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PREFACE

We would like to present, with great pleasure, the second issue of Matrix: Jurnal Manajemen Teknologi dan Informatika in Volume 13, Number 2, 2023. This journal is under the management of Scientific Publication, Research and Community Service Center, Politeknik Negeri Bali and is devoted to cover the field of technology and informatics management including managing the rapid changes in information technology, emerging advances in electrical and electronics and new applications, implications of digital convergence and growth of electronics technology, and project management in electrical, mechanical or civil engineering. The scientific articles published in this edition were written by researchers from Bumigora University, Panji Sakti University, Universitas Indonesia, Universitas Katolik Musi Charitas and Universitas Islam Negeri Alauddin Makassar. Articles in this issue cover topics in the field of Determination of The Best Rule-based Analysis Results from The Comparison of The Fp-Growth, Apriori, and TPQ-Apriori Algorithms for Recommendation Systems, Library Apps to Improve the Digitization of Sekolah Penggerak Program, Literature Review: Visible Light Communication System Business Model Scheme for Telecommunication Business in Indonesia, The Empirical Study of Joomla CMS Map Extension and Location Performance, and Optimizing Transaction Data Performance in Database Management Systems. Finally, we would like to thank reviewers for their efforts and hard work in conducting series of review phase thoroughly based on their expertise. It is our hope that the work of the authors in this issue will be a valuable resource for other researchers and will stimulate further research into the vibrant area of technology and information management in specific, and engineering in general.

Politeknik Negeri Bali, 29 July 2023

Editor-in-chief

Gusti Nyoman Ayu Sukerti, S.S., M.Hum.

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Determination of the best rule-based analysis results from the comparison of the Fp-Growth, Apriori, and TPQ-Apriori Algorithms for recommendation systems

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Abstract: The popular association rule algorithms are Apriori and fp-growth; both of these algorithms are very familiar among data mining researchers; however, there are some weaknesses found in the association rule algorithm, including long dataset scans in the process of finding the frequency of the item set, using large memory, and the resulting rules being sometimes less than optimal. In this study, the authors made a comparison of the fp-growth, Apriori, and TPQ-Apriori algorithms to analyze the rule results of the three algorithms. TPQ-Apriori is an algorithm developed from the Apriori algorithm. For experiments, the Apriori and fp-growth algorithms use RapidMiner and Weka tools, while the TPQ-apriori algorithm uses self-built application programs. The dataset used is the sales data for the Kopegtel NTB department store, which has been uploaded on the Kaggle site. As for the results of testing the base rules from the overall results of testing the rules with the good Kopegtel dataset for 100%, 50%, and 25% of the total volume of the dataset, a conclusion can be drawn that the larger the dataset to be processed, the results will be more optimal when using the fp-growth algorithm RapidMiner, but not optimal if the dataset to be processed is small. It is different from using the Apriori and Weka FP-growth algorithms, where the resulting rules are less than optimal if the dataset used is large and optimal if the dataset is small. Several rules do not appear in the fp-growth and Apriori Weka algorithms because the two algorithms do not have a tolerance value in Weka's tools for the support of the rules that will be displayed. Meanwhile, the TPQ-Apriori algorithm that has been developed is capable of producing optimal rules for both large datasets and small datasets.

Keywords: association rule, Fp-growth, apriori, TPQ-apriori, rapidminer

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Introduction

Data mining is a scientific discipline that aims to extract knowledge and find patterns from large amounts of data by studying and developing algorithms [1], [2]. In its role, data mining consists of estimation, forecasting, classification, clustering, and association [3]. In using the five roles of data mining to extract knowledge and find patterns, they must be adjusted to the characteristics of the data, because the better the data that will be processed by the data mining algorithm, the better the results that will be obtained. The role of associations is widely implemented in business fields such as e-commerce, retail, and restaurants [4], [5], but it can also be applied to other fields such as software bug analysis and the analysis of biological and medical data [6], so we ensure that the benefits are quite widely used in various fields. Association, or what is commonly referred to in terms of data mining as the association rule," is one of the data mining techniques to search for and find a set of association rules between a combination of items [7]. Or, in another sense, it is an associative rule of the implications of a combination of relationships between an item [6], [8], and [9]. Commonly used and developed association rule algorithms are Apriori, Fp-Growth, Eclat, and Hash-Based [10], [11]. The resulting association rule algorithm, it is a rule that can be measured using support, confidence, lift ratio, leverage, conviction, and certainty factors. Support is the percentage combination of these items in the database; confidence is the strength of the relationship between items in the association rules; lift ratio is to test the value of the validity of the relationship between items; and leverage

and conviction are to test how much influence and confidence there is between the antecedent and consequent.

