL Server 2012 that run on the main server. Figure 9 shows the configuration of the web server.

   As can be seen from Figure 9, the business intelligence will provide the analytics for each entity such as DB server, print server, and web browser. The issues that raised on the bedstead manufacturing on the web server configuration were mainly on analytics and monitoring. The architecture of web server configuration was similar to that in the study by Shmueli et al. [17]

4. People (who)

   Based on the organizational structure of the company described in Section 3.1 concerning the company overview, IT managers are responsible for the physical construction of DWs and business intelligence. The focus of the people will be on the construction of DW

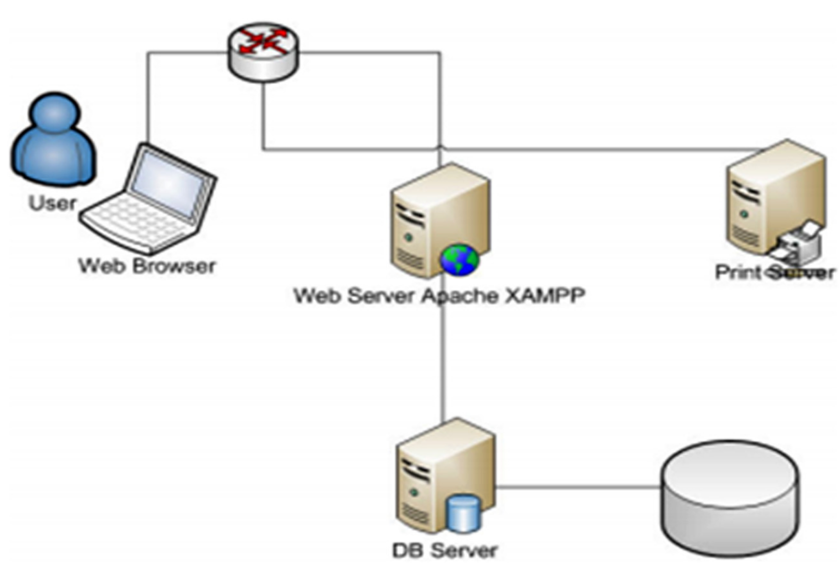

Figure 9: Web server configuration.

and ABI. The bedstead production plan was developed based on the construction of DW and ABI, in accordance with the findings presented in ref. [19]

5. Time (when)

   The time for the initial stages of physical development is determined by an IT manager who can understand the ability of each member of his division. The duration of technical and physical implementation depends on the time spent on each process managed by the IT manager. The above results are aligned with the result of the study by Ragulan and Subash [18] on the designing of the data warehousing and ABI in distribution company.

6. Motivation (why)

   The rules that are applied in the process of making ABI are that the web server used must be open source and the construction of the DW must use existing software, namely, SQL Server 2012. The choices of open source and the construction of the DW are critical due to the implementation of the ABI. The results are aligned with the study by Ragulan and Subash [18], which states that the Web server used must be open source and the construction of the DW must use existing software

4.5.5 Sub-contractor

In this section, the issues will be focused on the implementation stage that is responsible for developing ISs.

1. Data (what)

   The issue of sub-contractor will focus on the data source analysis. The concern will be on the relationship of entities or objects from the Syspro ERP database and IT infrastructure of the Bedstead Manufacturer. The source of data will be taken from several interconnected servers either locally or in a cloud. The findings from the study conducted by [11] indicate that the primary concerns regarding data are mostly focused on the installation of the linked server architecture.

2. Function (how)

   ABI can be built using PHP and the code igniter framework so that it can be accessed from anywhere and anytime. While the DW can be built using SQL Server 2012, as mentioned by Shmueli et al. [17], the issues related to DW and business intelligence are related with the accessing of data from anywhere and anytime. The scalability is also a main concern due to the volume and variety of the data that available on the server [18].

