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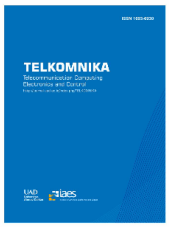

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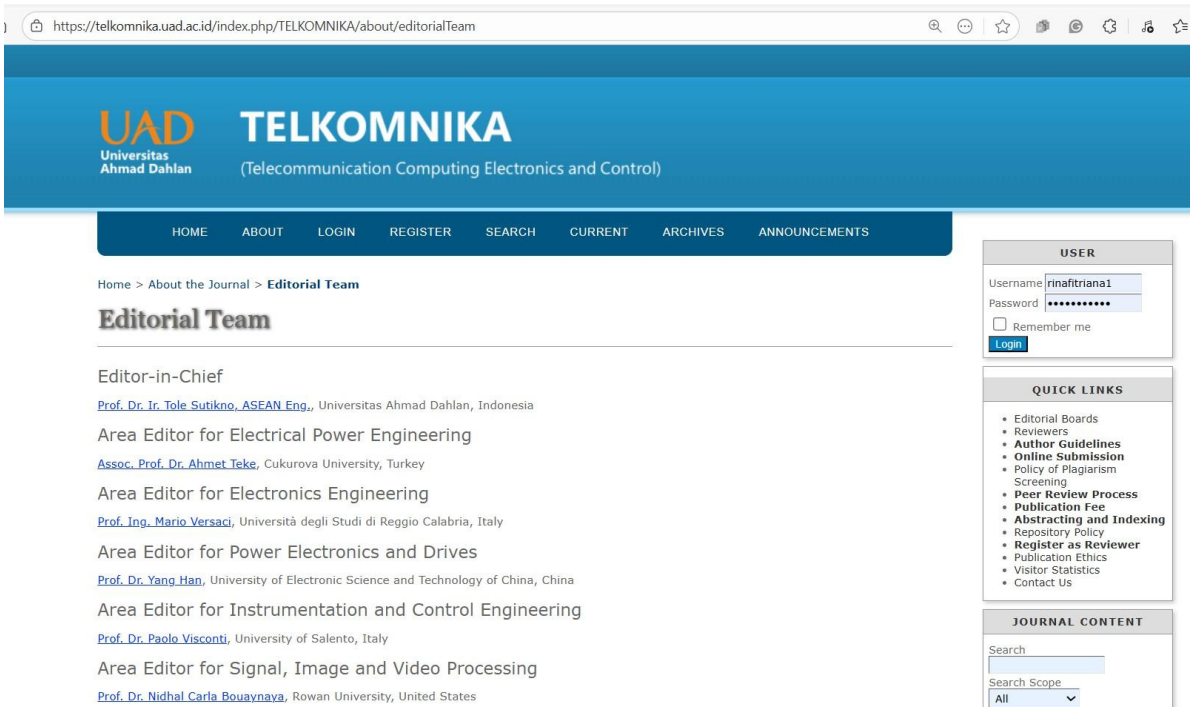

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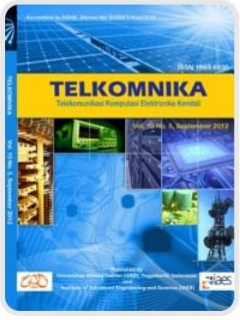

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Business intelligence for measuring global systems for mobile communication provider performance

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ABSTRACT

Internet access is getting easier in various places, including Indonesia. Telecommunication media are no longer dominated by the use of pulse signals but have shifted to relying on internet access. This study aims to create a data visualization of internet speed in Bekasi urban sub-districts using the business intelligence (BI) model with online analytical processing (OLAP). Clustering was carried out using two methods, namely the K-means and K-medoids methods which were selected based on the Davies Bouldin index (DBI) value. This study produced a visual data prototype from the results of clustering from the data mining process and was accompanied by supporting data in the form of information on the highest and lowest speeds in the studied sub-districts. The clustering process uses K-means for uploading data with a DBI value of 0.847, while the data download uses K-medoids with a DBI value of 0.871. The prototype displays observation data, maximum and minimum value information, and the clustering result. The functional test result for the prototype showed conformity with the requirements, while the validation test showed that the prototype passed the validation test with a score of 0.8833.

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1. INTRODUCTION

Indonesia, a developing country with huge market potential, started the era of internet use in the early 1990s. Currently, internet use in Indonesia is no longer the same as when it first appeared. Almost all aspects of life involve the internet. Payment methods such as bills, parking, shopping, and subscribing to various services can be made easily via the internet on a smartphone. Transfers and transactions between banks that previously required going to a bank or an automated teller machine (ATM) can now be done anywhere with internet access. This will be easier with the presence of fourth-generation (4G) technology and the development of fifth-generation (5G) technology. A previous study found that 36.8% of users spend 7-9 hours online, and 34.4% spend more than 9 hours. In utilizing internet access, 58% of respondents take advantage of smartphone use, and 41.1% use more than one gadget [1]. One study in 2020 said that the most popular social media used is YouTube, with 88% of internet users in Indonesia [2].

