Data Warehouse System for Multidimensional Analysis of Tuition Fee Level in Higher Education Institutions in Indonesia

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***Abstract*—In this study, we developed a data warehouse (DW) system for tuition-fee-level management for higher education institutions (HEI) in Indonesia. The system was developed to provide sufficient information to the administrators for decision making of tuition fees of applicants by integrating multisource data. A simple but sufficient method was introduced using the open-source following the business requirements of HEI's administrator. As a business intelligence (BI) approach, four procedures are applied e.g., preparation, integration, analysis, and visualization to construct a tuition-fee-level management system. The DW demonstrate four basic dimensions (faculty, year, entrant type, and tuition fee level) in all seven dimensions and three data regarding applicants, tuition fee level, and payment status. Analytical results were tuition fee level trends, top five faculty by applicants, and fees collected from the student trends. Those analysis results were presented in various charts and graphics contained at a dashboard of tuition fee level, which has many functions to provide insight relative to the business performance. The DW system described in this paper can be used as a guideline for tuition-fee-level management for HEIs in Indonesia.**

***Keywords*—Data warehouse; higher education institution; multidimensional analysis; Indonesia; tuition-fee-level management**

I. Introduction

The United Nations' Agenda for Sustainable Development Goals have identified higher education as an integral part of the lifelong learning vision to ensure high-quality education. As the instrument of higher education, higher education institutions (HEI) play an essential role in developing the national capacities of a country by educating students, publicizing research activities, and participating in the development of civil society. However, different countries and HEIs require different strategies to satisfy issues related to the access, affordability, and quality of higher education. Therefore, as in [1] differentiating tuition fees is one way for countries to adjust tuition fees.

In Indonesia, approximately three million high school graduates are competing to obtain one of approximately four hundred thousand regular seats in public HEIs [2]. In 2013, the Integrated Academic Fee (IAF) was introduced by the government to provide more opportunities to qualified citizens from low-income families. This policy implemented variable tuition fees for undergraduate students based on the financial ability of their parents or guardians [3]. To determine the level of tuition fees, HEIs are permitted to formulate parameters, e.g., family information (number of family members and number of children in college), income information (parent income), asset information (home or real estate equity), and monthly family expenses are commonly applied as general parameters. In addition, some techniques and methods to determine tuition fee level have been presented previously [4],[5].

HEIs face problems in managing the financial data after each applicant got their tuition fee level. For example, at Universitas Andalas, a public HEI in Indonesia, even though a web-based application was introduced to determine tuition fees for each applicant, different reports are submitted by university and faculty staff regarding the number of applicants and tuition fee collected at each level. Time is required to generate manual such reports. It is difficult for university staff to distribute students equitably among faculties and study programs when the data are inconsistent. The IAF states that the higher the level, the higher the amount of money paid by the applicants. The faculty is expected to receive as many applicants as possible who have been placed at a higher level of the tuition fee. Without consistent tuition fee data, HEI administrators do not have sufficient information to support financial decision making.

Another problem arises from the fact that the tuition-fee-level decision system functions independently of other information systems, e.g., student registration, payment, and teaching systems. Following student admission, the result of the tuition-fee-level decision system, i.e., the tuition-fee-level data for each applicant, must be migrated to these payment, registration, and teaching systems. IT staff must manage these data migration processes in consideration of the data structure of each faculty's database system. To provide reports, IT staff must raise an individual query for each database of faculty. As a result, the databases are frequently slow or even crash when retrieving reports.

To address these issues, the authors have investigated using open-source software to construct a data warehouse (DW) system, which is considered the backbone tool of a decision support system (DSS). The DW system consolidates various

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data sources from many transactional systems or files, and then stores them in an integrate information data store. The DW system also maintains historical data and provides analytical functionality to realize the users about the situation of their business [6], [7]. In addition, DW systems are considered a core component of business intelligence (BI), which is a general term that describes the analysis of information to improve and optimize business decisions and performance. In the remainder of this paper, as in [8], we use the term DW/BI to reflect the shift of emphasis from the DW being an end in itself to BI. The development of DW/BI in the education sector is very limited compared to other major sectors, e.g., financial services and the medical industry [9]. In [10] confirmed that many areas in the academic institution (e.g., enrollment data, course data, and alumni data) could identify data warehousing efforts and as in [11] described the importance of maintaining institutional strategy that accepts information systems as critical to decision making. In [12] was the first development of a DW in an HEI at Arizona State University in 1992. DW/BI in HEI has primarily been implemented in didactics and research fields [9], [13-15].

This study focuses on multidimensional analytics of the HEI tuition fee level in Indonesia under the IAF policy. Multidimensionally modeled data were designed to facilitate complex analysis and effortless visualization [13]. A data-driven decision approach was applied to enhance the DW system. The major features of a data-driven DSS are accessing and manipulating raw data and creating data displays [16]. These roles are performed by IT experts who know the metadata of the database systems and the tuition-fee-level decision system's workflow.

The goal of this study was to construct a DW system for tuition-fee-level management. A simple but sufficient method was used in this study compared to DW architecture and best practices for DW implementation in education. The proposed DW system was developed using the open-source Pentaho BI software suite, which includes a complete toolset for DW development. Note that the Community Edition of Pentaho was used to reduce the development cost, even if it employs IT experts to manage it.

The results are promising and demonstrate four basic dimensions (faculty, year, entrant type, and tuition fee level) and three data regarding applicants, tuition fee level, and payment status. Seven tuition-fee-level data were analyzed and visualized in charts and tuition-fee-level dashboard. The visualizations are realized via user interaction in the DW system. In addition, the visualization of the results is fast, accurate, and easy to understand.

The remainder of this paper is organized as follows. Section 2 describes work related to DSSs in HEI admission systems and the IAF policy in Indonesia. Section 3 describes the study methodology. Section 4 presents the development of the proposed DW system. Section 5 provides the system output and Section 6 prepares the discussion of multidimensional analysis of tuition fee level. Section 7 present result of this study, Section 8 presents conclusions, and Section 9 suggestions for future work.

