THE DEVELOPMENT OF DATA WAREHOUSE FROM PAYMENT POINT SERVICES OF IT BUSINESS SOLUTION PROVIDER

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Abstract – The goals of the research were to develop a data warehouse loaded from operational database of payment point service in IT business solution provider. The development scope was data analysis using Online Analytical Processing (OLAP) tools for identifying the trends of transaction and agent registration, and created reports and dashboards. The data warehouse was developed with Kimball method as known as the nine-step design methodology. The data and requirement were collected by observation and interview with Chief Technology Officer (CTO). The data warehouse was analyzed by OLAP tool provided by Pentaho Business Analytics software with additional plugin Pivot4J. The results show that the trends of transaction and agent registration between 2014 and 2015. It can be concluded that developed data warehouse can be used as an analysis tool to know the trends information.

Keywords: data warehouse, trend of transaction, agent registration, payment point

I. INTRODUCTION

The research object is an Information Technology (IT) business solution provider company in Jakarta. It is engaged in IT and outsourcing services such as software development, hardware development, and system integration. Its target markets are the financial sector, telecommunications, and government sectors. It has a customer base that includes most of the banking and financial institutions in Indonesia. The businesses focus on payment point services, procurement and the development of an Electronic Data Capture (EDC), Card Management System (CMS), PIN-pad, Public Key Infrastructure (PKI), and a kiosk machine.

The growth of digital and mobile phone era brings changes to the online and real-time payment of bills and purchases. From this growth, the company provides a payment point services that can run multiplatform (PC, Android devices, and EDC) including payment services and purchase services. The provided payment services are bill payment of telephone (Telkom), electricity (PLN), water (PDAM), subscription TV (Indovision and Aora TV), finance installment (Adira Finance), and payment of postpaid balance (Smartfren and Kartu Halo). Meanwhile, the provided purchase services are electric voucher (IM3, Mentari, SimPati, Kartu AS, XL, Axis, Smartfren, Bolt, and Esia), electricity token (PLN), and Orange TV voucher.

IT business solution provider applies the principle of partnership with business entities and individuals. One partner also is called an agent that can have more than one outlet that spreading in different cities. The agent must register first before using the provided service. The number of transaction on payment point services increases in line with the number of the agent. Due to the increasing number of transactions, IT business solution provider requires an update of the historical data that can be viewed from different dimensions especially the trends in transaction and agent registration. However, the data on all activities occurring in the payment point service is stored in the operational database and still can be changed. Thus, the operational database cannot store historical data and cannot provide the information accurately. The information obtained from operational databases cannot be used by IT business solution provider for analysis to know the occurred trend information of transaction and agent registration. Therefore, there is a need for the data warehouse that can store historical data and provide the necessary information for decision making regarding appropriate promotional strategies based on the trends.

The data warehouse stores the historical data from operational database for decision making purposes (Pardillo, Mazón, & Trujillo, 2010). The data warehouse has distinguished characteristics from the operational database. The data warehouse contains a collection of data that is subject oriented, integrated, time variant, and non-volatile (Abai, Yahaya, & Deraman, 2013). The data warehouse using data models based on multidimensional data model is known as a data cube. The data cube allows the data to be modeled and viewed in multiple dimensions. The data warehouse schema has two types of elements, namely facts and dimensions (Mohammed, 2014). The fact and dimension have the table called as the fact table and dimension table. The fact table contains data about a specific topic that is usually associated with a numerical value (measurable) which is known as a measure. Meanwhile, the dimension table contains data about an entity's perspective.

The tool of the data warehouse is Online Analytical Processing (OLAP). It can be used to analyze the data and provide information that is built on the multidimensional data model (Paskarina & Ayub, 2010). OLAP can be used to analyze the data with many operations, such as roll up, drill down, slice, dice, and pivot. Roll up operation is used to view the data as a whole through data clustering. Drill down operation is to describe the data in more detail so that the obtained information becomes more detailed. Then, slice operation is for dividing data to a certain dimension so that it can focus on the desired perspective. Dice operation is to divide data into two or more dimensions so can focus on the perspective in three-dimensional form. Last, pivot operation rotates the data so that it can provide an alternative data presentation (Paskarina & Ayub, 2010).

Moreover, the implementation of the data warehouse can be done in various fields and has the benefit for the company. For example, the data warehouse developed at the Department of Health in PT Ateja Multi Industri (Paskarina & Ayub, 2010) can produce the needed health information for decision making in the improvement of employee health services, employee health insurance, quota monitoring, and monitoring the health and performance of employees within a department. Then, with the establishment of a data warehouse at Cemerlang Skin Care, it makes the scattered data in various branches integrated and in a more compact form. Thus, the executive can analyze and make decisions more quickly (Darudiato, 2010). According to Oktavia (2011), the data warehouse designed in PT Atlas Transindo Raya helps the executive in the analysis of the report generated by various dimensions and is used as a tool to analyze the trends or tendencies that are currently underway for the company's service delivery through the dashboard.

Furthermore, the data warehouse designed for Farhrenheit Manufacturing Systems by Widianty (2015) can be used by the company in analyzing production cost. It is by comparing the result, production deviation, most resource, allocation, and monitoring stock of raw materials, packing materials, and finished goods.

The data warehouse does not only bring the benefit for the company, but also for the educational and government area. For example, Prihatin (2013) agreed that the data warehouses in Politeknik Negeri Lhokseumawe could be used by the management to look at the trends in the admission of new students and serve as a means of decision making. Then, the data warehouse developed in Faculty of Information Technology of Budi Luhur University by Mulyati, Amini, and Juliasari (2014) can be used by the management as a decision making tool for university and evaluation for lecturers to improve their future performance. Moreover, the data warehouse designed in STMIK Kadiri helps the management to use the academic data and into the information which is required to fill accreditation forms based on various required dimensions (Fadilah, Winarno, & Amborowati, 2016).

In the government area, the data warehouse in China's police intelligence decision system helps the policeman to explore the dynamic crime trends and characteristics from the integrated heterogeneous data sources. It is to help them making the correct judgments (Shen, Liu, Chen, & Wang, 2012). Otherwise, the modelling of data warehouse on food distribution center and reserves in the ministry of agriculture of Indonesia can facilitate monitoring food price in consumers and producers. It is based on different view by simplifying and tracking the flow of distribution between regions. Moreover, it can analyze the fluctuations of food price using historical data (Putra, Fifilia, Christian, & Sudarma, 2015).

From the research that has been mentioned, the implementation of the data warehouse is capable of storing historical data and bringing benefits. It displays the necessary information for making business decisions and can be used to view the trends. The development of the data warehouse is expected to help IT business solution provider in analyzing occurred trends of transaction and agent registration from different dimensions. Thus, it can make appropriate decisions regarding promotional strategies for the payment point services.