The problem this research will solve is the limited information available on internet speeds, using data mining to obtain more detailed information to decide on the best internet provider for an area. Some internet performance measurement tools, such as Ookla and M-Lab, can provide real-time measurements,

though with some limitations. Firstly, the server infrastructure is not reliable. Secondly, the test protocol is unable to saturate a connection [3]. This study implements business intelligence (BI) in providing information related to internet access speed at the sub-district level at Bekasi city with daily sample to increase the accuracy. Bekasi city is chosen as it is one of the most populous city and high demand of internet access. The BI system created will visually display data related to internet speed both upload and download and area mapping based on clustering made using Power BI. This research will utilize data mining methods to classify areas to be observed based on internet access speed criteria both in downloading and uploading data. Data mining algorithms answer urgent needs in the big data era and become a reliable tool for processing data and model adjustments [4]. The two methods that will be used in this study are K-means and K-medoids which are types of unsupervised machine learning. The result is visualized with Power BI comparing all provider in this research to earn a deep information related to internet provider speed.

In the previous study, K-means is a popular algorithm used for many cases like cosmetic products management [5] and grouping the web documents based on the similarity [6]. Meanwhile, K-medoids algorithm is used in fewer study. One of study compared both algorithms K-Means and K-Medoids [7]. BI as a data warehouse management tool is also used in several studies such as BI application for management accounting [8] and to analyze the signal strength and connection speed in cloud networks [9].

An internet service provider (ISP) is an institution or company that connects user computers to the internet. The internet service is a connection between various types of computers and networks in the world with different operating systems and applications using the transmission control protocol/internet protocol (TCP/IP) protocol, which contains information. The popularity of the internet and subsequent application developments have made online consumption the main form of consumption for the majority of people [10].

BI can be interpreted as a tool, technology, and process needed to change data into information to take knowledge for business development [8]. BI is the process of obtaining vast data mounts, analyzing them, and presenting them in the form of quality reports that contain a summarized version of the data essence based on business actions, allowing management to make daily business decisions [11]. BI is a set of techniques and tools to convert data into important information for business analysis by leveraging the use of technology and the internet. In previous studies, BI was used to facilitate the interpretation of human behavior, such as transaction patterns [12]. A study of higher education states that the BI model is divided into 5 levels, namely data sources at the first level, then data mapping, data warehouse, monitoring and forecasting, and dashboards [13].

BI systems are useful for improving the quality and availability of information. In this case, BI utilizes the data warehouse as a repository of information structures and analysis, both online analytical processing (OLAP) and data mining. A data warehouse is a separate repository of extracted data to produce data sources for data analysis and decision support. Figure 1 shows the extract, transform, load (ETL) process, which begins with data collection, which is then retrieved and transformed so that it can be entered into the data warehouse. Furthermore, the data can be recalled for processing [14].

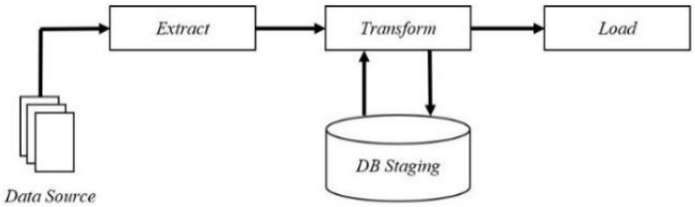

Figure 1. KDD process

Currently, data on an industrial scale consists of 2 categories, namely online transaction processing (OLTP) which requires low latency to read and write data, and OLAP which aims to read data but with more complex queries. OLAP is one of the crucial applications in the industry for many companies to understand their business situation [15]. OLAP is a process that is used to answer the needs of data analytics. OLAP allows data to be presented in a multidimensional manner so that it can be viewed from different perspectives. The goal of implementing OLAP is pattern identification and use, where a multi-dimensional model displays a conceptual representation of a particular data warehouse schema and consists of interrelated entities [16]. The multidimensional data model itself is part of the data warehouse that uses a set of dimensions and facts. The fact itself is marked by the existence of a measure while the dimension is a perspective that forms the basis for carrying out the analytical process [17].

Data mining is a technique for extracting useful data from big data that aims to find information or knowledge [18]. This opinion is supported by other studies that state that data mining is used to obtain patterns and trends that are currently occurring in the data collected [19]. Data mining itself is the main part of the entire knowledge discovery in databases (KDD) method which is a data collection activity and the use of historical data to find knowledge and information in big data [20]. Figure 2 shows a diagram of the knowledge discovery process in finding information from big data.

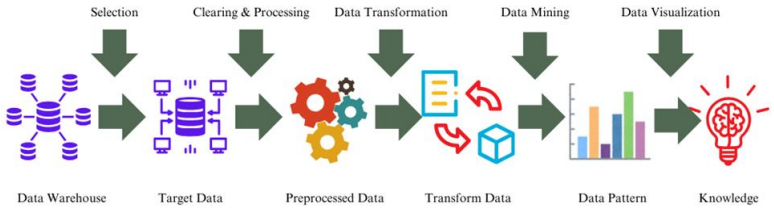

Figure 2. Knowledge discovery process

Several types of data mining methods can be used to process data, including classification, regression, clustering, summarization, dependency modeling, and change and deviation detection. There is a difference between the classification and clustering method. Classification is supervised learning that needs to split the data into 3 parts, training data, validation data, and testing data with a certain ratio like 70/15/15 [21]. Clustering is a very useful tool in data science where this method groups a data set that is grouped based on the greatest similarity in one cluster and the biggest difference between different clusters [22]. Clustering tries to collect data that has similarities in one group and does not appear again in another group. The difficulty level of clustering is very dependent on the form of the data used. For two-dimensional data, human vision is still good enough for grouping. But when the number of dimensions increases, a clustering algorithm is needed to do it [23].