II. Related Work

A. DSS in HE Admission System

DSSs for admission or enrollment systems in HEIs have been studied in recent years. As in [17], the knapsack problem approach was introduced to optimize admission exercise in Nigerian institutions. Reference [18] points to the trends in 21st century education and trends in transferring student's curriculum of Thai students in HEI. In [19], the admission process discussed as an academic business process in the SADIA System of a Portuguese university. Reference [20] described a web-based DSS application to improve the efficiency of admission to universities in Saudi Arabia.

Author in [21] studied an intelligent DSS for developing student admission policies based on an enterprise resource planning system. As in [22], a DW for the marketing process in Indonesia's HEIs has been discussed relative to support management in marketing decision making. Here, the primary marketing process was identified to analyze needs in a private university. In addition, DW models and data mining techniques were employed to design a higher education star scheme for analytic tools in 19 subsystems [23].

We found that the available current works do not address the admission system to manage the applicants' classification following the family background paying the student tuition fees.

B. IAF Policy for HEI in Indonesia

Under the Law on Higher Education 12/2012, higher education must set reasonable fees according to the financial qualifications of the students, their parents, or guardians. The IAF (or *Uang Kuliah Tunggal*) is the current admission policy for undergraduate students in public HEIs in Indonesia. Here, integrated means the students pay a fixed amount for education expenses each semester rather than several unit costs, e.g., development cost, number of credit units, and laboratory costs. The fixed tuition fee is derived from the calculation of all education costs in a year for a given study program. An annual regulation of the Ministry of Research and The Higher Education (MRTHE) is issued for the exact number of tuition fee levels at each HEI across the country. In addition to this regulation, the amount of money following on each tuition fee level for a given study program at each HEI was also provided.

The IAF policy determines tuition fees for only two regulars of all three programs in undergraduate entrant type: SNMPTN, and SBMPTN. SNMPTN is national selection based on high school academic reports, national exam scores, and another academic achievement, e.g., finalist at reputable science/sports/arts competitions, to rank qualified applicants relative to their HEI and study program of choice. SBMPTN is a second round of entrance by examination. Applicants who pass the tests of these regular entrance types must undertake a decision system to get their tuition fee level. The final round of HEI entrance is an independent program, which is automatically set to the highest tuition fee level for each study program.

The IAF policy targets 122 HEIs and 6725 study programs [2]. The IAF policy also covers public HEIs managed by the

MRTHE and other ministries, e.g., 58 HEIs are managed by the Ministry of Religious Affairs. The number of designated HEIs typically increases each year following government regulation to take over private HEIs and by extending the scope of HEIs under other ministries. After six years of IAP policy implementation, the national gross enrollment ratio (GER) increased from 29.15% (2014) to 34.58% (2018) [2]. The GER is a measure that compares the number of undergraduate students (diploma and bachelor) with the population aged 19–23 years.

III. Proposed Method

To determine what dimensional data could be obtained from tuition-fee-level data, we examined two approaches, i.e., the three-tier DW architecture [24] and the five-step DW implementation in education [9]. The three-tier approach is the broadest DW conceptual architecture is encapsulated for a development environment and divided into three levels or layers, i.e., bottom, middle, and top tier. We then associated the three-tier approach to the practical method of DW implementation in education. In [9] surveyed data warehousing in education and found five steps as a best practice implementation method are as follows: (1) information needs analysis and requirements analysis, (2) data source and data supply analysis, (3) DW design and multidimensional modeling, (4) extract, transform, and load (ETL) processes, and (5) system, application, reporting, dashboard, and online analytical processing (OLAP) development.

In this study, we formulated four procedures, i.e., preparation, integration, analytics, and visualization. The main motivation for choosing the proposed method is to merge the longer step of best practice and modest conceptual DW architecture, then following the software tools capability. A designated software utilized by a software suite for each procedure, except in the preparation procedure because it is such kind of examination. Fig. 1 shows our method used and how it correlates with three-tier DW architecture and five-step DW implementation in education.

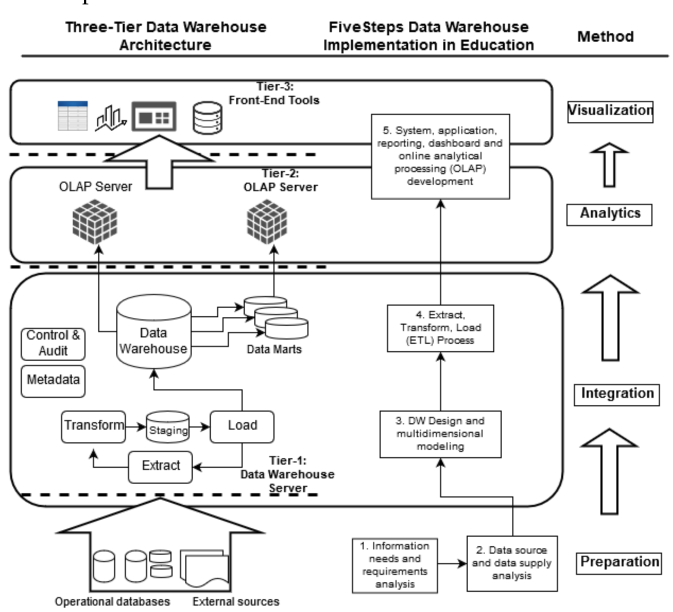

Fig. 1. Proposed Method.

A. Preparation

The preparation procedures capture the first of two steps in the best practice DW implementation in education. Information requirements, sources analysis, DW system stakeholder identification, and goalsetting for each decision can be obtained by field observations, document checking, and regulation. The data-driven approach gives a realistic view of IT experts relative to determining the dimensions of analytics by analyzing data sources (operational databases or external sources) that must be incorporated into a single data repository.