The forerunner of the association algorithms is the Apriori algorithm, which was first presented in a seminar [12] and then repaired a year later [13]. In its implementation, Apriori can produce optimal rules, but the time used to scan datasets is very long because the approach used by Apriori in finding frequencies uses candidate generation, where all items must be traced to determine k-itemset candidates, where k-itemset means how many iterations will be generated from all traces and result in heavy use of memory. Repairs made by [14] with the fp- tree approach, which we now know as the fp-growth algorithm, are very good in terms of datasetscan time because it only does two scans of the dataset, but the rules produced by the fp-growth algorithm are not as optimal as Apriori, and also the memory usage is still large enough [15], which we now know as Frequent Pattern Growth (Fp-Growth). Then the last one that the author refers to is the TPQ-Apriori algorithm developed by [16]. This reference article has penetrated into one of t journals in Japan. The technique used in this research is to transform the horizontal format that has been used by the Apriori algorithm to a vertical format. This technique can reduce tuples so that the dataset dimensions are reduced, and the dataset will be processed into several partitions, which results in a faster dataset scan. The working process of the method proposed by the researcher [16].

To determine the state of the art of this research, the authors reviewed several papers relevant to the topics discussed. There are several journals that discuss the application and comparison of association rule algorithms. The first was in 2021, which was carried out by Aisyatul Maulidah and Fitra A. Bachtiar with the title "Application of the Association Rule Mining Method for the Ulsan Association for Aspects of Tourist Attractions" [7]. In this study, the aim was to find visitor recommendation patterns in Jatim Park 3, with 1067 Indonesian language review data. Comparison between Google reviews and the Apriori algorithm: the drawbacks are more to tourist recommendation reviews; there are no comparisons and details from the rule base for evaluating rule testing using support, confidence, and liftratio. The second was in 2022, which was carried out by Michael Henry et al. with the title "Implementation of an Apriori Algorithm for Music Genre" [17]. In this study, the aim of this research is that the pattern that is found can be a reference for music producers in terms of making or distributing their new music using the fp-growth algorithm with RapidMiner tools. Only using RapidMiner tools with the FP-algorithm growth without any comparison. Even though the dataset contains quite a lot of recorded data, there is no description of which part of the data was processed until it entered the FP-growth regression stage to evaluate rule testing using support and confidence.

The third was carried out by Rizky Wandri Anggi Hanafiah with the title "Analysis of Information Technology (IT) Goods Sales Patterns Using the FP-Growth Algorithm" [18]. In this study, the aim is to analyze marketing transaction patterns using the FP-growth algorithm with RapidMiner tools to look for correlation relationships to take policies, but the dataset used is only 70 transactions, and the lack of datasets used is very small. We find it difficult to prove that these results are maximized for the evaluation of rule testing using support and confidence.

Fourth in 2022, which was carried out by Komang Ardika Viantama and Painem with the title "Implementation of the Apriori Algorithm for Product Sales Analysis at Perjuangan Collection Stores" [19], in this study, the aim is to analyze sales transaction patterns at clothing retail stores using a web-based system using the Apriori algorithm. Disadvantages The application of Apriori algorithms based on the Algorithmmobile does not require analysis and comparison of algorithms. Only limited to making information systems for evaluating rule testing using support, confidence, and listrasio.

Lastly, in 2022, which was carried out by Zulham et al. with the title "Pattern Analysis of Drug Procurement System With FP-Growth Algorithm" [20], In this study, the aim was to analyze the correlation pattern of drug sales at the Medan Marela Health Center. Using Weka and Rapidman tools with the FP-growth algorithm Weaknesses in the dataset are not described in detail, even though they have been compared. preprocessing stages, and so forth, for the evaluation of rule testing using support and confidence.

Methodology

This section contains the stages of the research method. This stage is also used to explain the proposed solutions to research problems and to achieve the objectives of the research.