K-means is a clustering method that uses a looping algorithm. In this method, the value of K is the initial clustering center, where the distance between each object and the initial clustering center is calculated and assigned to the nearest clustering center [24]. The K-means algorithm is considered one of the most popular and widely used data mining algorithms in research [25]. Determining the number of clustering and the average distance needs to follow some steps as in:

1) Select the number of k partitions in which the objects will be clustered
2) Partition the objects into k subsets in a dimensional feature space
3) Choose k random points from the partitioning sets as the initial cluster centroids
4) Calculate the distance between the data point and the initial cluster centroids for each cluster using Euclidian distance
5) Assign objects to the group with the shortest distance
6) Identify the new cluster centroid by recalculating the positions of all objects assigned to that cluster
7) Repeat steps 3 and 6 until convergence or reach a fixed number of iterations, and confirm that the object has the shortest Euclidian distance from the cluster centroid
8) Calculate the average dissimilarity of the cluster [26]

The K-medoids algorithm is categorized as partitional clustering which gives better results when dealing with outliers and the mean or median is not present in the data. However, K-medoids also have a higher level of computational complexity [27]. K-medoids is a statistic that states that the data members of a data set have a minimum dissimilarity to all other members of the set. Therefore, the medoid is not the same as the mean. It represents the most centralized member of the data set. The way the K-medoids algorithm works is similar to K-means. Starting from choosing k-item data randomly as the initial medoid to represent K clusters. All other remaining members belong to a cluster that has the medoid closest to them. Then a new medoid is determined that can better represent the cluster. All remaining data items are reassigned to the cluster that has the closest medoid. In each iteration, the medoid changes its location. This method minimizes the number of differences between each data item and the corresponding medoid. This cycle is repeated until none of the medoids change their placement [23].

2. METHOD

The research conducted aims to design a BI for internet speed information from each global system for mobile communications (GSM) operator in each urban sub-district of Bekasi City. The data obtained is

then combined into 1 data warehouse to produce a fact table which will be processed using OLAP. The data obtained is then used for the urban sub-districts clustering process in the city of Bekasi based on the speed of internet access both upload and download using the K-means and K-medoids methods to then compare the accuracy of the results obtained. The algorithm with the smallest Davies Bouldin index (DBI) value is considered the best algorithm with a predetermined k value. Figure 3 shows the architectural model of the BI system that will be created in this study.

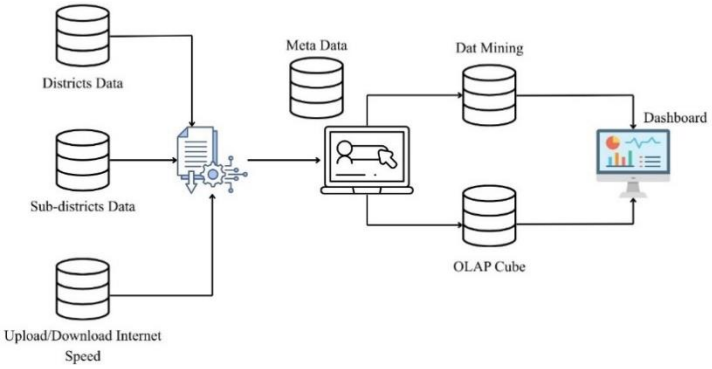

Figure 3. BI architecture model

In general, a study consists of three important stages, namely the stage of making a research design, the implementation stage, and the results and discussion stages [28]. Figure 4 clearly shows each stage carried out for each stage of the research carried out. The research phase begins with collecting data from related data sources, such as field observations for internet access speed, and urban sub-districts data using the web scraping method, such as population data, sub-district codes, and sub-districts. Furthermore, the data is entered into the data warehouse that was created before. In data warehouse design, attribute determination is an important thing to note so that the expected dimension table is produced. The next stage is the OLAP design to obtain the median value of the observation data for internet access speed to be processed in the next process. The required data is then processed using the K-means and K-medoids methods to classify sub-districts based on internet speed. Testing is carried out using the black box method, where testing focuses on the output based on the input given [29]. There are several studies using K-means and K-medoids for birth data collection in Muzaffarabad, Kashmir [23]. The other study uses K-means and K-medoids to group cities based on their smart performances [30]. The data will be processed with the BI method, which is used to collect, manage, and analyze business information. A study used this method to create a visualization of an evaluation framework [31].