B. Integration

The integration procedure occupies bottom tier of the three-tier DW architecture, which has access to the databases or data storage systems. The integration procedure also involved Steps 3 and 4 of DW implementation in education to design a multidimensional model and ETL processes. Existing data calls extracted from sources are transformed in the staging area and loaded into the DW. As a logical design of the DW, the dimension and fact tables are designed using a star or fact constellation schema. This model allows the DW system to observe the data in n-dimensional aspects.

C. Analytics

In the analytics procedure, an online analytical processing (OLAP) server functions in the middle tier of the DW architecture. OLAP is a common approach to analyzing and differentiating multidimensional data [8]. The aggregation of data is conceptualized in cubes by assigning which dimension tables apply to what fact table and how the fact table is measured. Multidimensional of analytics provided in the drilling-down or drilling-across ways is obtained by querying fact tables. Relative to the five steps of the DW implementation method in education, the analytics procedure corresponds to a part of Step 5 in OLAP development. The OLAP development satisfies the need for user visualization of reports, graphics, and a dashboard.

D. Visualization

Analytics data are automatically provided in many reports and graphics in dashboard. It is clear that the visualization procedure matches the top tier of the DW architecture as frontend tools. This procedure shares the same activities as part of step 5 of the DW implementation method in education on building system, application, reporting, and dashboard. The visualization data are displayed based on user privilege in the tuition-fee-level support system. Here, several actions are provided to further process the visualized data, e.g., conversion to Excel files or saving as images.

IV. System Development

A. Preparation

1) Data and Tools Specifications

The data used for the proposed DW system are for an Indonesian public HEI located in Sumatera Island. As discussed in Section 2.B, the IAF policy is complex and is applied to all public HEI in Indonesia. This HEI has experienced changes in tuition fee levels (five to seven levels) because the MRHTE regulated it five years ago. Data were taken from 15 faculties and 51 study programs over five years of policy implementation.

Furthermore, the data type was categorized as structured data because they data are highly organized and fit in fields and columns. In this study, we considered the software, which offers many toolsets and components that accommodate the four procedures discussed in Section 3. Here, we utilized Pentaho BI Suite Community Edition (CE), which has features in data integration, reporting, OLAP pivot table, and dashboarding [25]. Gartner places Pentaho in the visionary quadrant due to its mature data access, deep data transformation (provided by Pentaho Data Integration [PDI]), and advanced analytic capabilities (through the Data Science Pack). As in [26], Pentaho can integrate structured data from enterprise DWs with unstructured data from social media or IoT sources.

2) Information Requirements and Sources Analysis

When investigating the relevant regulations of the IAF policy, we focused on the probability of attributes changing. For example, the number of faculty (comprising numerous hierarchical study programs), the study program identifier, the number of tuition fee levels, and entrant types have a high possibility to change.

In the stakeholder analysis, we defined three groups engaged in tuition-fee-level management, i.e., HEI administrators, IT staff, and financial staff. The HEI administrators comprise administrators at the university, faculty, and study program levels concerned about tuition fee data of applicants by level and admission type. Note that IT staff engage in all operations of DW management, and the primarily interest of financial staff is an applicant's payment status.

After implementation of the IAF policy, the HEIs' financial decisions are determined based on such a multidimensional model. The primary problems targeted by this study occur at the institution management level (between the university and faculty levels). The following summarizes several example decisions.

- How should tuition fee levels be distributed among faculty?
- Which faculty obtains the highest number of students in each tuition fee level?
- Percentage of each tuition fee level in university or certain faculty.
- Trends of fees collected from students.
- Which one has a significant portion among high-level groups of tuition fee levels (level 5–7) and low-level groups (level 1–4)?

For tuition-fee-level management, the source databases are UKT (*Uang Kuliah Tunggal* – IAF), SIREG (Student Registration), and SIA (Academic/Didactics System). Database selection depends on the information requirements and target decision. Table I shows a data source analysis with correlation to information needs, decision category, and loading frequency.

TABLE I. DATA SOURCE ANALYSIS

Decision Category	Information needs	Data Source	Loading frequency
Accepted applicant data	Applicant distribution among faculty	UKT, SIREG	Twice per year
Tuition Fee Level	Tuition Fee Classification among faculties	UKT, SIREG, SIA	Twice per year
Payment	Tuition Fee Level Distribution of successful payment	SIREG, SIA	Daily in designated period

The data sources for retrieving accepted applicant analysis are integrated from the UKT and SIREG databases. This analysis is performed twice per year following the regular undergraduate admission program, i.e., SNMPTN and SBMPTN. With the accepted applicant analysis, the level of tuition fee analysis can be performed. However, all three databases (i.e., UKT, SIREG, and SIA) must be incorporated to analyze tuition fee level. The SIREG and SIA databases are involved in student payment analysis because SIREG database records the payment with detailed data for each tuition fee level and the SIA database stores the data of student registration in certain semesters. Completing or canceling tuition fee payment indicates the status of student registration in certain semester. Note that student payment analysis is performed daily during the payment period, and the data are recorded in the SIREG database.

After examining all data sources, we decided to integrate all data sources in consideration of tuition-fee-level management and enterprise-scale education analysis, e.g., course systems and student performance.

3) Improvement System

Data-driven approaches to decision making improve information requirement analysis. The preparation procedure is initiated by understanding the relevant regulation, reviewing the HEI business strategy, and gathering experience from IT experts engaged in the implementation of this policy. In this study, we acted as IT experts with knowledge about the workflow for the tuition-fee-level decision system. Thus, as explained in [16], we obtained the benefits of a data-driven approach because we had full access to current database structures.