II. METHODS

The basis of this research on payment point services of IT business solution provider is originated from the problems formulated into a solution of the existing problems. The formulation of this problem is supported by data collection and the observation and interview with Chief Technology Officer (CTO). Once the data are collected, IT business solution provider finds that it is difficult to know the trends of the transaction and the agent registration based on the transaction history of the payment point services. Therefore, IT business solution provider needs a data warehouse that can store the historical data and provide the necessary information for decision-making in promotional strategies for payment point services.

The data warehouse development is done by using a nine-step design methodology (Kimball & Ross, 2015) and Pentaho software. Furthermore, OLAP is used to analyze the data according to the needs of IT business solution provider and create the reports and dashboards to help IT business solution provider in viewing the trends and making an appropriate decision regarding promotional strategies. The research framework can be seen in Figure 1.
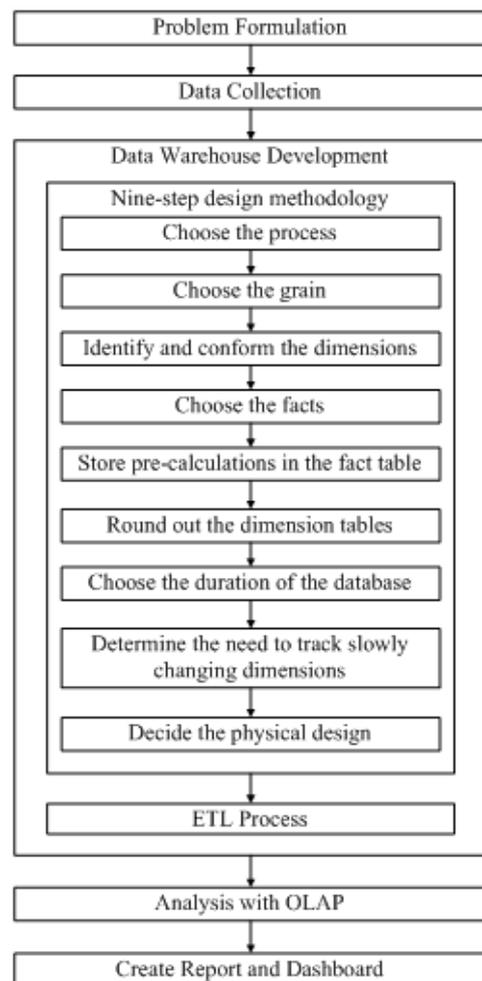

Figure 1 Research Framework

III. RESULTS AND DISCUSSIONS

Data warehouse is developed with Kimball's method or nine-step design methodology. First is choosing the process. The selected process refers to the subject matter of the business process in payment point services of IT business solution provider. There are two business processes that will be used in the development of data warehouse. The first processes are agent registration. The agent registration is carried out before the partner can use the provided services in payment point. IT business solution provider requires agent registration information such as the trend including the number of agent registration based on the location and specific time. Then, the second processes are the transaction. After the registration has been processed, agents can use payment point services. In here, IT business solution provider requires transaction information such as the trend including the number of transactions based on the biller type, product, location, platform, transaction hours, and specific time.

Second is choosing the grain. The selection of grain means determining what is represented on a record in the fact table. Grains are divided into two business processes. The first processes are one line per agent registration that stores the history of time and agent location. Then, the second processes are one line per transaction that stores the history of time, transaction hours, biller type, product, location, and platform.

Third is identifying and confirming the dimensions. The dimensions are selected according to the needs of the data warehouse for payment point service. Dimensions are required for each business process. The first business process is agent registration consisting of date (dim_date table) and agent location dimension (dim_agent table). The second is the transaction. It consists of date (dim_date table), transaction hours (dim_time table), biller type (dim_biller table), product (dim_product table), and location and platform dimension (dim_terminal table).

Fourth is to choose the facts. It requires fact tables for agent registration and transaction processes. The first processes are called as fact_agent_registration. It has three attributes, namely id_dim_date, id_dim_agent, and qty (measure). The second processes are called as fact_transaction. It has five attributes. Those are id_dim_date, id_dim_time, id_dim_biller, id_dim_product, id_dim_terminal, and qty (measure).

Fifth is to store pre-calculations in the fact table. However, there is no need to store pre-calculations in the fact table. Sixth is to round out the dimension tables. The description of the attributes of the dimension tables is added at this stage. It is shown in Table 1.

Seventh is choosing the duration of the database. The selection of the duration of the database matches the needs of required historical information by IT business solution provider. The duration of the selected database is the previous two years (2014-2015). The database is adjusted to the operational database (PostgreSQL).

Eighthis to determine the need to track slowly changing dimensions. The need to track changes in the dimensions also called as slowly changing dimension should be determined for the changes of dimension attribute that can happen over the time. The handlings of slowly changing for each dimension are divided into two types. Type 1 is the first dimension. It will overwrite the changed dimension attributes. Three dimensions use this type, namely date dimension (dim_date table), transaction hours dimension

(dim_time table), and biller type dimension (dim_biller table). Meanwhile, type 2 is the second dimension. It will create a new record in the dimension table if there is a change in dimension attributes and history data will be stored with a different primary key. Agent location dimension (dim_agent table), product dimension (dim_product table), location and platform dimension (dim_terminal table) use this type.

Last is deciding the physical design. At this stage, administrative, backup, and security of the data warehouse are not discussed. It is because the scope of this research is limited to the development of the data warehouse that can be used to help IT business solution provider in knowing the trend.

Based on the results of the data warehouse designed with nine-step design methodology, it obtains two-star schemas. Those are illustrated in Figure 2 and Figure 3. This can be combined to be the fact constellation schema in Figure 4.