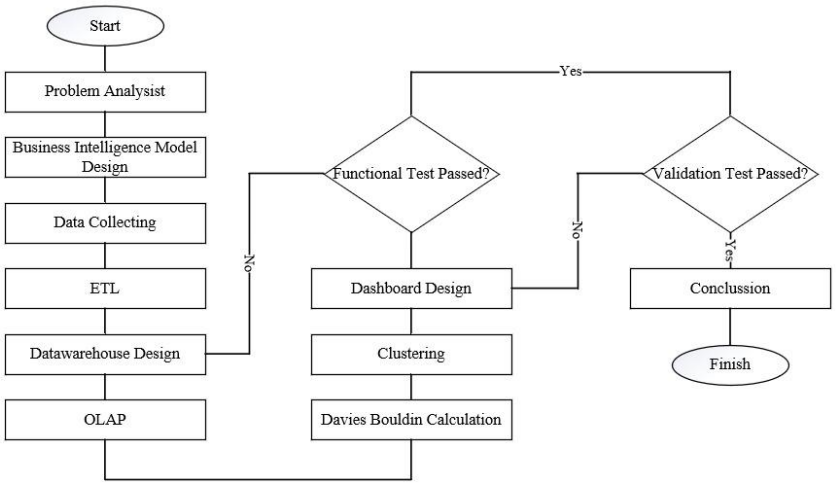

Figure 4. Research stage

2.1. BI model system

This study uses the BI system to obtain information about internet speed in each sub-district of Bekasi city. This BI system will later be supported by a dashboard display that displays the required information. Figure 5 shows the BI model used in the research conducted.

Primary data in this study consists of 2 types, namely internet speed data when uploading and internet speed data when downloading. The data obtained is data taken randomly from several points in each sub-district using the simple random sampling method. The primary data used has several important attributes that will be used, namely the sample code, sub-districts, provider 1 (P1), provider 2 (P2), provider 3 (P3), and provider 4 (P4). All these attributes will be used for both upload and download data.

The secondary data that will be used in this study consists of 2 data, namely data on sub-districts in the city of Bekasi and data on urban sub-districts in the city of Bekasi. These data were obtained by scraping websites using Python. The two datasets were obtained from different sources, namely:

a. District data was obtained from https://id.wikipedia.org. Attributes obtained include the Ministry of Home Affairs code, district, number of sub-districts, and a list of sub-districts.
b. The urban sub-district data for the city of Bekasi was obtained from https://www.infojabodetabek.com. The attributes obtained from the data include sub-districts and sub-district codes. This data is obtained by scraping websites using Python.

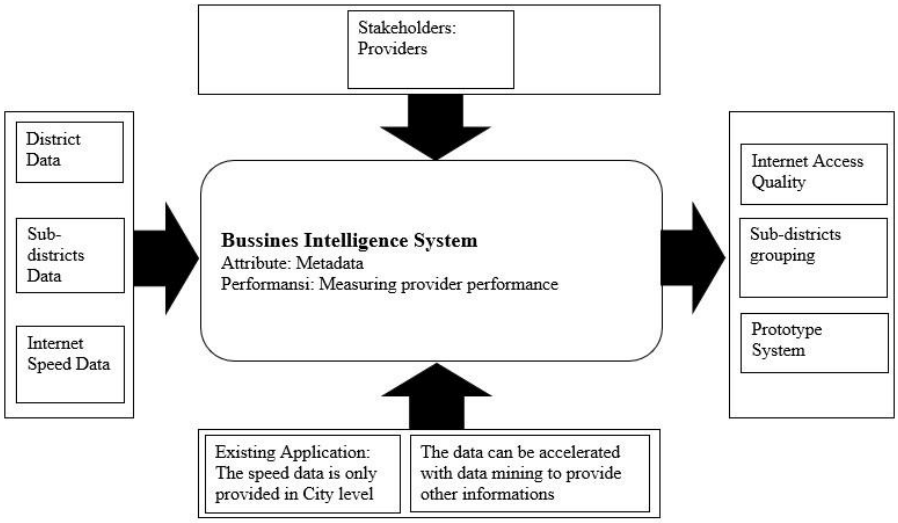

Figure 5. BI model system

2.2. OLAP design

This study uses OLAP to create 3-dimensional data to make it easier to understand. The three dimensions that will be used are the sub-district dimension, the GSM operator dimension, and the sample dimension for measuring internet speed. The final result of the OLAP used is the median value of internet speed measurements in the fact upload table and the fact_download table.

2.3. Data mining process

This study uses the K-means and K-medoids methods to cluster sub-districts in the city of Bekasi based on internet speed information. The determination of the k value or the number of clusters used by the K-means and K-medoids methods is based on the DBI value for each k value, starting from $k = 2$ to $k = 6$ [32]. The internet speed value used is the mean value generated at the OLAP design stage for both upload and download. The clustering results obtained will then be visualized together with other data, such as the name of the district and the name of the sub-districts.

2.4. Data visualization

This stage displays the results of the research that has been done, namely the clustering results obtained in the previous stage. Visualization is made using Power BI based on the data warehouse that has been created. Some views that will appear in the data visualization that will be made in this study include:

a. Overview page: contains a table of contents and the initial appearance of the dashboard that will be created.
b. Data upload page: contains a graphical display of internet speed data when measuring data uploads. The data that appears can be filtered using the filtering operator.
c. Data download page: contains a graphical display of internet speed data when measuring data downloads. The data that appears can be filtered using the filtering operator.
d. Data upload all page: contains a graphic display of data upload speed for all providers studied.
e. Data download all page: contains a graphic display of data download speed for all providers studied.
f. Cluster upload page: contains a display of the results of the clustering data uploaded previously.
g. Cluster download page: contains a display of the results of clustering data downloaded previously.