The goal of this study is identical to BI solutions. The proposed DW system provides not only the integration of multiple information systems into a single repository but also data analysis to facilitate better-informed decision making to achieve an institution's goals. Moreover, the analytics is displayed as a simple graphical user interface that is easy to understand. All features in the proposed DW system are deployed using single open-source software suites that have both technical and financial advantages.

4) System Configuration

The system configuration is shown in Fig. 2. The PDI tool is used to build ETL function from all MySQL-based data sources to a PostgreSQL-based DW. First, data are fed into staging area and then loaded onto warehouse in the form of dimension table and fact table. In the application server, the Mondrian analytics engine uses OLAP schema and *Multidimensional Expressions* (MDX) query to handle requests from client that is performed using a tool called *Pentaho Schema Workbench* (PSW). Pentaho *Business Analytics* (BA) Server, a web container that interacts with Java servlets, responds to all requests from the client that accessed via a web browser. On the top of Pentaho BA server, Saiku and CTools, a set of community-driven plugins are installed to create dashboard, chart, and graphics. Note that users only access the system using a web browser.

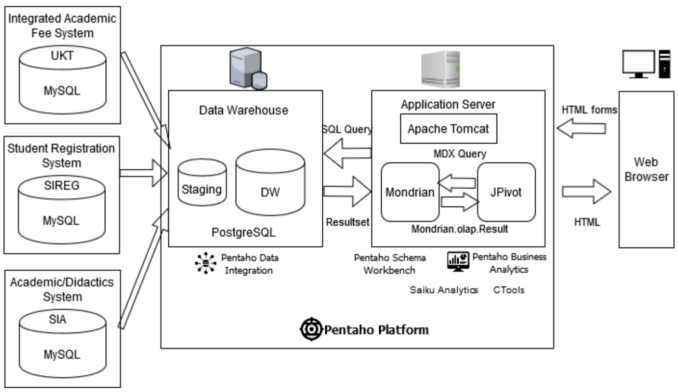

Fig. 2. System Configuration Diagram.

B. Integration

1) DW Schema

The DW system is designed to support all stakeholders in their roles. As a decision support instrument, the DW system is configured according to a top-down approach according to user information requirements. The core of the DW technology is a dimensional design comprising fact and dimensional data [27]. Fact data represent a set of business measurements to analyze, e.g., tuition-fee-level distribution and tuition fee percentage. In contrast, dimensional data represent the context descriptors of the measurements.

We define the basic dimensions used in the tuition fee level DW system as follows.

(1) *Faculty*. This dimension is the structure representing the level of management in HEI. This dimension is organized into a hierarchy of three levels, i.e., university, faculty, and study program. Each level is permitted to aggregate data at a desired level of abstraction. The attributes of the dimension are surrogate key ID (system-generated identifier to distinguish the dimension), study program ID, name of program study, faculty ID, and faculty name. In this dimension table, the faculty ID column is related via parent-child relation with the study program ID column, where the same faculty ID could has several study program IDs.

(2) *PreRegistrationPeriod*. This dimension is the structure for the period of the HEI's entrance type. This period occurs twice per year as two types of HEI's entrant that must determine the tuition fee level. The attributes of this dimension are the surrogate key ID, period ID (existing primary key from source data), year, name (description of the context), and entrant type.

(3) *GroupEntranceType.* This dimension is the structure of the HEI entrant type. As discussed in Section 2.B, only two types of admission (i.e., SNMPTN and SBMPTN) must participate in determining the tuition fee level.

(4) *TuitionFeeClass.* This dimension structures the level of tuition fees in reference to government regulation for each institution. For the case examined in this study, there were data for only seven levels of tuition fee during the five-year implementation of the IAF policy.

These basic dimensions can be used by any cube to define measurements and data aggregation. These dimensions are essential elements in the solution to the defined problem. Note that other supporting dimensions were designed, i.e., *Applicant*, *Date*, and *PaymentStatus* dimensions.

The information requirements shown in Table I have different processes and occur independently. Here, the fact data include *Applicant* data, *Tuition-fee-level* data, and *Payment* data. A denormalized facts constellation is used to relate dimension tables and multiple fact tables. In [24] explained that the facts constellation (also referred to as the galaxy schema) can serve multiple processes and has several shared dimensions. The schema applied in this study is illustrated in Fig. 3.

In this schema, the *Faculty* dimension is shared across all three fact tables, and the *Tuition-fee-level* fact table has six dimensions and two measures, i.e., *paymentAmount* and distinct count of *fk_applicant* derived from the *Applicant* dimension table. Note that all fact tables were designed as fact-less fact tables that tracked the tuition fee level of each applicant because each applicant has only a single tuition fee level. Reference [28] described many activities in educational institution admissions as the condition of events probability that might happen; thus, we employed the fact-less fact table design. The fact constellation schema comprises multiple star schemas; thus, a denormalized table was formed. A primary objective of the dimensional model is simplicity relative to reducing the number of tables and reducing disk consumption. The denormalized facts constellation schema was designed to optimize query efficiency and improve the DW processing speed.

2) Functionality in Integration Process

The integration procedure employs the PDI tool, which includes several functions required to construct the DW system.

a) Database Connection Pool Management

The connection to another database is critical for extracting data from sources and loading data to the target DW. Note that many types of databases with many access types can be utilized in connection pool management. In this study, as the Java-based technology, PDI required a Java Database Connectivity (JDBC) for connection to the MySQL-based data sources and PostgreSQL-based target DW.