Table 1 Attributes of Dimension Tables

| Dimension Table	Attributes	Data Type
dim_date	id_dim_date	Varchar (8)
	full_date	Date
	day_in_month	Int
	week_in_month	Varchar (7)
	month	Int
	month_name	Varchar (10)
	quarter	Varchar (2)
	year	Int
dim_time	id_dim_time	Varchar (2)
	range_of_time	Varchar (13)
dim_agent	id_dim_agent	Int
	cifno	Varchar (15)
	city	Varchar (30)
	region	Varchar (30)
	country	Varchar (30)
	valid_from	timestamp
	valid_to	timestamp
	version	Int
	current	Boolean
dim_biller	id_dim_biller	Serial
	biller_id	Int
	biller	Varchar (50)
dim_product	id_dim_product	Serial
	product_id	Int
	product	Varchar (30)
	brand	Varchar (50)
	valid_from	timestamp
	valid_to	timestamp
	version	Int
	current	Boolean
dim_terminal	id_dim_terminal	Serial
	tid	Varchar (8)
	terminal_type	Varchar (20)
	city	Varchar (30)
	region	Varchar (30)
	country	Varchar (30)
	valid_from	timestamp
	valid_to	timestamp
	version	Int
	current	Boolean
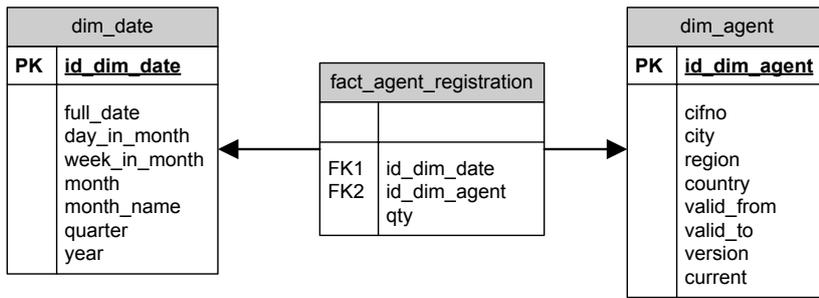
Figure 2 Agent Registration Star Schema
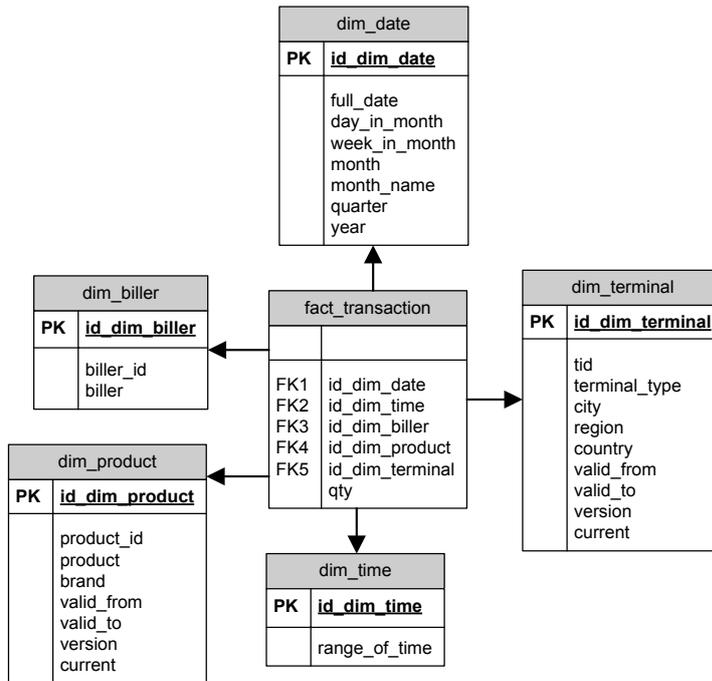
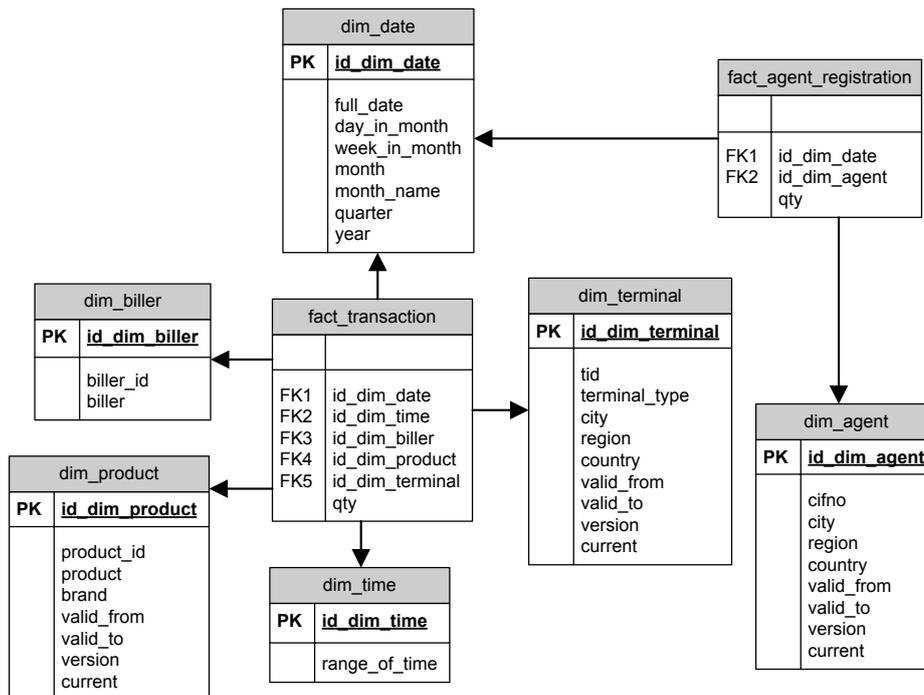Figure 3 Transaction Star Schema

Figure 4 Fact Constellation Schema

Moreover, the data warehouse integrates the data from multiple sources of diverse information and transforms it into a multidimensional representation for decision support applications (Gahlot & Yadav, 2014). Therefore, it is necessary to do Extract, Transform, and Load (ETL) in building a data warehouse (El-Sappagh, Hendawi, & El Bastawissy, 2011). The first step in building a data warehouse is to extract the data from multiple data sources to be used in the data warehouse. After the data extraction process is done, the next step is transforming the data. This process involves the transformation of data in the data cleansing process to obtain the accurate, correct, complete, consistent, and unambiguous data. According to Prihatin (2013), the data transformation process is done by combining the data coming from the different source. The final step of the ETL process is loading the data that has been extracted and transformed into the dimension tables and fact tables in the data warehouse.

ETL processes aim to load the necessary data from the operational database into the data warehouse. The operational database and data warehouse use PostgreSQL. The ETL process is performed using Pentaho Data Integration (PDI) software because it can be used to perform ETL processes in various types of databases. One of those is PostgreSQL.

Figure 5 shows all ETL processes. The processes are done to load the necessary data into each of the dimension tables. After all the necessary data are loaded into the dimension tables, the data containing measure and foreign key connected to the primary key in the related dimension tables are loaded into the fact table. Then, Figure 6 to Figure 11 show the ETL processes for each dimension tables. Meanwhile, Figure 12 and Figure 13 show the ETL processes for each fact tables.
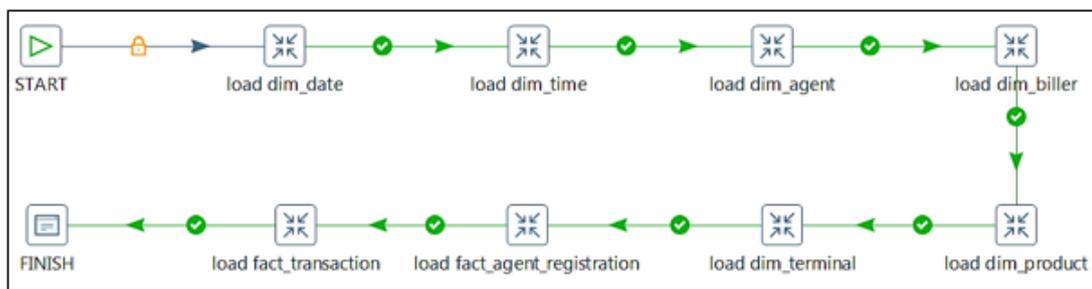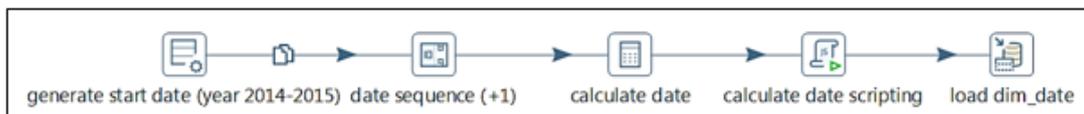