The functionality test is carried out to find out whether the system created can run properly. This test uses the black-box method to see whether the program created is as desired without looking at the program code used [29]. The validity test carried out aims to find out whether the system created is to the wishes of the user. The method used to test the validity of this research is the content validity method with 4 experts. The validity test using content validity was used in previous research in testing foot care instruments for people with diabetes mellitus (DM) to determine the treatment that is important for sufferers in maintaining healthy feet [33].

3. RESULTS AND DISCUSSION

3.1. Data collection

This study uses primary and secondary data. Primary data was obtained by measuring Internet access speed in sub-districts in Bekasi city for each GSM provider, including P1, P2, P3, and P4. Measurements were carried out using the Simple Random Sampling method at 7 points for each sub-district both for upload speed and speed when downloading data.

The secondary data used in this study is data on sub-districts and sub-districts in the city of Bekasi along with their uni codes. This data is used to complete the data visualization of the internet speed clustering process that is being carried out. Information data about sub-districts in the city of Bekasi along with sub-district codes were obtained from id.wikipedia.org. The results of the scrapping process carried out can be seen in Table 1. The next secondary data that will be used is the list of sub-districts in the city of Bekasi. This study took sub-district data from https://www.infojabodetabek.com.

Table 1. The results of scraping the list of districts in the city of Bekasi

Kemendagri code	Districts	No. of sub-districts	Sub-districts
32.75.02	Bekasi Barat	5	Bintara Bintara Jaya Jakasampurna Kota Baru Kranji
32.75.04	Bekasi Selatan	5	Jakamulya Jakasetia Kayuringin Jaya Marga Jaya Pekayon Jaya
32.75.01	Bekasi Timur	4	Aren Jaya Bekasi Jaya Duren Jaya Margahayu
32.75.03	Bekasi Utara	6	Harapan Baru Harapan Jaya Kaliabang Tengah Marga Mulya Perwira Teluk Pucung
32.75.09	Jatiasih	6	Jatiasih Jatikramat Jatiluhur Jatimekar Jatirasa Jatisari
32.75.10	Jatisampurna	5	Jatikarya Jatiraden Jatirangga Jatiranggon Jatisampurna

3.2. ETL process

This research goes through the ETL stage to carry out the process of extraction, transformation, and entering data into the database so that it contains dimension tables and fact tables that will be used. The ETL process in this study was carried out with the help of the Pentaho application. This research requires several dimension tables to form the required data warehouse, including district dimension tables (dim_districts), sub-districts dimension tables (dim_sub_districts), upload dimension tables (dim_upload), and download dimension tables (dim_download).

The dim_sub_districts table is generated by carrying out the ETL process on the sub_districts data obtained through the data scrapping process. The sub-district data obtained consists of several attributes, namely the Kemendagri code, sub-district, number of sub-districts, and list of sub-districts. Figure 6 shows the ETL process carried out using Pentaho.

The next table that will be created is the dim_sub_districts table which is a dimension table for information about the existing sub_districts in the city of Bekasi. ETL process to generate this dimension table is shown in Figure 7.

Figure 6. ETL process on the dim_districts table

Figure 7. ETL process on the dim_sub-districts table

This study uses two fact tables based on the primary data obtained, namely the fact_upload table and the fact_download table. Figure 8 shows the process of creating a fact table for both the data warehouse upload speed and download speed. From the Figure 8, it can be seen that the two fact tables use the dimension tables dim_sub_districts and dim_districts to form the two fact tables. The difference between the two fact tables lies in the internet speed data used depending on the fact table to be created. The output results on the two fact tables are the attributes Kode_Sub_districts, Kode_Districts, Kode_Take_Data Collection, Provider, and Upload_Speed for the fact_upload table and Download_Speed for the fact_download table.