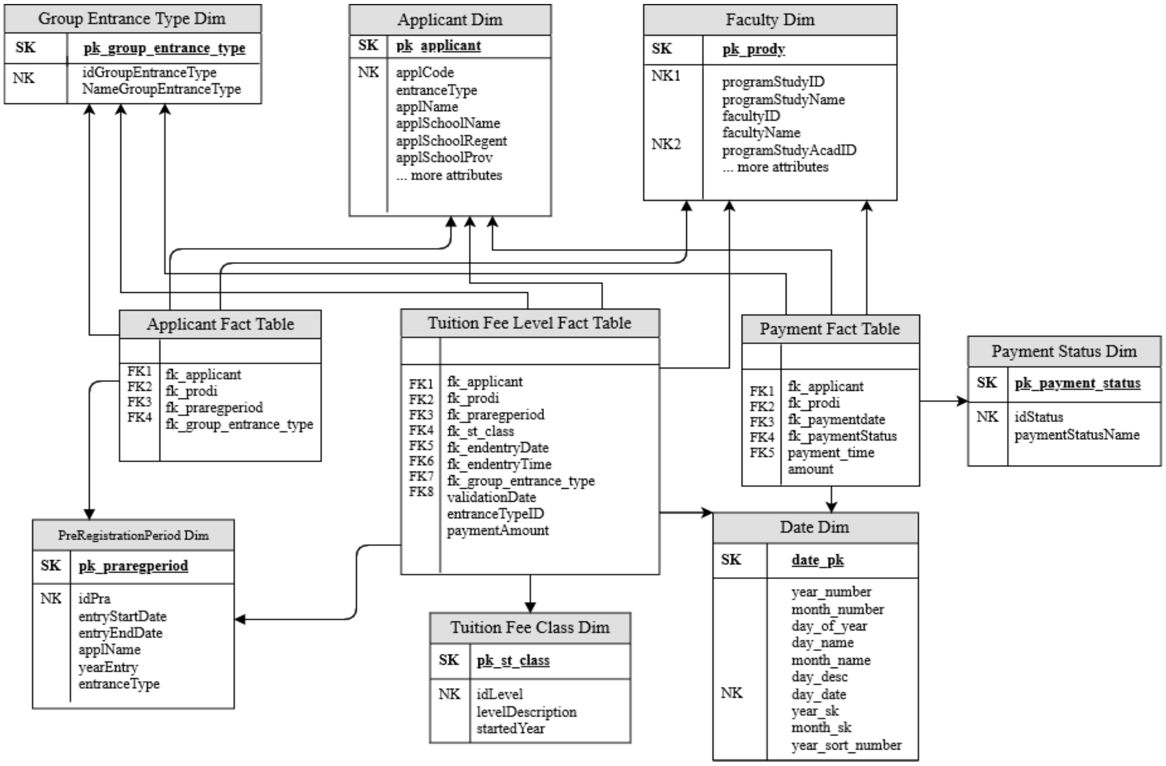

Fig. 3. Denormalized Multidimensional Facts Constellation Schema.

b) ETL Processes

Based on the PDI perspective, several ETL transformation files and a single job file for unifying processes were created. Transformations describe the ETL data flow, e.g., source connection, transforming data, and loading data into the target location. Jobs are used to coordinate ETL activities, e.g., flow definition, dependencies, and query execution preparation [29]. In the proposed DW system, ETL transformation is divided into four processes, i.e., loading data source to the staging area, performing dimension table creation, pre-fact table creation, and fact table creation. Table II shows the results of the ETL processes.

c) Automating ETL Processes

ETL jobs and transformation processes can be scheduled to run automatically at specific times. The Pentaho CE only provides a scheduler method by scripting an executor file using *cron* on a Linux-based server and a task scheduler or *at command* on a Windows-based server. This method needs to call the PDI command as the executer. In this study, the proposed DW system ran on a Windows-based server; therefore, a task scheduler application service was employed.

TABLE II. RESULTS OF ETL PROCESSES

Phase	Type of file	No. of files
Loading data source to the staging area	Transformation	11
Dimension table creation from staging area	Transformation	8
Pre-fact table creation	Transformation	3
Fact table creation	Transformation	3

C. *Analysis of Tuition Fee Level*

In a DW, the data analysis techniques refer to OLAP. OLAP is represented as a cube that stores a summary of corresponding dimension values in multidimensional space. Author in [30] described the data cube can be indexed in various ways, e.g., roll-up, drill down, slice, dice, and pivot. These OLAP operations are efficient ways to access the data cube for multidimensional analysis.

The OLAP cube of tuition-fee-level data is shown in Fig. 4. As a measurement, the number of applicants in the year 2017 is displayed and surrounded by a set of dimensions, i.e., the *Faculty*, *PreRegistrationPeriod*, *GroupEntranceType*, and *Tuition-FeeClass* dimensions. This multidimensional structure stores and distinct intersection values for the tuition fee level.

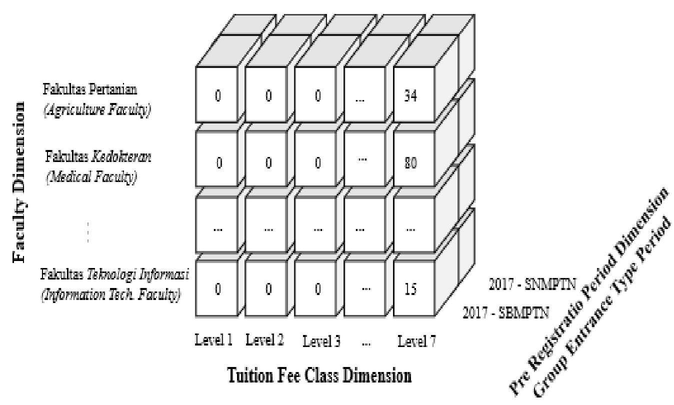

Fig. 4. OLAP Cube of Tuition Fee Level.