Figure 5 ETL Processes

Figure 6 ETL Process for Dim_Date

Figure 7 ETL Process for Dim_Time

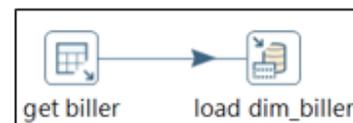Figure 8 ETL Process for Dim_Agent

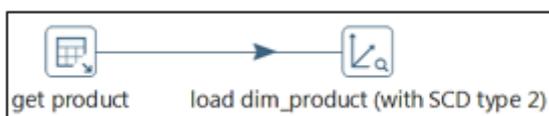Figure 9 ETL Process for Dim_Biller

Figure 10 ETL Process for Dim_Product

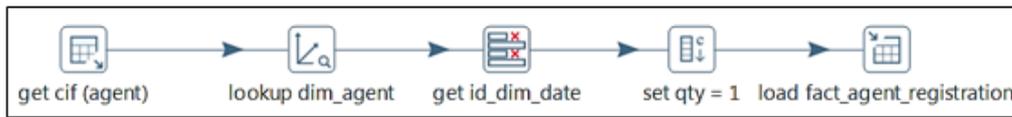Figure 11 ETL Process for Dim_Terminal

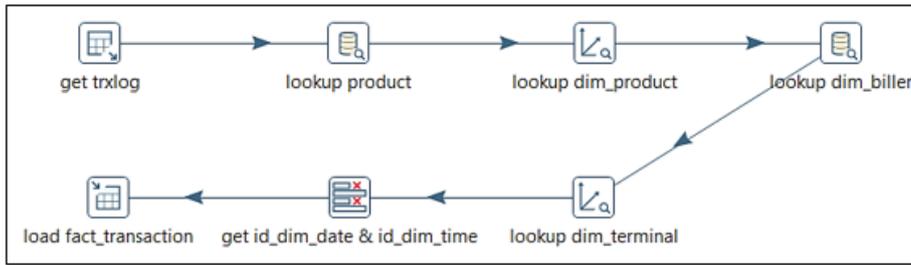Figure 12 ETL Process for Fact_Agent_Registration

Figure 13 ETL Process for Fact_Transaction

After the ETL processes are performed as described previously, the historical data are stored in the data warehouse. It is used for the analysis to know the trends information of agent registration and transaction in the payment point service. The analysis is performed using OLAP tool. It is provided by Pentaho Business Analytics software with additional plugin Pivot4J.

Before the data warehouse can be used for analysis using OLAP tool, it needs to create the data warehouse schema that describes the relationship between the dimension tables and the fact table and the used measure. The schemas are designed using Pentaho Schema Workbench (PSW). Those can be seen in Figure 14 and Figure 15.

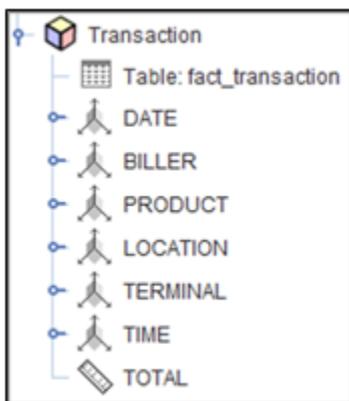Figure 14 Agent Registration Schema

Figure 15 Transaction Schema

The first schema is agent registration analysis result with OLAP. The trend analysis for the agent registration includes the number of registration. This is based on the

location and the agent location in 2014 and 2015. It uses agent registration cube. Furthermore, Figure 16 shows the examples of the analysis presented by the plugin Pivot4J on Pentaho Business Analytics.

The arrow icon in Figure 16 can be used to perform OLAP drill down and roll up operations. From the analysis with OLAP, it can be obtained that the number of registrations decreases significantly from the first quarter of 2015 to the second quarter, and through the fourth quarter of 2015. It is shown in Figure 17. Then, Figure 18 shows that Jakarta becomes the most common location of agent registration in 2014 and 2015.

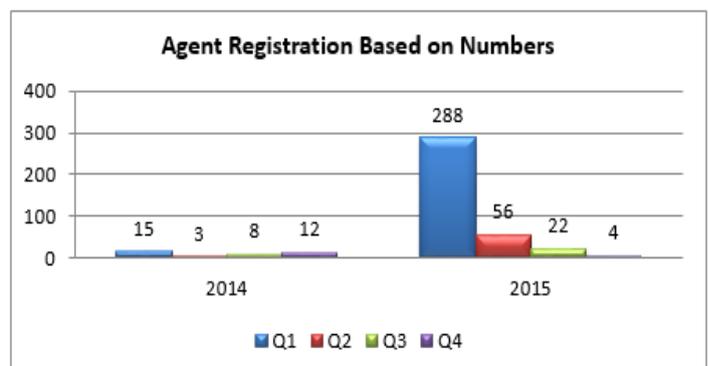Figure 16 Agent Registration Analysis with OLAP

Figure 17 Agent Registration Trend Based on Numbers

The second schema is transaction analysis result with OLAP. The trend analysis for the transaction includes the number of the transaction. It is based on biller type, product, location, platform, and the transaction time flows in 2014

and 2015. It uses transaction cube. Figure 19 and Figure 20 show the examples of the transaction analysis presented by the plugin Pivot4J on Pentaho Business Analytics. Meanwhile, Figure 21 to Figure 26 are the trends of the transaction based on the analysis result with OLAP.

Figure 21 shows that the number of transactions increased in 2015, and they go up and down for each quarter.