3. Network (where)

   Based on IT and ISs that exist at the Bedstead Manufacturer, the DW can be built on the main server and with co-location servers, and business intelligence can be realized in the form of cloud. As shown by AWS [11], the DW design will be focused on the main servers most of which will be in the form of cloud.

4. People (who)

   Based on the organizational structure of the company described in Section 3.1, concerning the overview of the company, IT managers are responsible for the construction and creation of DW algorithms and business intelligence. We explored in more detail the result of the study by Brito et al. [14], which mentioned that the assigning of responsibility to each IT staff will be focused on the construction and creation of DW algorithms and business intelligence.

5. Time (when)

   The time for the initial stages of development and making algorithms is determined by IT managers who can understand the capabilities of each member of the division. The initiation of the sub-contractor is critical as well to make sure that the project will run smoothly. Time is also critical since the completion of the sub-contractor will depend on the capability of each member of the division as well [17].

6. Motivation (why)

   This paper examines the security considerations associated with data warehousing and business intelligence, specifically focusing on the limitations imposed on user access privileges. The business intelligence feature must be provided with features to be able to download in excel format. As stated in the source [19], the primary attention of the subcontractor in the context of data warehousing and business intelligence lies in ensuring user-friendliness and addressing security concerns. The format of data will be mainly focused on the type of data itself.

4.5.6 Function enterprise

The user perspective is a viewpoint that represents the tangible embodiment of the results achieved through implementation.

1. Data (what)

   The results of this blueprint if realized are in the form of a DW that can be useful in business intelligence accompanied by a dashboard of reports needed by the Bedstead Manufacturer. The implication of the result on the level of enterprise as shown by Hadhoud and Salameh [19] will provide in-depth understanding on how data play a pivotal role in the bedstead manufacturing.

2. Function (who)

   The business intelligence system based on this blueprint is a web application and can be accessed via the internet. As shown by Ragulan and Subash [18], the DW and business intelligence will provide critical point on deciding the function and value of the level of enterprises.

3. Network (where)

   The DW runs on the main server and business intelligence runs in the cloud. The implications of running on the cloud are advantageous as well as disadvantageous. DW and business intelligence implications on the enterprise scope will be dependent on the network architecture. The report provide by Hadhoud and Salameh [19] shows that the connectivity and transaction on the network will primary focus on the processing of the data.

4. People (who)

   The stakeholder that involves will be mainly from the areas of DW user companies. Those people will be mainly on the IT divisions and business intelligence. The users involved are from top management including account managers, marketing managers, and production managers. As mentioned by AWS [11], the issues related to people will become more critical than that prior to the implementation of DW and business intelligence.

5. Time (when)

   After the development phase, both physically and the algorithm wise, is complete and has received approval from the director, the DW and business intelligence are ready for the Go Live stage. The issues that relate to duration of implementation of functional enterprises will have a crucial impact on the bedstead enterprises. As mentioned in the result of the study by Shmueli et al. [17], the adoption on the level of the enterprise will provide extra effort and time to get the enterprise impact.

6. Motivation (why)

   It is necessary to conduct socialization for business intelligence users and establish the standard operational procedure that applies in the bedstead manufacture. The issues that relate to socialization with standard operational procedure requires focus on the motivation of the stakeholder involved [18]. In the bedstead manufacture, the issues that relate to the standard operational procedure is crucial since the culture of the organization will influence the success of implementation of DW and business intelligence.

5 Conclusion

According to the findings and discussions, the usage of ISs and IT at the Bedstead Manufacturer is currently confined to a "Transaction Processing System" and lacks a "Decision Support System" in decision-making. It was also discovered that IT and ISs must be used in accordance with the Company's vision and mission. The "DW" and "business intelligence" blueprints are anticipated to be used as effectively as possible in supporting the company's vision and goal. This study offers a comprehensive analysis of the contributions made by many areas of planning based on Zachman's framework, including the Business Model, System Model, Technology Model, Sub-Contractor, and Function enterprise.