1. **Research design**
   The research method used is an experimental earch method, with research stages including dataset collection, data pre-processing (pre-processing), methods used for comparison, experimentation and method testing, and evaluation.
2. **Data Collection**
   Collection or collection of data is the initial stage in which it is carried out, where from existing problems, related data will be collected in the form of datasets obtained from minimarket telkom cooperative minimarket data in the city of Mataram, NTB Indonesia, The dataset used that can be downloaded is the dataset obtained from the telecom employee cooperative minimarket in the city of Mataram-NTB. The dataset has been uploaded on the website www.kaggle.com for more details and can be downloaded at https://www.kaggle.com/datasets/syahrir12345678/datasetjualbelikopegtelntb.
3. **Initial Data Processing (Pre-processing)**
   Before entering the data algorithm model, it must be pre-processed to ensure the format that will enter the model is as expected. The better the data to be processed, the more optimal the results of the algorithmic process will be. In this study, the pre-processing process changes the format to the required form.
4. **Method Comparison**
   For comparison, we use three methods, namely the Apriori algorithm, the fp-growth algorithm, and the TPQ-apriori algorithm, while the tools used are Weka, Rapidminer, and self-designed application programs. There are three association rule algorithms that will be used in this study to analyze the rules formed by comparing the three algorithms.
5. **Apriori Algorithm**
   The apriori algorithm is one of the association rule algorithms with data collection techniques using an associative rule approach to determine the association relationship of an item combination. The importance of an associative rule can be determined by two parameters, namely support and confidence [6], [21]. Support (supporting value) is the percentage of that item combination e database. Confidence (and certainty value) is the strength of the relationship between items in the association rules. An association rule is said to be interesting if the support value is greater than the minimum support and the confidence value is greater than the minimum confidence. Meanwhile, to test the Three association rule algorithms willft ratio.
   a. Support Formulas:

$$\text{Support}(\text{A},\text{B}) = \frac{Jml\,TransaksiAdanB}{\sum Transaksi} x100\% \quad (1)$$

   b. Confidence Formula:

$$Confidence(A,B) = \frac{JmlTransaksiAdanB}{\sum Transaksi\,A} x100\% \quad (2)$$

   c. LiftRatio Formula:

$$Liftrasio = \frac{Support(A,B)}{SupportAxSupportB} \quad (3)$$

6. **Fp-Growth Algorithm**
   The fp-growth algorithm was developed from the Apriori algorithm; of course, the two are complementary. The fp-growth in the search process for item frequency is very good from the Apriori algorithm, but the resulting rules are not as good as the Apriori algorithm, and the memory usage is still quite large. The fp-growth algorithm is an algorithm from the association rules technique that can be used to determine the most frequently occurring data set (frequent itemset) in a data set by approaching the fp-tree concept [22].

7. TPQ-Apriori Algorithm

TPQ stands for Tid-list Vertical Partitioning Query and uses a vertical tid-list format technique with a query-based partitioning system. The algorithm is claimed to be able to process dataset scans in a frequency search for itemsets and is able to generate optimal rules [16]. The initial stage is carried out, namely pre-processing to adjust the format as needed with the dot SQL (.sql) extension. In the next stage, the dataset is partitioned, and each partition will be applied to a vertical tiling list approach. The goal with this approach is to trim the records. We can see the complete flow of the TPQ-Apriori algorithm in Figure 1.