Meanwhile, Figure 22 shows the trend of transaction based on biller type. It can be concluded that Telkom as the most common biller type in 2014, and E-Voucher as the most common biller type in 2015. Then, Figure 23 shows the trend of transaction based on product for E-Voucher biller. It can be concluded that SimPati and XL are two top brands for E-Voucher biller in 2014 and 2015.
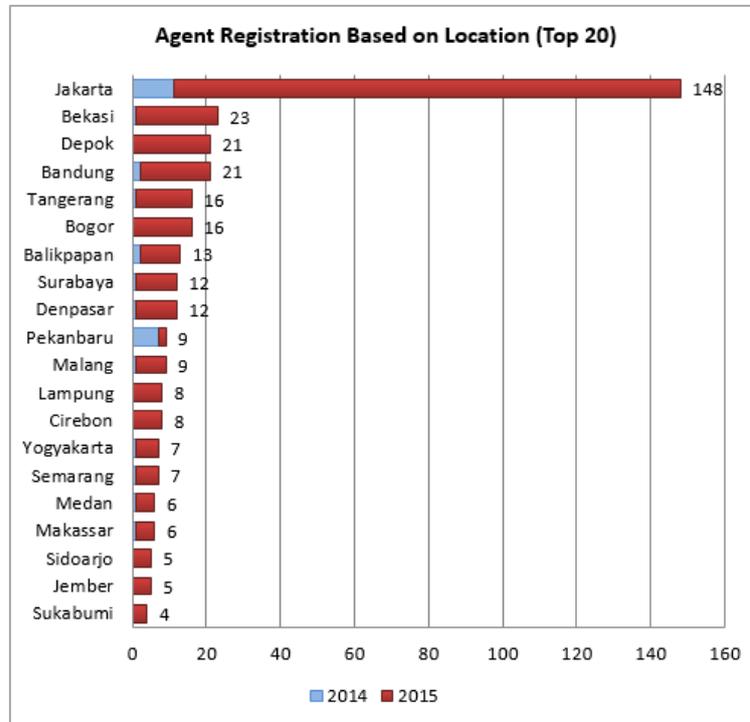

Figure 18 Agent Registration Trend Based on Location

DATE	TIME		BILLER
			ALL BILLERS
			Measures
(All)	(All)	HOUR	TOTAL
ALL DATES	ALL TIMES	00:00 – 00:59	119
		01:00 – 01:59	62
		02:00 – 02:59	39
		03:00 – 03:59	65
		04:00 – 04:59	66
		05:00 – 05:59	206
		06:00 – 06:59	455
		07:00 – 07:59	996
		08:00 – 08:59	1,567
		09:00 – 09:59	2,125
		10:00 – 10:59	2,086
		11:00 – 11:59	1,704
		12:00 – 12:59	1,441
		13:00 – 13:59	1,432
		14:00 – 14:59	1,554
		15:00 – 15:59	1,499
		16:00 – 16:59	1,607
		17:00 – 17:59	1,323
		18:00 – 18:59	1,197
		19:00 – 19:59	1,388
		20:00 – 20:59	1,125
		21:00 – 21:59	919
		22:00 – 22:59	719
		23:00 – 23:59	278
		Total	23,972

Figure 19 Transaction Analysis with OLAP (Example 1)

	BILLER	PRODUCT	LOCATION	DATE		
				ALL DATES		Total
				2014	2015	
				TERMINAL	TERMINAL	
				ALL TERMINALS	ALL TERMINALS	
	BILLER	PRODUCT	LOCATION	Measures	Measures	Measures
(All)	BILLER	(All)	(All)	TOTAL	TOTAL	TOTAL
ALL BILLERS	ADIRA FINANCE	ALL PRODUCTS	ALL LOCATIONS	2	18	20
	AORA TV	ALL PRODUCTS	ALL LOCATIONS	1		1
	E-VOUCHER	ALL PRODUCTS	ALL LOCATIONS	221	15,138	15,359
	INDOVISION	ALL PRODUCTS	ALL LOCATIONS	5	42	47
	ORANGE TV	ALL PRODUCTS	ALL LOCATIONS	6	1	7
	PDAM	ALL PRODUCTS	ALL LOCATIONS	9	75	84
	PLN NON TAGIHAN LISTRIK	ALL PRODUCTS	ALL LOCATIONS	3	2	5
	PLN PASCA BAYAR	ALL PRODUCTS	ALL LOCATIONS	1	1,254	1,255
	PLN PRA BAYAR	ALL PRODUCTS	ALL LOCATIONS	1	1,068	1,069
	SMARTFREN POSTPAID	ALL PRODUCTS	ALL LOCATIONS	2	3	5
	TELKOM	ALL PRODUCTS	ALL LOCATIONS	2,494	2,446	4,940
	TELKOMSEL KARTU HALO	ALL PRODUCTS	ALL LOCATIONS	15	1,165	1,180
			Total	2,760	21,212	23,972

Figure 20 Transaction Analysis with OLAP (Example 2)
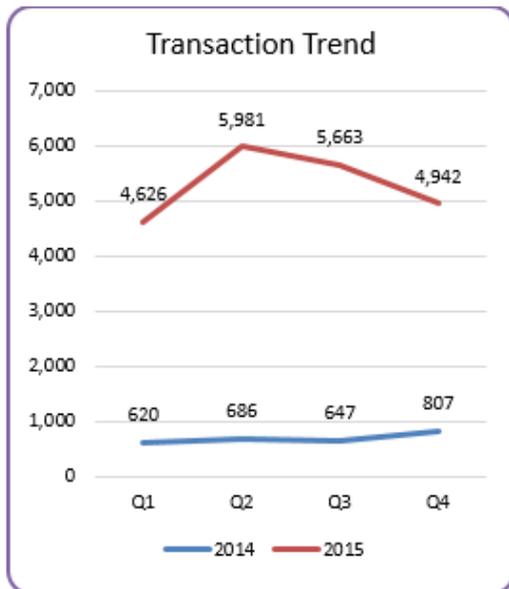

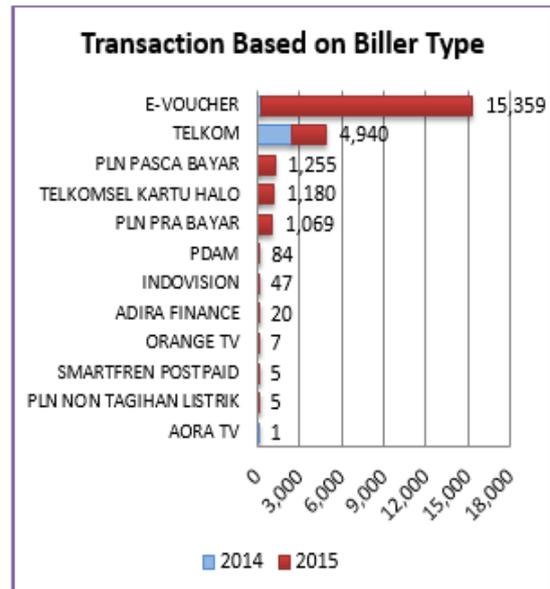Figure 21 Transaction Trend

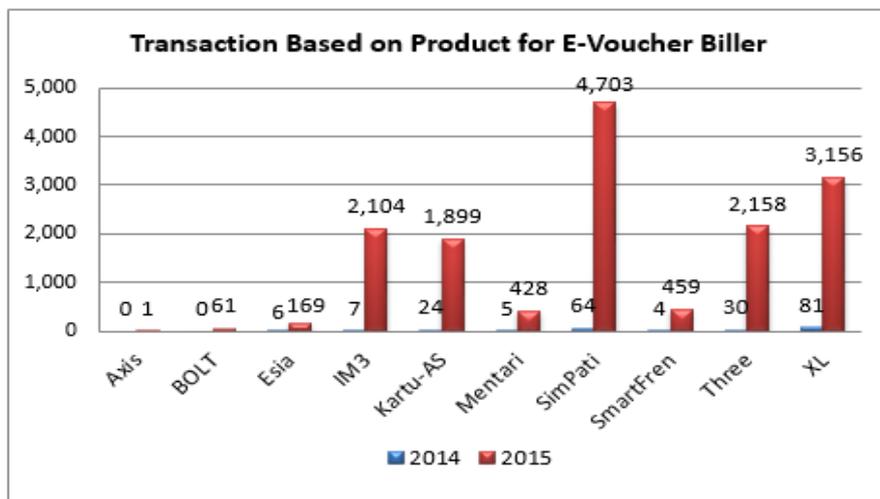Figure 22 Transaction Trend Based on Biller Type

Figure 23 Transaction Trend Based on Product for E-Voucher Biller

Figure 24 shows the trend of transaction based on platform. It shows that user most highly interested do any transactions using PC platform in the first quarter (Q1) of 2014, while using Android platform became more interested from the second quarter (Q2) of 2014.