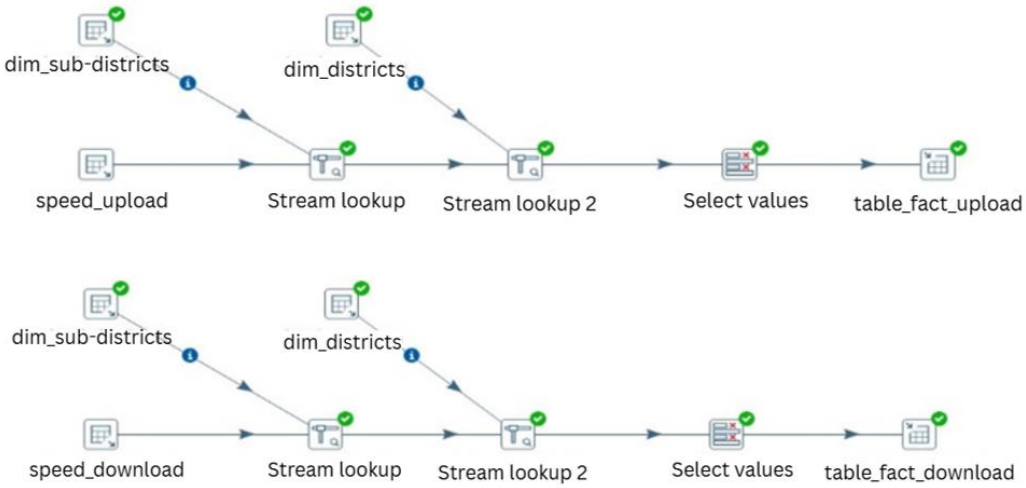

Figure 8. The process of forming a fact table

3.3. Data warehouse design

The first step in preparing the required data warehouse is to make a grain declaration which will be the basis for determining the dimension tables and fact tables that will be created. Table 2 shows the selection of grains related to determining the information that will appear in the fact table. In this Table 2, it is determined that the fact table that will be made is information about internet upload and download speeds from each provider. The data warehouse that will be created in this study uses a star schema consisting of dimension tables for dim_districts and dim sub_districts, as well as fact tables for upload and download speeds.

Table 2. Table grain in the formation of data warehouse

Dimension	Grain	
	Uploading speed	Downloading speed
Districts	V	V
Sub-districts	V	V

The dimension tables and fact tables that will be used are then combined into a schema called the star schema. Formation begins with determining the attribute that becomes the primary key in the dimension table and the foreign key in the fact table. The foreign key determination in the fact table is done to link the same attribute in the dimension table and fact table. The process begins by selecting the uploaded fact table and selecting the structure. The next step is to write a query that functions to determine the attributes that will be used as foreign keys, namely the Kode_Sub_districts and Kode_Sub_districts tables.

Determination of the primary key and foreign key in the previous process is used to link the dimension table with the fact table that has been created so that a data warehouse schema is formed. This study uses a star schema to form a data warehouse that will be used. Figure 9 shows the star schema created for upload speed information, where the fact_upload table is connected to the dim_sub_districts table via the Kode_Sub_districts attribute and the dim_districts table via the Kode_Districts attribute.

The design of the star schema for download speed data is almost the same as the star schema for upload speed data. The difference between the two data warehouses lies in the fact table used, whereas the download speed data uses the fact_download table. Figure 10 shows the star schema on download speed data.

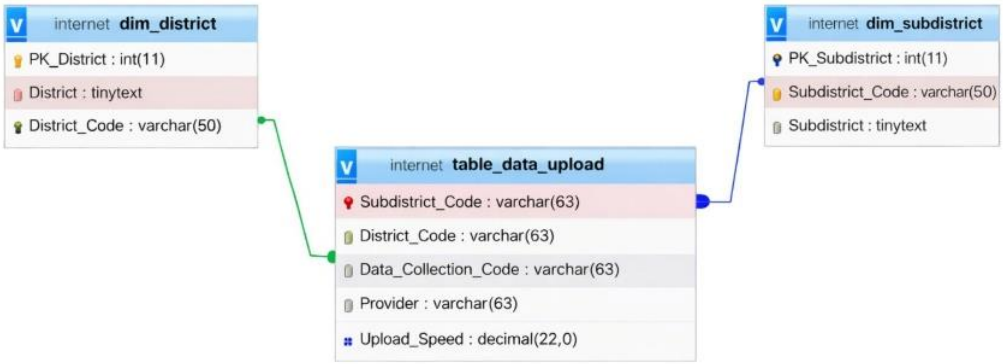

Figure 9. Star schema for upload speed data warehouse

Figure 10. Star schema for download speed data warehouse

3.4. OLAP design

The OLAP design in this study begins with creating an OLAP cube model from the data to be used. Figure 11 shows an overview of the OLAP cube with 3 dimensions, namely sub-district data, provider data, and data samples. The OLAP design in this study was carried out on both fact tables in each data warehouse.

The OLAP cube design process was carried out using Python to obtain the median value of internet upload and download speed. Table 3 shows the information obtained in the resulting OLAP process. The highest score in the upload process was obtained when using the P2 provider with 78 Mbps, while the lowest score in the upload process was 880 Kbps using the P1 provider. The highest score for the download process is obtained when using the P4 provider with 100 Mbps, while the lowest score for the upload process is 100 Kbps using the P2 provider.

Table 3. Highest and lowest internet speed table

Description	Upload		Download	
	The highest	The lowest	The highest	The lowest
Speed	78 Mbps	880 Kbps	100 Mbps	100 Kbps
Sub-districts	Bintarajaya	Telukpucung	Pengasinan	Jatiwarna
Provider	P2	P3	P4	P2
Sampling code	P2-042	P3-167	P4-381	P2-359