TABLE III. PIVOTED TUITION-FEE-LEVEL DATA

	PreRegistrationPeriod	**2017**	
	Group Entrant Type	***SBMPTN***	***SNMPTN***
Faculty	***Level Tuition Fee***	***No. of Participant***	
Agriculture Faculty	Level 1	0	0
	Level 2	0	0
	Level 3	2	3
	…		
	Level 7	34	19
Medical Faculty	Level 1	0	0
	Level 2	0	0
	Level 3	1	0
	…		
	Level 7	80	54
…			
Information Tech. Faculty	Level 1	0	0
	Level 2	0	0
	Level 3	0	0
	…		
	Level 7	6	15

OLAP operations can be applied to view data from different perspectives. For example, roll-up of the year in the *PreRegistrationPeriod* dimension is performed to aggregate or generalize year without counting entrant type data. The drill-down operation shows deep and smaller parts of the dimension, e.g., showing the number of applicants in the industrial engineering program as the lower level of the Engineering Faculty hierarchy in the *Faculty* dimension. The slice operation selects a single dimension, e.g., showing only Level 7 of the *TuitionFeeClass* dimension. An example of the dice operation is the selection of two or more dimensions as a filter/examination of tuition fee data for the Agriculture faculty by entrant type of SBMPTN in the year 2017. In addition, the pivot operation allows us to rotate the data axes of tuition fee level (Table III). With OLAP, analysis can be performed quickly because the data can be pre-calculated and pre-aggregated.

Another analysis can be performed using the MDX language as a written query language that is appropriate for multidimensional databases. To show the rank of faculty with the highest number of applicants in a particular year, the MDX query uses the *Topcount* syntax, and then shows the measurement data and faculty data in columns and rows. As a result, the percentage and trends of tuition fee levels can be analyzed.

D. Visualization

The visualization procedure is available in a web-based client application. As shown in the system configuration diagram (Fig. 2), users can access the DW system using a web browser in HTML format. This allows an easy access to the DW for HEI administrator (university or faculty level) and financial staff. The user logins will show the user console and load individualized result applicable to stakeholder's information requirements.

1) Charts and Graphics

The result of tuition-fee-level analysis is illustrated using many different types of charts. These charts are immediately loaded by querying the script that was deployed from many functionalities of the OLAP cubes. Bar chart, line chart, and pie chart are chosen to represent the report and analysis. The bar chart is usually designed to represent percentages, totals, and count. The graphic of tuition fee by faculty, the top five faculty by applicant, and the trend of fees collected from students are presented in the bar chart. The line chart is used to show the tuition fee level trend by year. Another type of graphic, e.g., stacked area chart, *heatgrid* chart, and metric dot chart, can be chosen with relevance to the data for display.

2) Dashboard

The dashboard represents a user interface for the DW system. The dashboard operates as a graphic container that displays analysis data in a single view. Many analytics and charts can be displayed together on the dashboard as shown in Fig. 5. The dashboard enables convenient multidimensional identification of tuition-fee-level analytics for users.

3) Dashboard Functionality

Dashboard functionality and interactivity are selected as the features of the dashboard. As in [31], the filter or parameters, alert, drill down, and data conversion are included in these features. A parameter is assigned a value from the attributes of the dimensional data to narrow the search as well as to filter and classify the fact data [32]. In the dashboard of the tuition fee level, two parameters are used, i.e., year and entrant type. An alert delivers a quick note monitoring a single event within the dashboard. The design of these charts is also designed to be exported to Excel or PDF formats for further action.

V. SYSTEM OUTPUT

The detailed analytical results are presented in three graphs outlined in red in Fig. 5. The analysis of tuition fees by faculty provides insightful and valid data for HEI administrators.

A. Tuition Fee Level Trends

Tuition Fee Level Trends illustrates the trend in the level of tuition fees from 2015 to 2018. As can be seen, Level 7 increased significantly in the last two years. Level 6 fluctuated over the entire period and declined significantly in 2018 compared to the level in 2017. In this period, Levels 3, 4, and 5 decreased every year, with Level 4 showing the most significant reduction.

B. Top Five Faculty by Applicants

The top five faculties by applicants are presented in bottom middle of Fig. 5. As can be seen, the Engineering Faculty (*Fakultas Teknik*) attracted the greatest number of applicants, i.e., approximately 1600 applicants, over the last five years. The Economics Faculty (*Fakultas Ekonomi*) ranked second with approximately 1250 applicants, followed by Agriculture (*Pertanian*), Law (*Hukum*), and Medical (*Kedokteran*) faculties. The others bar represents an aggregate number of applicants from 10 other faculties.