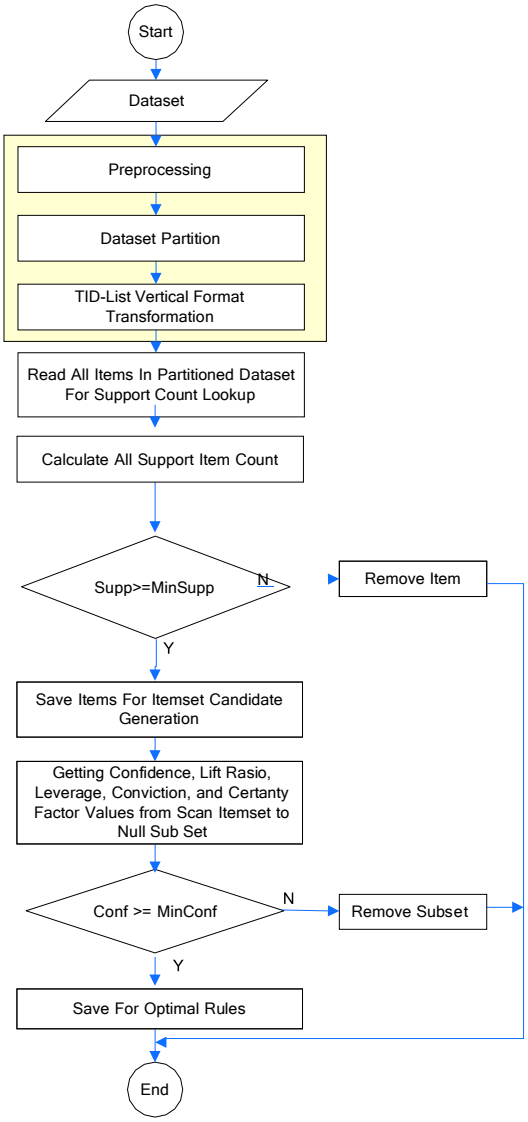

Figure 1. TPQ-Apriori flowchart

8. Experiment and Testing Methods

The experimental stages of the proposed method are:

a. Setting up datasets
b. Comparative analysis of the results of TPQ-Apriori and Fp-Growth in the rapidminner, Fp-Growth weka, and Apriori weka tools using the Telkom employee cooperative minimarket dataset in Mataram City-NTB

For rule testing, Fp-Growth will be compared in RapidMiner and Weka Tools, as well as Apriori in Weka Tools, while the dataset for rule testing is the Telkom employee cooperative minimarket dataset in Mataram (NTB). The dataset can be downloaded.

https://www.kaggle.com/datasets/syahrir12345678/datasetjualbelikopegtelntb. In this study, tests were carried out using the TPQ-Apriori tools, which were developed by themselves using Microsoft Visual Studio 2013 and MySQL Server 5.5 tools, which support parallelization.

9. Evaluation

The evaluation process will provide results regarding the value of support, confidence, lift ratio, conviction, leverage, and certainty factors. Support determines how often the rule is applied in the dataset [6], [21], [23], and [24]. Support is an indication of how often the item set appears in the dataset. Support can be formulated like Formula 5.

$$Support, s(X \rightarrow Y) = \frac{\sigma(X \cup Y)}{N} \quad (5)$$

Where :
N = Transaction Totals
X = Antecedent
Y = Consequent

Confidence determinesof frequency of items in Y appearing in transactions that contain X. Confidence or belief in how often the rule or rules are proven to be true. Confidence can be formulated as in Formula 6.

$$confidence, c(X \rightarrow Y) = \frac{\sigma(X \cup Y)}{X} \quad (6)$$

To test whether a rule or a relationship between items is valid or not, a lift ratio is used. Lift ratio is a value that measures the magnitude of the relationship between the antecedent and consequent that is independent [6], [21], [23], and [24]. The lift ratio has a range from 0 to 1. Values close to 1 indicate that the antecedent and consequent have no dependence. Values far from 1 indicate that the antecedent provides information about the consequent. Or, with another understanding, if the lift is > 1, it lets us know to what extent two events are dependent on each other, which makes the rule potentially useful for predicting the consequent in a dataset. And if lift is 1, that lets us know that the items replace each other. This means that the presence of one item has a negative effect on the presence of another item, and vice versa.

$$lift(X \rightarrow Y) = \frac{\sigma(X \cup Y)}{\sigma(X) * \sigma(Y)} \quad (7)$$

Where :
∞ = Infinity Or Null
σ = Support Count
U = Relate

Apart from the lift ratio, we can test it with another formula, namely conviction or the value of belief [6], [25], [23], [24]. Conviction is a value that measures the degree of implication of a rule. Conviction is very concerned about the direction of an association rule. Conviction indicates that conviction (X→Y) ≠ conviction (Y→X).

$$conv(X \rightarrow Y) = \frac{1 - \sigma(Y)}{1 - c(X \rightarrow Y)} \quad (8)$$

Forthe number of antecedent and consequence items sold simultaneously in a dataset is more than we would expect using Leverage. A value of 0 indicates antecedent and consequent independent. Leverage has a value range from -0.25 to 0.25. Can be formulated as in formula 9.

$$lev(X \rightarrow Y) = \sigma(X \cup Y) - (\sigma(X) * \sigma(Y)) \quad (9)$$

In this study, additional evaluation is needed to make a decision about assessing the relationship or correlation rule that is formed using the certainty factor method. The certainty factor method, according to David McAllister "is a method for proving whether a fact is certain or uncertain in form, a metric that is usually used in expert systems".