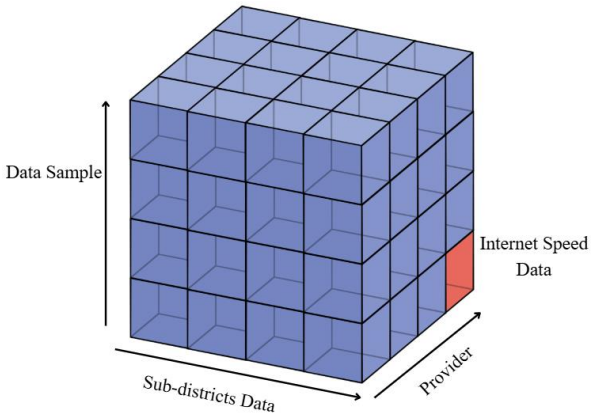

Figure 11. OLAP cube internet speed data

3.5. Application of data mining

Determining the number of clusters (k) in the K-means and K-medoids algorithms in this study uses the DBI value of each observed cluster. The process begins by importing the data generated in the OLAP cube design step into the read excel operator. In the clustering operator, the k value is determined for each clustering operator from 2 to 6. The performance operator aims to see the average centroid distance value for each k value to be graphed. Table 4 is the table of DBI values for the K_means and K-medoids methods for uploading and downloading speed data.

Table 4. List of DBI values for each k value

K value	K-means		K-medoids	
	Upload data	Download data	Upload data	Download data
$k = 2$	1.249	1.522	2.933	1.124
$k = 3$	1.070	1.237	2.741	0.988
$k = 4$	1.099	1.059	2.272	0.871
$k = 5$	0.953	1.102	1.730	1.142
$k = 6$	0.847	0.935	1.803	1.290

From the Table 4, the lowest DBI value for the K-means algorithm is 0.847 at $k = 6$ for uploaded data and 0.935 at $k = 6$ for downloaded data. The lowest DBI value in the K-medoids algorithm is 1.803 at a value of $k = 6$ for uploaded data and 0.871 at a value of $k = 4$ for downloaded data. Based on the DBI data, it can be concluded that for upload data, the best k value is found in the K-means algorithm with a value of $k = 6$. The best k value for download data is found in the K-medoids algorithm with a value of $k = 4$. Based on the results of these calculations, the clustering process for uploading data is carried out using the K-means algorithm at a value of $k = 6$, while the data download uses the K-medoids algorithm with a value of $k = 4$. Table 5 shows the cluster of each sub-district for booth upload and download data.

Table 5. The results of the clustering process from data upload and download

Sub-districts	Upload cluster	Download cluster	Sub-districts	Upload cluster	Download cluster
Bantar Gebang	0	3	Jatirasa	1	3
Ciketing Udik	0	1	Jatisari	1	1
Cikiwul	3	3	Jatikarya	2	3
Sumurbatu	1	1	Jatiraden	2	3
Bintara	1	1	Jatirangga	3	3
Bintarajaya	2	3	Jatiranggon	1	3
Jakasampurna	2	1	Jatisampurna	3	3
Kotabaru	1	3	Harapanmulya	4	3
Kranji	1	3	Kalibaru	5	2
Jakamulya	1	3	Medan Satria	1	3
Jakasetia	3	2	Pejuang	1	1
Kayuringinjaya	1	3	Cimuning	0	3
Margajaya	1	3	Mustikajaya	2	3
Pekayonjaya	3	2	Mustikasari	1	3
Arenjaya	2	3	Padurenan	2	3
Bekasijaya	0	1	Jatibening	4	3
Durenjaya	3	1	Jatibening Baru	1	3
Margahayu	1	3	Jaticempaka	1	3
Harapanbaru	1	3	Jatimakmur	2	3
Harapanjaya	0	0	Jatiwaringin	0	0
Kaliabang Tengah	4	3	Jatimelati	5	1
Margamulya	4	1	Jatimurni	5	1
Perwira	4	3	Jatirahayu	2	0
Teluk Pucung	2	3	Jatiwarna	4	2
Jatiasih	3	2	Bojong Menteng	4	3
Jatikramat	1	3	Bojong Rawalumbu	1	3
Jatiluhur	3	3	Pengasinan	2	1
Jatimekar	1	1	Sepanjangjaya	2	3

Figure 12 shows the results of clustering using upload speed data. It shows cluster 0 has 6 members, cluster 1 has 20 sub-districts, cluster 2 has 12 sub-districts, cluster 3 has 8 sub-districts, cluster 4 has 7 sub-districts, and cluster 5 has 3 sub-districts. Figure 13 shows the results of clustering using download speed data. It shows 0 has 3 sub-districts, cluster 1 has 13 sub-districts, cluster 2 has 5 sub-districts, and cluster 3 has 35 sub-districts.