Furthermore, this research can be used as a consideration in the development of "data warehouse" and "business intelligence," so as to provide solutions for managerial parties in making decisions based on "business intelligence" planned for the company's future progress.

Acknowledgements: We would like to acknowledge the support and facilities given by Binus Graduate Program as well as Advanced Institute of Industry Technology, Tokyo, Japan during the research.

Funding information: The authors state no funding involved.

Author contributions: F.L.G. and R.A.S. have initiated the study, conducted the experiments, and made the first draft of this article. T.M. gave experts' opinions and contributed to the experimental phase. All authors have read and approved the final manuscript.

Conflict of interest: The authors state no conflict of interest.

Data availability statement: The datasets used and/or analyzed during the current study are available from the corresponding author on reasonable request.

References

[1] Aulia A. Development of Data Mining to Know the Pattern of Potential Students in Academic Field at Bina Nusantara University. Jakarta: Binus University; 2014.
[2] Chen H, Chiang R, Storey V Intelligence and Analytics Business: From Big Data to Big Impact. USA: MIS Quarterly, 2012.
[3] Celebic B, Breu R, Felderer M, Haser F, Towards collaborative requirements engineering tool for ERP product customization. Lecture Notes in Information Systems and Organizations, Springer; 2014.
[4] Rahayu A. Utilization of Architecture Application Planning for Manufacturing Information System Design at PT. RH. Binus Press; 2014.
[5] Chou DC, Tripuramallu HB. BI and ERP integration. Inf Manag Comput Sec. 2005;13:340–9.

[6] Bouaziz S, Nabli A, Gargouri F. From Traditional Data Warehouse to Real Time Data Warehouse. Binus Press; 2017. p. 467–477. doi: 10.1007/978-3-319-53480-0_46.
[7] Liang T-P, Turban E, Aronson JE. Decision Support Systems and Intelligent Systems. Yogyakarta: Andi Offset; 2005.
[8] Harianto Y. Analysis and Making of IT Blueprint in Manufacturing Industry (Case Study of PT NLK Indonesia). Jakarta: Binus University; 2016.
[9] Hersanto, Analysis of the Success of Implementing SAP (System Application and Product) based ERP (Enterprise Resource Planning) in Heavy Equipment Dealer Companies Using the Delone and McLean Approach Information System Success Model Framework. Jakarta: Binus University: 2017.
[10] Jhonsons M. Blueprint of IS/IT Strategic Plan in Utilizing E-Learning at USNI University (Universitas Satya Negara Indonesia). Jakarta: Binus University; 2015.
[11] Amazon Web Services (AWS), Data Warehouse Concepts. https://aws.amazon.com/data-warehouse/, accessed August 2022.
[12] Salman. Design of Business Intelligence Systems as Supporters of Decision Making at Amikom Mataram. Jakarta: Binus University; 2016.
[13] (http://datawarehouse4u.info/OLTP-vs-OLAP.html), Accessed on December 12, 2018.
[14] Brito SM, Briegas JJ, Iglesias AI. Creativity for business intelligence. J Develop Educ Psychol. 2019;1:155–63. doi: 10.17060/ijodaep.2019.n1.v1.1401.
[15] Vercellis C. Business Intelligence: Data Mining and Optimization for Decision Making. USA: Wiley; 2009.
[16] Kimball R, Caserta J. The Data Warehouse ETL Toolkit. USA: Wiley; 2014.
[17] Shmueli G, Bruce PC, Gedeck P, Yahav I, Patel NI. Data mining for business analytics concepts. Techniques, and Applications. Hoboken, New Jersey, Amerika: Wiley; 2022.
[18] Ragulan B, Subash R. Designing a data warehouse system for sales and distribution company. Big Data Min Analyt. 2021;1:1–6.
[19] Hadhoud R, Salameh WA. How business intelligence can help you to better understand your customers. Int J Bus Intell Res. 2020;11(1 Jan 2020):50–8.