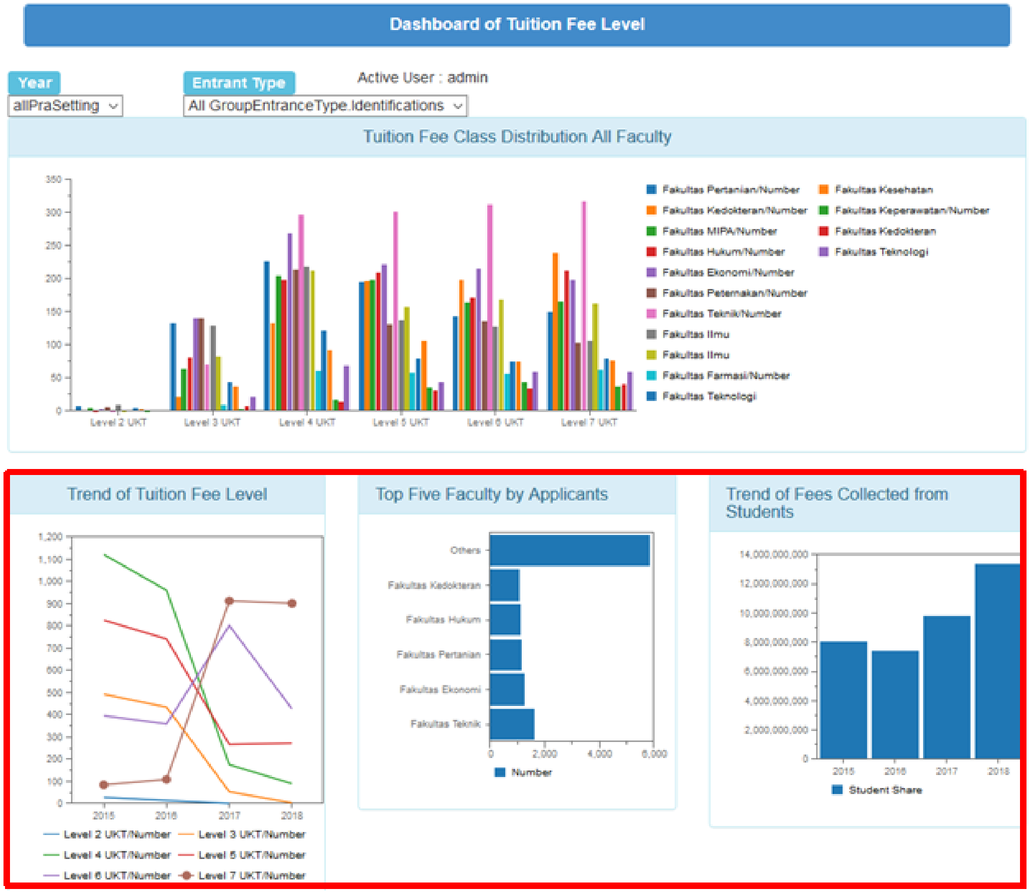

Fig. 5. Dashboard for Tuition Fee Level Management.

C. Fees Collected From The Student Trends

Fees collected from the student trends provides information about the funds collected from the students in HEIs for the years 2016–2018. Over this period, the lowest amount was collected in 2016, i.e., approximately 7 billion Indonesian Rupiah (IDR). The student share increased steadily over the next two years, reaching approximately 13 billion IDR in 2018.

VI. Discussion

The proposed DW system to manage the disparity of tuition fees and decision making based on tuition fee data was evaluated through a systematic analysis of three-tier DW architecture and a five-step method for an educational DW project implementation. In this study, we simplified the five-step method into four procedures, preparation, integration, analytics, and visualization. Based on a case study of a public HEI in Indonesia, the results indicate that DW technology makes multidimensional analysis of tuition fees possible. Multiple queries representing different data perspectives were processed against the same unified data repository. A visual representation of the level of tuition fees among all faculties allows university administrators to better understand the economic characteristics of the applicants to each faculty. The top faculties by applicants reveal the extent to which particular faculties are able to attract applicants and the extent of their financial contribution to the institution (Section 5.B). The trend of student fees over a period of four years was shown in Section 5.C. Financially, HEIs want to obtain higher levels of tuition fees for their financial stability on educational cost.

The configuration of the proposed DW system (Fig. 2) appears to ensure fast and accurate analysis results. First, dividing database functionality into the source (operational database) and the target (staging area and DW) resulted in stable performance. The multidimensional queries were only connected to the DW, were formulated at different aggregation levels, and executed automatically. The system of transactional processes worked for this DW system merely at the designated schedule (Table I). Second, the designed to the hierarchy of study program, faculty, and university level in Faculty dimension. The use of a hierarchical dimension in the DW enabled data to be measured at the desired level.

VII. Result

The analysis resulted in many charts that can be assembled on a dashboard. This feature should enhance a manager's ability to process information and act [33]. The dashboard for tuition-fee-level management (Fig. 5) displays different analyses in various charts and provides insight into tuition-fee-level performance relative to a particular faculties' revenue target. When analysis results reveal positive trends in the previous year for both student share and the number of applicants, administrators should make decisions designed to sustain such trends. Furthermore, when the analysis indicates that many faculties have attracted comparatively fewer applicants, the administration can take various actions, e.g., develop an advertising campaign or special promotion to attract potential candidates.

An improved data-driven decision approach is expected to enhance the development of the proposed DW system. Determining business requirements and performance indicators requires the engagement of IT experts who understand the workflow of tuition-fee-level decisions. IT experts are also required to develop DW functions using the open-source BI tools. In our opinion, the Pentaho CE utilized in this study has a sufficiently comprehensive toolkit as the open-source BI Suite. HEIs must provide an IT expert to manage this software; however, as noted in [15], we believe that this investment in human resources is essential to effectively implement BI tools.

VIII. Conclusion

The multidimensional tuition fee management presented in this paper is part of the admission DSS. For the case in Indonesia, the disparity of tuition fee level, independence of current HEI system, and time consumption in providing reports causes the lack of student-based income data credibility that affects the sustainability of HEIs. The development of DW system offers a way out for having a single source of truth by integrating multisource data following the business requirements of HEI's administrator.

As a BI approach, the DW system supports the aggregation of information at desired levels required by users. A predefined OLAP analysis improves the processing speed that enables safe operational database when retrieving electronic historical data. Analysis results were presented in various charts, graphic, and dashboard of tuition fee level, which has many functions to provide insight relative to the business performance.

IX. Future Work

The DW system described in this paper can be used as a guideline for tuition-fee-level management for HEIs in Indonesia. The government of Indonesia has a strategy to increase the number of public HEIs, and they apply the IAF policy to all public HEIs under all ministries. The proposed DW system does not require an unreasonable amount of effort to implement.

Future research should involve monitoring HEI capacity, the actual paid tuition fees to capture the gap between paid and unpaid payment status, and the gap between collected tuition fees by level and the standard education cost. This study should also be extended to other academic units, such as the teaching process, staff data, and research areas.

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References

[1] Organization for Economic Cooperation and Development. Education at a Glance 2019: OECD Indicators. Paris: OECD Publishing, 2019.

[2] Indonesian Ministry of Righer Education. Higher Educational Statistical Year Book 2018. Jakarta: Pusdatin Iptek Dikti, Setjen, Kemenristekdikti, 2018.

[3] M. N. Y. Utomo, A.E. Permanasari, E. Tungadi, and I. Syamsuddin, "Determining single tuition fee of higher education in Indonesia: a comparative analysis of data mining classification algorithms," 4th International Conference on New Media Studies, Yogyakarta, Indonesia, 2017.