$$CF(X \rightarrow Y) = \frac{c(X \rightarrow Y) - \sigma(Y)}{1 - \sigma(Y)} \quad (10)$$

Results and Discussions

Experiments to overcome the problems of scanning old datasets, the rules that are formed, and the use of memory and processor, which is still quite large, by integrating the TID-List Vertical approach and data partitioning Where data partitioning is used to partition datasets so that the dataset volume can be partitioned to a smaller size than the original dataset. And for each dataset that has been partitioned, the initial table format partition results will be transformed to a vertical form, and with these two approaches, the frequency search process in the developed Apriori algorithm becomes faster. The runtime testing process is repeated 10 times to ensure consistent dataset scan times.

The following is a comparison of the results of testing the Rule Apriori Tools Weka, Fp-Growth Tools Rapidminer, and TPQ-Apriori. The results of testing the three algorithms in different tools have been obtained. To simplify the comparison, the results are put together in tabular form. As for the tabular form for the section:

1. TPQ-Apriori algorithm on TPQ-Apriori tools, with rapidminer's Fp-Growth Algorithm for 100% of Kopegtel datasets. Can be seen in Table 1.
2. TPQ-Apriori Algorithm on TPQ-Apriori tools, with Weka's Fp-Growth Algorithm for 100% Kopegtel dataset. Can be seen in Table 2.
3. TPQ-Apriori algorithm on TPQ-Apriori tools, with Weka's Apriori Algorithm for 100% of Kopegtel datasets. Can be seen in Table 3.
4. The TPQ-Apriori algorithm on the TPQ-Apriori tools, with the rapidminer Fp-Growth Algorithm for 50% of the Kopegtel dataset. Can be seen in Table 4.
5. TPQ-Apriori algorithm on TPQ-Apriori tools, with Weka's Fp-Growth Algorithm for 50% of the Kopegtel dataset. Can be seen in Table 5.
6. TPQ-Apriori algorithm on TPQ-Apriori tools, with Weka's Apriori algorithm for 50% of the Kopegtel dataset. Can be seen in Table 6.
7. TPQ-Apriori algorithm on TPQ-Apriori tools, with rapidminer's Fp-Growth Algorithm for 25% of the Kopegtel dataset. Can be seen in Table 7.
8. TPQ-Apriori algorithm on TPQ-Apriori tools, with Weka's Fp-Growth Algorithm for 25% of the Kopegtel dataset. Can be seen in Table 8.
9. The TPQ-Apriori algorithm on the TPQ-Apriori tools, with the Weka Apriori Algorithm for 25% of the Kopegtel dataset. Can be seen in Table 9.

Table 1. Results of the TPQ-Apriori algorithm rule with fp-growth rapidminer for 100% of the Kopegtel dataset

No	Antecedent	Consequent	Item set	Freq	Supp	TPQ-Apriori				Fp-Growth Rapidminer			
						Conf	Lift	Conv	Leve	CF	Conf	Lift	Conv
1	MIE 89, SOSIS SONICE SAPI, KUDA MAS MAKARONI	KUDA MAS STIK	4	48	11.62%	1.00	3.06	∞	0.08	1.00	1.00	3.06	∞
2	KUDA MAS MAKARONI, JAGOAN NEON	KUDA MAS STIK	3	67	16.22%	0.99	3.01	67.31	0.11	0.99	0.99	3.01	45.77
3	MIE 89, KUDA MAS MAKARONI	KUDA MAS STIK	3	64	15.50%	0.98	3.01	33.66	0.10	0.97	0.98	3.01	43.75
4	SOSIS SONICE SAPI, KUDA MAS MAKARONI, JAGOAN NEON	KUDA MAS STIK	4	49	11.86%	0.98	3.00	33.66	0.08	0.97	0.98	3.00	33.66
5	KUDA MAS STIK, KELAPA MUDA, JAGOAN NEON	KUDA MAS MAKARONI	4	43	10.41%	0.98	3.13	34.38	0.07	0.97	0.98	3.13	30.26