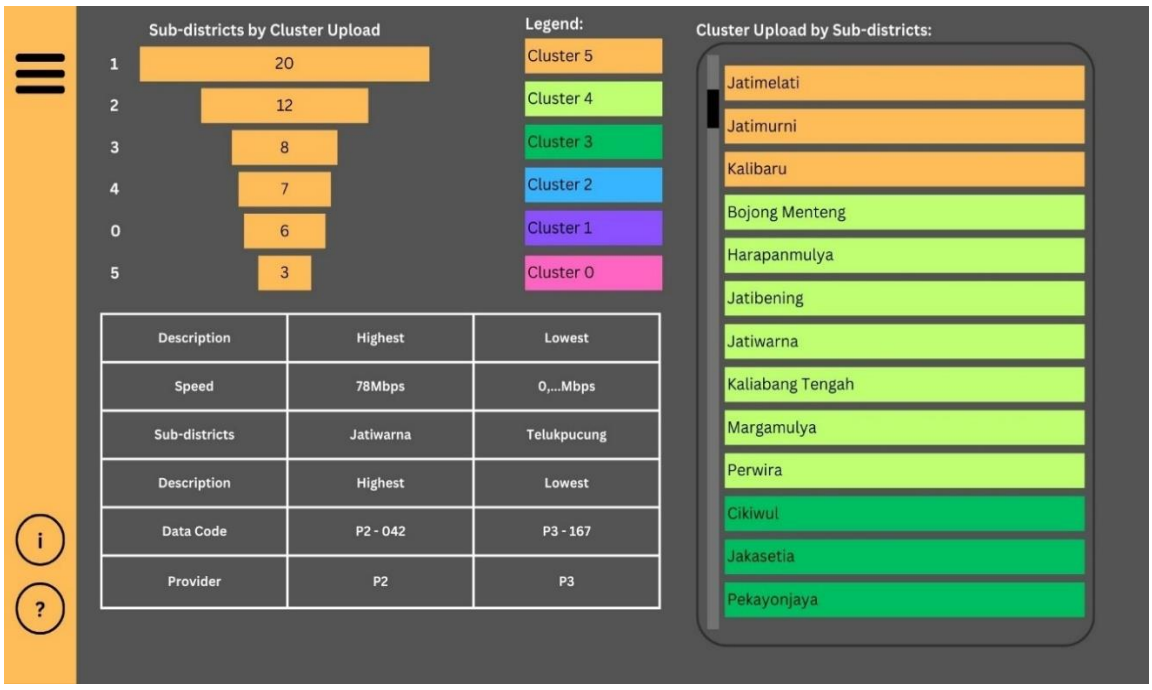

Figure 12. Dashboard display of clustering data upload speed results

Figure 13. Dashboard display of clustering data download speed results

3.6. System evaluation

This study uses the black box testing method to test the applications that have been made. Testing with the black box testing method is used to test an application without having to pay attention to details and only check the output based on the input given [29]. Functionality testing using the black box testing method in this study was carried out by testing the suitability of the actions taken on the dashboard that was made. The results obtained in the functionality test show that every action performed on the created dashboard meets the requirements.

The validity test in this study uses the content validity method to measure how important things are on the dashboard to display. The test was carried out by conducting direct interviews with 4 experts to assess whether the contents of the dashboard that were made were important or not. Testing is done by testing the contents of the dashboard that is made. A value of 1 is given if the content being tested is considered important and a value of 0 is given if the content being tested is considered unimportant. The values obtained from each expert are then summed up and the average value is sought. The average value obtained is added up again and divided by 15 according to the number of items tested to get the scale-level content validity index (S-CVI) value. The S-CVI value obtained in the validity test conducted was 0.88333. This value is above the minimum value of 0.8 which means that the dashboard has passed the content validity test.

To earn an informative dashboard, the primary data is collected with daily data collection to define the median speed in each sub-district separately. The data is processed using BI method to create a data warehouse for the next process. The result is shown in a dashboard showing the clustering information that can not be found in other internet measurement application.

This study is limited by the visualization displayed only for the most accurate clustering, that is the clustering using K-medoids with $k = 4$. Based on the data displayed, the result shown a big difference between the highest and the lowest internet speed.

The purpose of this study is to give an information through the dashboard showing the clustering of sub-district in Bekasi city based on their internet speed, both upload and download speed. With this dashboard, the best internet provider can be considered in each sub-district. It can help people to choose the internet provider brand in their place. For the company using this information, they can strengthen their quality in the low-speed internet area to get more consumers. Creating the public visualization can be done in next study so that the information can be accessed publicly.

4. CONCLUSION

The BI model was created using district list data, sub-district list data, and internet speed data to produce OLAP models, data mining models, and dashboard prototypes to display the information obtained in the form of upload speed, download speed, OLAP data, as well as clustering results 2. In the OLAP process,

the highest and the lowest internet speed can be found for each ISP with the sub-district. The clustering information is showed in some graph form both the number of sub-districts in each cluster and the cluster information for each district. Additionally, the data visualization can be shown in a web page view in subsequent studies so that it can be easily accessed by the public.

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AUTHOR CONTRIBUTIONS STATEMENT

This journal uses the Contributor Roles Taxonomy (CRediT) to recognize individual author contributions, reduce authorship disputes, and facilitate collaboration.

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C : **C**onceptualization
M : **M**ethodology
So : **So**ftware
Va : **Va**lidation
Fo : **Fo**rmal analysis
I : **I**nvestigation
R : **R**esources
D : **D**ata Curation
O : Writing - **O**riginal Draft
E : Writing - Review & **E**diting
Vi : **Vi**sualization
Su : **Su**pervision
P : **P**roject administration
Fu : **Fu**nding acquisition

CONFLICT OF INTEREST STATEMENT

Authors state no conflict of interest.

DATA AVAILABILITY

The data that support the findings of this study are available on request from the first author [Yusri Eli Hotman Turnip] The data, which contain information that could compromise the privacy of research participants, are not publicly available due to certain restrictions.

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