[4] B. Karim, S. Sentinuwo, A. Sambul, "Decision of integrated academic fee for new entrant at Sam Ratulangi University using data mining" (Penentuan besaran uang kuliah tunggal untuk mahasiswa baru di Universitas Sam Ratulangi menggunakan data mining), E-Journal Teknik Informatika Vol 11, No.1, Sam Ratulangi University, Manado, Indonesia, 2017.

[5] Indonesian Ministry of Education and Culture Regulation (No 55. Integrated Academic Cost and Integrated Academic Fee for State High Education Institutions, 2013.

[6] M. Golfarelli and S. Rizzi, "From star schemas to big data: 20 + years of data warehouse research". In: Flesca S., Greco S., Masciari E., Saccà D. (eds) A Comprehensive Guide Through the Italian Database Research Over the Last 25 Years. Studies in Big Data, vol 31. Springer, Cham. pp 93-107, 2017.

[7] V. Rainardi, Building a data warehouse with examples in SQL Server. Berkeley, CA: Apress, New York, 2008.

[8] R. Kimball and M. Ross, The Kimball Group Reader: Relentlessly practical tools for data warehousing and business intelligence. Indianapolis, IN: John Wiley & Sons, 2016.

[9] O. Moscoso-Zea, J. Paredes-Gualtor, and S. Luján-Mora, "A holistic view of data warehousing in education," IEEE Access Volume 6. pp. 64659-64673, 2018.

[10] D. Wierschem, J. McMillen, and R. McBroom, "What academia can gain from building a data warehouse," Educause Quarterly, Vol. 26 No. 1. pp 41-46, 2003.

[11] J. Guan, W. Nunez, and J. F. Welsh, "Institutional strategy and information support: the role of data warehousing in higher education" Campus-Wide Information Systems, Vol. 19 Issue: 5. pp.168-174, 2002.

[12] J. D. Porter and J. J. Rome, "Lessons from a successful data warehouse implementation," Cause/Effect (Winter) . pp. 43-50, 1995.

[13] F. D. Tria, E. Lefons, F. Tangorra, "Academic data warehouse design using a hybrid methodology," Computer Science and Information Systems, Vol. 12, No. 1, pp. 135–160, 2015.

[14] I.M. Aljawarneh, "Design of a data warehouse model for decision support at higher education: A case study," Information Development, Vol. 32, No. 5, pp. 1691–1706, 2016.

[15] B. Scholtz, A. Calitz, and R. Haupt, "A business intelligence framework for sustainability information management in higher education," International Journal of Sustainability in Higher Education, Vol. 19 No. 2, pp 266-290, 2018.

[16] D.J. Power, "Understanding data-driven decision support systems," Information Systems Management, 25:2, pp 149-154, 2007.

[17] H. Bello and A. M. Jingi ,"Admission Decision Support System for Nigerian Universities," International Journal of Computer Application, Vol 181, No.42, pp 35-44, 2019.

[18] L. loywatanawong ,"Decision Support Systems Model for Admission to Higher Education," 2nd IEEE International Conference on Computer and Communication, Chengdu, China, Oct 14-17, 2016.

[19] E. Cardoso, H. Galhardas, and R. Silva, "A decision support system for IST academic information," Informatica (Slovenia) Vol. 27 No. 3, pp 313-323, 2003.

[20] A. Alotaibi, A. Ayesh, and R. Hall, "Managing admission in Saudi universities: a system approach," International Journal of Information and Education Technology, Vol. 6, No. 4, pp 314-321, 2016.

[21] R. Vohra1 and N.N. Das, "Intelligent decision support systems for admission management in higher education institutes," International Journal of Artificial Intelligence And Applications, Vol.2, No.4, pp 63-70, 2011.

[22] Rudy and E. Miranda, "Management report for marketing in higher education based on data warehouse and data mining," International

Journal of Multimedia and Ubiquitous Engineering, Vol. 10, No. 4, pp. 291–302, 2015.

[23] Rudy, E. Miranda, and E. Suryani, “Implementation of datawarehouse, datamining and dashboard for higher education,” Journal of Theoretical and Applied Information Technology, Vol. 64, No. 3, pp. 710–717, 2014.

[24] J. Han, M. Kamber, and J. Pei, Data Mining: Concepts and Techniques (3rd. ed.). San Francisco, CA: Morgan Kaufmann Publishers Inc, 2012.

[25] R. Bouman and J.V. Dongen, Pentaho Solutions: Business Intelligence and Data Warehousing with Pentaho and MySQL. Indianapolis, IN: Wiley Publishing, 2009.

[26] H. Yoshida; https://community.hitachivantara.com/s/article/bridging-the-gap-in-bimodal-it; Oct. 2, 2019.

[27] C. Adamson, Star Schema: The Complete Reference. New York: McGraw-Hill Company, 2010.

[28] R. Kimball and M. Ross, The Data Warehouse Toolkit: The Definitive Guide to Dimensional Modeling, 3rd edition. Indianapolis, IN: John Wiley & Sons Inc, 2013.

[29] Pentaho Doc; https://help.pentaho.com/Documentation/6.0/0J0/0C0/030; Oct. 2, 2019.

[30] S. Chaudhuri and U. Dayal, “An overview of data warehousing and OLAP technology. ACM SIGMOD Record, Vol 26 No.1, pp 65-74, 1997.

[31] N. Rasmussen, C.Y. Chen, and M. Bansal, Business Dashboards; A Visual Catalog for Design and Deployment. Hoboken, NJ: John Wiley & Sons, 2009.

[32] P. Rob and C. Coronel, Database System: Design, Implementation, and Management, 8th ed. Boston: Thomson Learning, 2009.

[33] W. Bremser and W.P. Wagner, “Developing dashboards for performance management. CPA Journal 83, pp 62-67, 2013.