Figure 25 shows the trend transaction based on location. It shows that Jakarta is the most common location of transaction in 2014, and followed by Bandung, Yogyakarta, and Surabaya. In 2015, Jakarta is still the most common location of transaction. Then, it is followed by Balikpapan, Tangerang, Bogor, and Bekasi. Moreover, Figure 26 shows the trend of transaction based on time. It can be seen for overall, a few of transactions happen from 00:00 to 04:59. The number of transactions increases from 05:00. The time span at 09:00 to 09:59 is when transaction most happens. The number of transactions decreases from 10:00 to 13:59, 16:00 to 18:59 and 19:00 to 23:59.

The reports are created using Pentaho Report Designer (PRD) and presented in the PDF format. The agent registration report is created to provide a monthly report and shows the trend based on the location. Figure 27 shows the example of agent registration report. Meanwhile, the transaction report is created to give a monthly report containing the number of transactions and the trend. Figure 28 shows the example of transaction report.

Then, the dashboards are created using Pentaho Community Dashboard Editor. The creation of the dashboards aims to help IT business solution provider in making promotional strategies decisions based on the actual trends. It is in the context of the number of agent registration and transaction.

Moreover, the agent registration dashboard provides a dynamic visual representation of the ratio of the number of agent registration for each quarter in the selected year and top ten locations. Figure 29 shows the example of the agent registration. It shows the selected year is 2015 and the second quartal (Q2). The bar chart in the top ten locations (cities) panel can show the information about top ten most common locations of agent registration in the second quartal of 2015.

Meanwhile, the transaction dashboard is a dynamic visual representation of the several ratios. Those are the ratio of the number of transaction for each quarter in the selected year, a number of transactions based on the platform used, top ten locations, top five billers, top ten products, and the transaction time flow. Figure 30 shows the example of transaction dashboard when the selected year is 2015 in the third quartal (Q3). Then, the dashboard can dynamically update the number of transactions for each panel in this dashboard based on the data in third quartal in 2015.
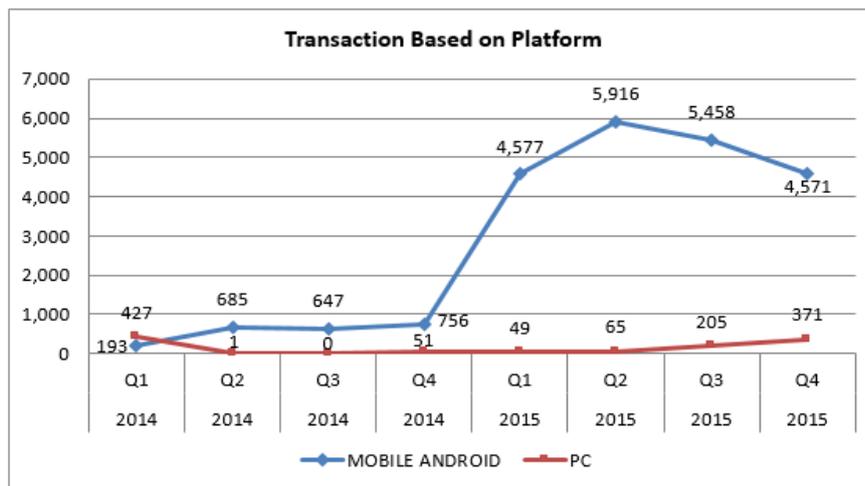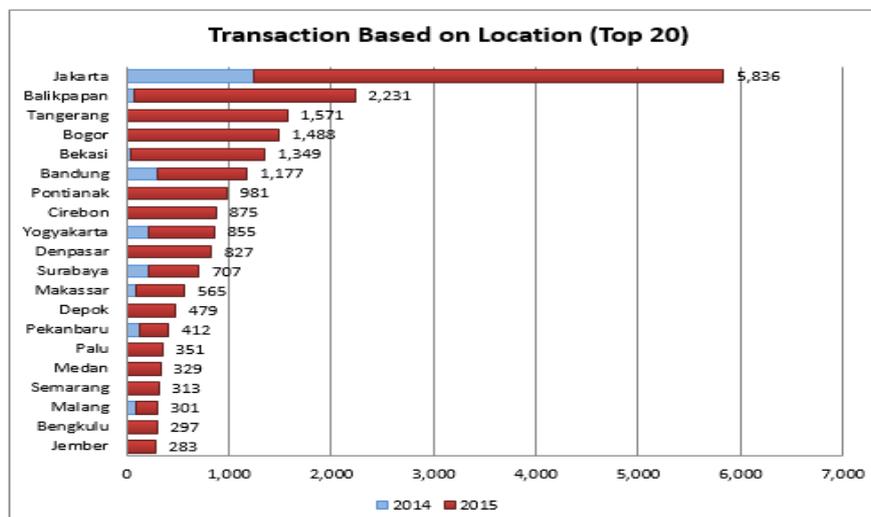