No	Antecedent	Consequent	Item set	Freq	Supp	TPQ-Apriori				Fp-Growth Rapidminer			
						Conf	Lift	Conv	Leve	CF	Conf	Lift	Conv
6	MIE 89, KUDA MAS MAKARONI, KELAPA MUDA	KUDA MAS STIK	4	43	10.41%	0.98	2.99	33.66	0.07	0.97	0.98	2.99	29.62
7	KUDA MAS MAKARONI, KELAPA MUDA,JAGOAN NEON	KUDA MAS STIK	4	43	10.41%	0.98	2.99	33.66	0.07	0.97	0.98	2.99	29.62
8	KUDA MAS MAKARONI	KUDA MAS STIK	2	122	29.54%	0.95	2.89	13.46	0.19	0.93	0.95	2.89	12.40
9	KUDA MAS MAKARONI, KELAPA MUDA	KUDA MAS STIK	3	69	16.71%	0.95	2.89	13.46	0.11	0.93	0.95	2.89	12.28
10	SOSIS SONICE SAPI, KUDA MAS MAKARONI	KUDA MAS STIK	3	80	19.37%	0.95	2.91	13.46	0.13	0.93	0.95	2.91	14.14
11	KUDA MAS STIK, KELAPA MUDA	KUDA MAS MAKARONI	3	69	16.71%	0.95	3.03	13.75	0.11	0.93	0.95	3.03	12.55
12	KUDA MAS STIK, JAGOAN NEON	KUDA MAS MAKARONI	3	67	16.22%	0.94	3.02	11.46	0.11	0.91	0.94	3.02	12.21
13	SOSIS SONICE SAPI, KUDA MAS STIK, JAGOAN NEON	KUDA MAS MAKARONI	4	49	11.86%	0.94	3.02	11.46	0.08	0.91	0.94	3.02	11.92
14	SOSIS SONICE SAPI, KUDA MAS MAKARONI, KELAPA MUDA	KUDA MAS STIK	4	46	11.14%	0.94	2.87	11.22	0.07	0.91	0.94	2.87	10.99
15	MIE 89, KUDA MAS STIK, KELAPA MUDA	KUDA MAS MAKARONI	4	43	10.41%	0.93	2.99	9.82	0.07	0.90	0.93	2.99	10.54
16	SOSIS SONICE SAPI, KUDA MAS STIK	KUDA MAS MAKARONI	3	80	19.37%	0.92	2.94	8.60	0.13	0.88	0.92	2.94	8.55
17	SOSIS SONICE SAPI, KUDA MAS STIK, KELAPA MUDA	KUDA MAS MAKARONI	4	46	11.14%	0.92	2.95	8.60	0.07	0.88	0.92	2.95	8.60
18	KUDA MAS STIK	KUDA MAS MAKARONI	2	122	29.54%	0.90	2.89	6.88	0.19	0.85	0.90	2.89	7.14
19	MIE 89, SOSIS SONICE SAPI, KUDA MAS STIK	KUDA MAS MAKARONI	4	48	11.62%	0.89	2.85	6.25	0.08	0.84	0.89	2.85	6.19
20	MIE 89, KUDA MAS STIK	KUDA MAS MAKARONI	3	64	15.50%	0.88	2.81	5.73	0.10	0.83	0.88	2.81	5.58
21	KELAPA MUDA, JAGOAN NEON	KUDA MAS STIK	3	44	10.65%	0.88	2.69	5.61	0.07	0.82	0.88	2.69	5.61
22	KELAPA MUDA, JAGOAN NEON	KUDA MAS MAKARONI	3	44	10.65%	0.88	2.82	5.73	0.07	0.83	0.88	2.82	5.73
23	MIE 89, JAGOAN NEON	KUDA MAS STIK	3	43	10.41%	0.88	2.68	5.61	0.07	0.82	0.88	2.68	5.50
24	KELAPA MUDA, JAGOAN NEON	KUDA MAS STIK, KUDA MAS MAKARONI	4	43	10.41%	0.86	2.91	5.03	0.07	0.80	0.86	2.91	5.03
25	MIE 89, TEPUNG WHITE BEAR	GULA PTPN	3	84	20.34%	0.85	1.98	3.81	0.10	0.74	0.85	1.98	3.77
26	SOSIS SONICE SAPI, JAGOAN NEON	KUDA MAS STIK	3	52	12.59%	0.84	2.57	4.21	0.08	0.76	0.84	2.57	4.17
27	MIE 89, GULA PTPN	TEPUNG WHITE BEAR	3	84	20.34%	0.82	1.99	3.26	0.10	0.69	0.82	1.99	3.32
28	SOSIS SONICE SAPI, JAGOAN NEON	KUDA MAS MAKARONI	3	50	12.11%	0.81	2.58	3.62	0.07	0.72	0.81	2.58	3.55
29	TEPUNG WHITE BEAR	GULA PTPN	2	137	33.17%	0.80	1.87	2.86	0.15	0.65	0.80	1.87	2.87

From the analysis results in Table 1, all evaluation values between the Fp-Growth rapidminer algorithm and the algorithm proposed in the TPQ-Apriori tools are all the same starting from confidence, liftration, and leverage, but there are some differences in the conviction values from the test, but the values are close. The rules generated by the two algorithms are 29 rules; if we refer to the threshold that we set, namely the minimum support of 0.1 and the minimum confidence of 0.8, the resulting rule is very optimal. In the TPQ-Apriori tools developed in this study, there is an additional formula for evaluating rules other than lift ratio, leverage, and conviction, namely the certainty factor. The certainty factor is one of the methods used to make it easier for us to understand the results of evaluating the possibility of determining whether or

not a rule applies. This makes it easier for us to assess that the antecedent and consequent relationships in the rule have useful links and information. The calculation of conviction refers to the standard conviction formula to ensure that the conviction value in TPQ-Apriori is correct.

Table 2. Results of the tpq-Apriori algorithm rule with fp-growth weka for 100% of the Kopegtel dataset

No	Antecedent	Consequent	Item set	Freq	Supp	TPQ-Apriori					Fp-Growth Weka		
						Conf	Lift	Conv	Leve	CF	Conf	Lift	Conv
1	MIE 89, SOSIS SONICE SAPI, KUDA MAS MAKARONI	KUDA MAS STIK	4	48	11.62%	1.00	3.06	∞	0.08	1.00			
2	KUDA MAS MAKARONI, JAGOAN NEON	KUDA MAS STIK	3	67	16.22%	0.99	3.01	67.31	0.11	0.99	0.99	3.01	45.77
3	MIE 89, KUDA MAS MAKARONI	KUDA MAS STIK	3	64	15.50%	0.98	3.01	33.66	0.10	0.97			
4	SOSIS SONICE SAPI, KUDA MAS MAKARONI, JAGOAN NEON	KUDA MAS STIK	4	49	11.86%	0.98	3.00	33.66	0.08	0.97	0.98	3.00	33.66
5	KUDA MAS STIK, KELAPA MUDA, JAGOAN NEON	KUDA MAS MAKARONI	4	43	10.41%	0.98	3.13	34.38	0.07	0.97	0.98	3.13	30.26
6	MIE 89, KUDA MAS MAKARONI, KELAPA MUDA	KUDA MAS STIK	4	43	10.41%	0.98	2.99	33.66	0.07	0.97			
7	KUDA MAS MAKARONI, KELAPA MUDA,JAGOAN NEON	KUDA MAS STIK	4	43	10.41%	0.98	2.99	33.66	0.07	0.97	0.98	2.99	29.62
8	KUDA MAS MAKARONI	KUDA MAS STIK	2	122	29.54%	0.95	2.89	13.46	0.19	0.93	0.95	2.89	12.40
9	KUDA MAS MAKARONI, KELAPA MUDA	KUDA MAS STIK	3	69	16.71%	0.95	2.89	13.46	0.11	0.93	0.95	2.89	12.28
10	SOSIS SONICE SAPI, KUDA MAS MAKARONI	KUDA MAS STIK	3	80	19.37%	0.95	2.91	13.46	0.13	0.93	0.95	2.91	14.14
11	KUDA MAS STIK, KELAPA MUDA	KUDA MAS MAKARONI	3	69	16.71%	0.95	3.03	13.75	0.11	0.93	0.95	3.03	12.55
12	KUDA MAS STIK, JAGOAN NEON	KUDA MAS MAKARONI	3	67	16.22%	0.94	3.02	11.46	0.11	0.91	0.94	3.02	12.21
13	SOSIS SONICE SAPI, KUDA MAS STIK, JAGOAN NEON	KUDA MAS MAKARONI	4	49	11.86%	0.94	3.02	11.46	0.08	0.91	0.94	3.02	11.92
14	SOSIS SONICE SAPI, KUDA MAS MAKARONI, KELAPA MUDA	KUDA MAS STIK	4	46	11.14%	0.94	2.87	11.22	0.07	0.91	0.94	2.87	10.99
15	MIE 89, KUDA MAS STIK, KELAPA MUDA	KUDA MAS MAKARONI	4	43	10.41%	0.93	2.99	9.82	0.07	0.90			
16	SOSIS SONICE SAPI, KUDA MAS STIK	KUDA MAS MAKARONI	3	80	19.37%	0.92	2.94	8.60	0.13	0.88	0.92	2.94	8.55
17	SOSIS SONICE SAPI, KUDA MAS STIK, KELAPA MUDA	KUDA MAS MAKARONI	4	46	11.14%	0.92	2.95	8.60	0.07	0.88	0.92	2.95	8.60
18	KUDA MAS STIK	KUDA MAS MAKARONI	2	122	29.54%	0.90	2.89	6.88	0.19	0.85	0.90	2.89	7.14
19	MIE 89, SOSIS SONICE SAPI, KUDA MAS STIK	KUDA MAS MAKARONI	4	48	11.62%	0.89	2.85	6.25	0.08	0.84			
20	MIE 89, KUDA MAS STIK	KUDA MAS MAKARONI	3	64	15.50%	0.88	2.81	5.73	0.10	0.83			
21	KELAPA MUDA, JAGOAN NEON	KUDA MAS STIK	3	44	10.65%	0.88	2.69	5.61	0.07	0.82	0.88	2.69	5.61
22	KELAPA MUDA, JAGOAN NEON	KUDA MAS MAKARONI	3	44	10.65%	0.88	2.82	5.73	0.07	0.83	0.88	2.82	5.73
23	MIE 89, JAGOAN NEON	KUDA MAS STIK	3	43	10.41%	0.88	2.68	5.61	0.07	0.82			
24	KELAPA MUDA, JAGOAN NEON	KUDA MAS STIK, KUDA MAS MAKARONI	4	43	10.41%	0.86	2.91	5.03	0.07	0.80	0.86	2.91	5.03
25	MIE 89, TEPUNG WHITE BEAR	GULA PTPN	3	84	20.34%	0.85	1.98	3.81	0.10	0.74			
26	SOSIS SONICE SAPI, JAGOAN NEON	KUDA MAS STIK	3	52	12.59%	0.84	2.57	4.21	0.08	0.76	0.84	2.57	4.17
27	MIE 89, GULA PTPN	TEPUNG WHITE BEAR	3	84	20.34%	0.82	1.99	3.26	0.10	0.69			