Figure 24 Transaction Trend Based on Platform

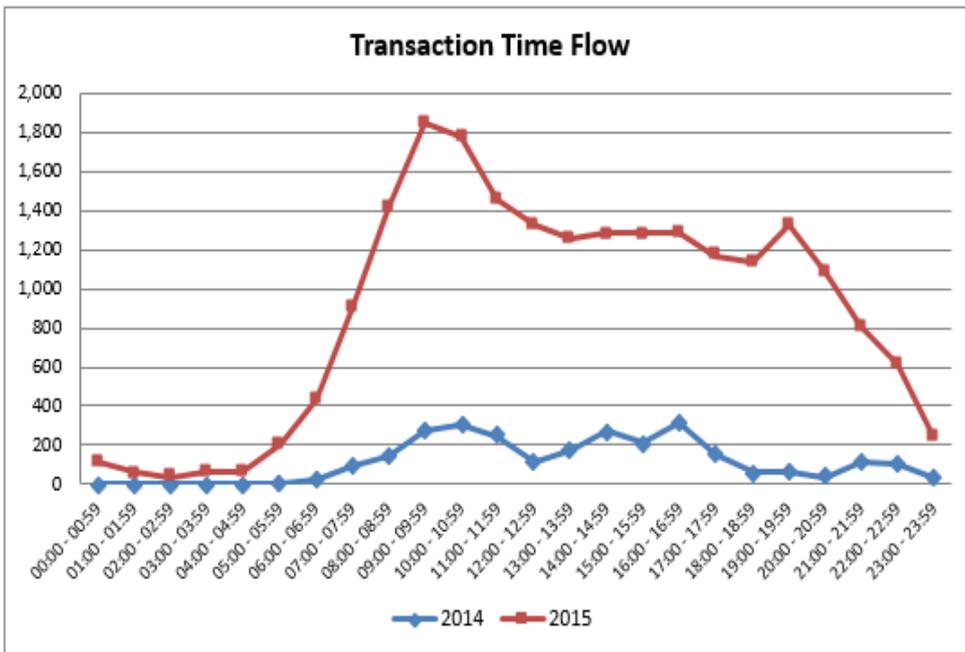Figure 25 Transaction Trend Based on Location

Figure 26 Transaction Time Flow

AGENT REGISTRATION

Year : 2015   **Month : June**

CITY	TOTAL
Jakarta	5
Manado	3
Palu	2
Bekasi	1
Depok	1
Lampung	1
TOTAL REGISTRATION	**13**
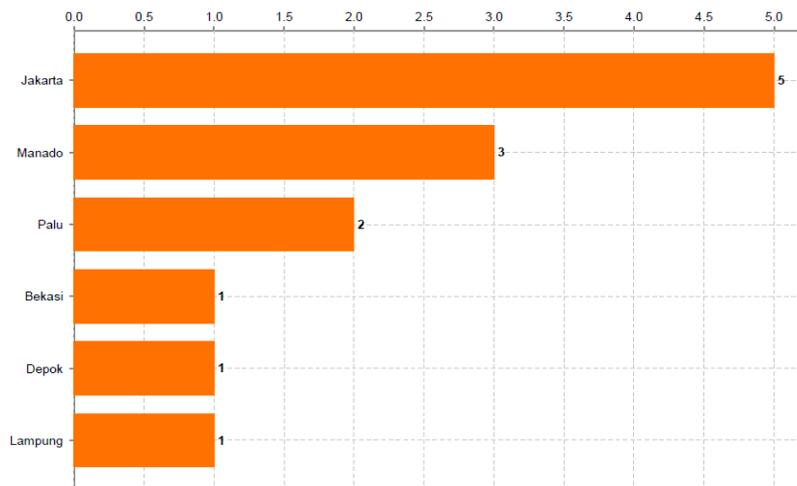
Figure 27 Example of Agent Registration Report

TRANSACTION

Year : 2015   **Month : April**

City : Bekasi

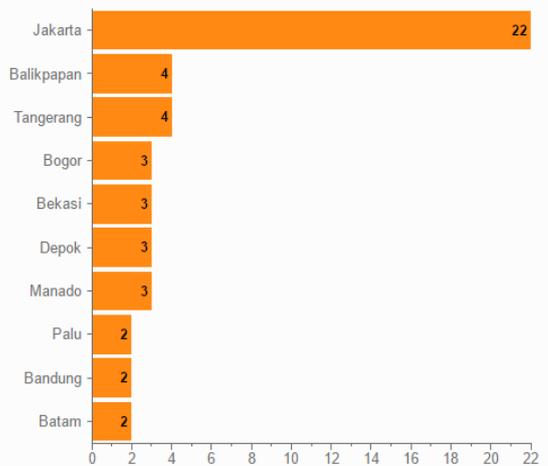| BILLER	TOTAL
E-VOUCHER	59
PLN PRA BAYAR	13
TELKOM	3
PLN PASCA BAYAR	2
INDOVISION	1
TELKOMSEL KARTU HALO	1
TOTAL TRANSACTION	**79**
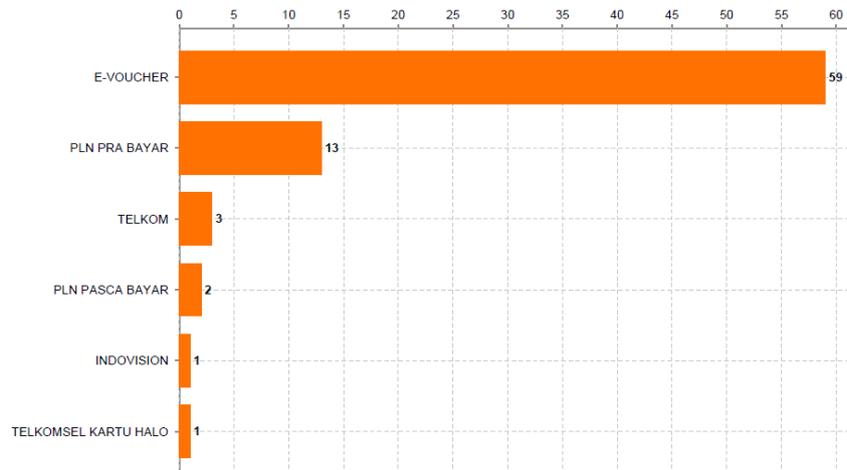
Figure 28 Example of Transaction Report

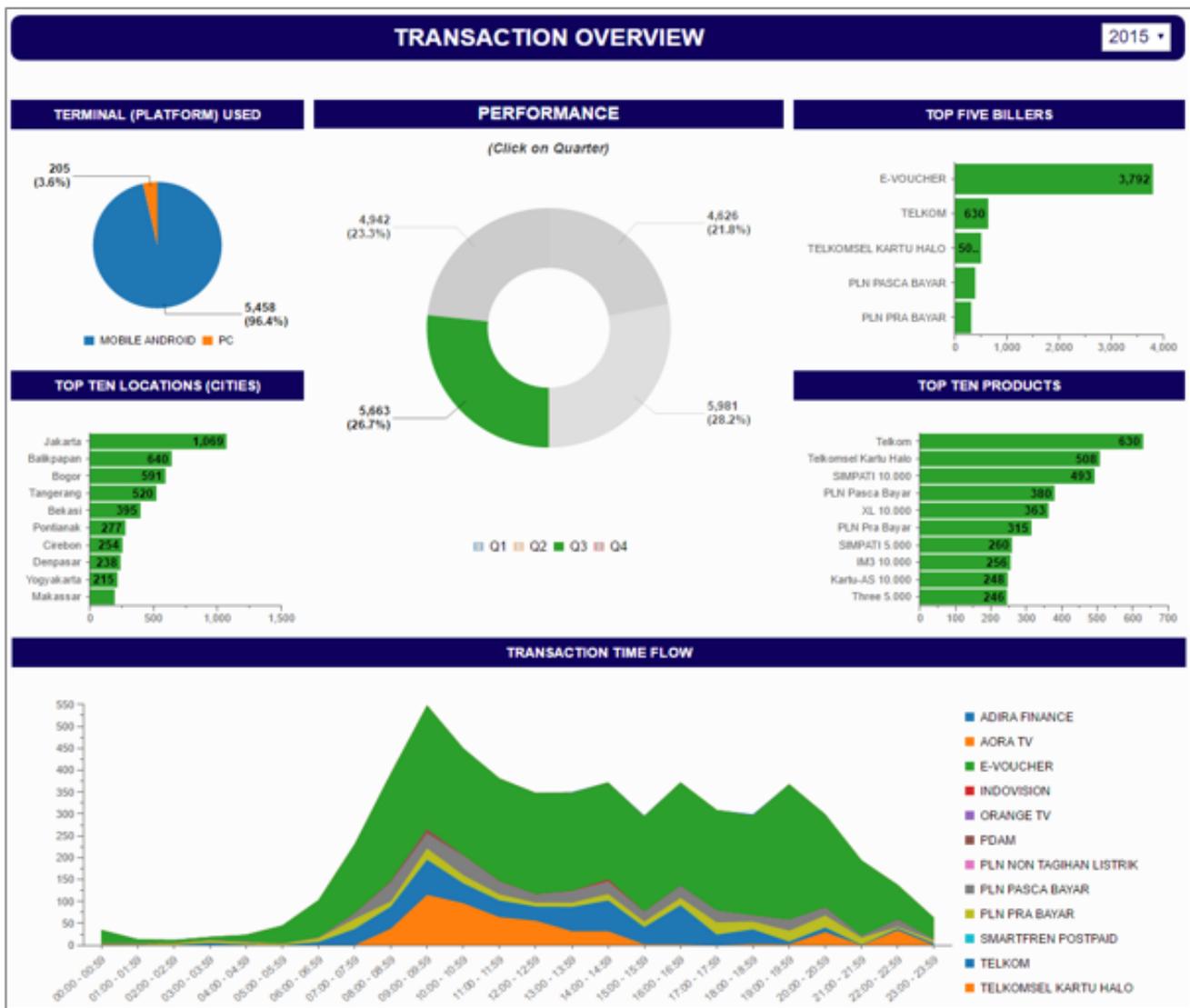Figure 29 Agent Registration Dashboard Example

Figure 30 Transaction Dashboard Example

IV. CONCLUSIONS

The data warehouse that has been developed can be used as an analysis tool to know the trends information in 2014 and 2015. This information is presented in the form of reports and dashboards that help IT business solution provider in making the promotional strategies decisions based on the common trends in 2014 and 2015.

From the analysis with OLAP, The transaction trends are obtained. There is an increment in the number of transactions in 2015. The most favored biller type in 2014 is Telkom, and in 2015, it is E-Voucher. SimPati and XL are two top brands. Moreover, Jakarta is the most common location of transactions in 2014 and 2015. In the first quarter of 2014, the agents do the transactions mostly using PC platform. However, from the second quarter of 2014, they mostly use Android devices. Overall, a few of transactions happen from 00:00 to 04:59. The number of transactions increases from 05:00. The time span at 09:00 to 09:59 is when transaction most happens. Nevertheless, the number of transactions decreases from 10:00 to 13:59, 16:00 to 18:59 and 19:00 to 23:59. Conversely, the obtained result for agent registration trends is in Jakarta as the most common location of agent registration in 2014 and 2015. Then, the number of registrations decreases significantly from the first quarter of

2015 to the second quarter, and through the fourth quarter of 2015.

However, the trend information which is presented in this research only contain the trends of the agent registration and transaction in 2014 and 2015. Thus, the development of data warehouse can be continued to know the trends in the next years (after 2015). The further researcher can also analyze how much nominal transaction and the profit can be gained by IT business solution provider.

REFERENCES

Abai, N. H. Z., Yahaya, J. H., & Deraman, A. (2013). User requirement analysis in data warehouse design: A Review. *Procedia Technology 11*, 801-806. https://doi.org/10.1016/j.protcy.2013.12.261

Darudiato, S. (2010). Perancangan data warehouse penjualan untuk mendukung kebutuhan informasi eksekutif Cemerlang Skin Care. In *Seminar Nasional Informatika 2010* (pp. 350-359). Yogyakarta.

El-Sappagh, S. H. A., Hendawi, A. M. A., & El Bastawissy, A. H. (2011). A Proposed model for data warehouse ETL processes. *Journal of King Saud University -*

Computer and Information Sciences, 23(2), 91-104. https://doi.org/10.1016/j.jksuci.2011.05.005

Fadilah, U., Winarno, W. W., & Amborowati, A. (2016). Perancangan Data Warehouse Untuk Sistem Akademik STMIK Kadiri. *Jurnal Sisfotenika, 6*(2), 217-228.

Gahlot, A., & Yadav, M. (2014). An overview of data warehousing, data mining, OLAP and OLTP technologies. *International Journal of Innovative Research in Technology, 1*(6), 448-455.

Kimball, R., & Ross, M. (2015). *The kimball group reader: Relentlessly practical tools for data warehousing and business intelligence.* Indianapolis: Wiley Publishing, Inc.

Mohammed, K. I. (2014). Data warehouse design and implementation based on quality requirements. *International Journal of Advances in Engineering & Technology, 7*(3), 642-651.

Mulyati, S., Amini, S., & Juliasari, N. (2014). Perancangan data warehouse untuk pengukuran kinerja pengajaran dosen. *Jurnal Telematika MKOM, 6*(1), 1-5.

Oktavia, T. (2011). Perancangan model data warehouse dalam mendukung perusahaan jasa pengiriman. In *Seminar Nasional Informatika 2011* (pp. 93-100). Yogyakarta.

Pardillo, J., Mazón, J. N., & Trujillo, J. (2010). Extending OCL for OLAP querying on conceptual multidimensional models of data warehouses. *Information Sciences, 180*(5), 584-601. https://doi.org/10.1016/j.ins.2009.11.006

Paskarina, S., & Ayub, M. (2010). Aplikasi analisis data kesehatan dengan memanfaatkan teknologi OLAP untuk Departemen Kesehatan PT Ateja Multi Industri. *Jurnal Informatika, 6*(2), 119-130.

Prihatin, N. (2013). Perancangan data warehouse calon mahasiswa baru Politeknik Negeri Lhokseumawe. *Jurnal Litek, 10*(1), 62-66.

Putra, E. P., Fifilia, Christian, L., & Sudarma, H. (2015). Modelling of data warehouse on food distribution center and reserves in the Ministry of Agriculture. *ComTech, 6*(3), 422-434.

Shen, L., Liu, S., Chen, S., & Wang, X. (2012). The application research of OLAP in police intelligence decision system. In *Procedia Engineering 29* (pp. 397-402).

Widianty. (2015). Data warehouse design with Kimball Method: Case study of Farhrenheit Manufacturing Systems. *ComTech, 6*(4), 604-612.