No	Antecedent	Consequent	Item set	Freq	Supp	TPQ-Apriori					Fp-Growth Weka		
						Conf	Lift	Conv	Leve	CF	Conf	Lift	Conv
28	SOSIS SONICE SAPI, JAGOAN NEON	KUDA MAS MAKARONI	3	50	12.11%	0.81	2.58	3.62	0.07	0.72	0.81	2.58	3.55
29	TEPUNG WHITE BEAR	GULA PTPN	2	137	33.17%	0.80	1.87	2.86	0.15	0.65	0.80	1.87	2.87

From the test results in Table 2, there are 20 rules generated by Fp-Growth Weka. If we refer to the threshold set, namely the minimum support 0.1 and minimum confidence 0.8, the rules produced by the Fp-Growth algorithm in Weka tools are not optimal because there are 9 rules not found. And if we analyze the results from Table 6, what causes rule 9 not to be found is that of the 9 rules, all the rules that are not found are rules that have items or attributes with the name "MIE 89." The item or attribute "MIE 89" in the Kopegtel dataset is the item that has the highest frequency in the first iteration, namely 207 occurrences. In its implementation, when referring to the Fp-Growth algorithm developed by Jiawei Han, the item with the highest support count or with the highest frequency in the first iteration will be the initial node, and this initial node is not included in the path formed in the Fp-tree. For information, the column marked in orange is a rule that was not found.

Table 3. Results of the tpq-Apriori algorithm with Apriori weka for 100% of the Kopegtel dataset

No	Antecedent	Consequent	Itemset	Freq	Supp	TPQ-Apriori					Apriori Weka	
						Conf	Lift	Conv	Leve	CF	Supp	Conf
1	MIE 89, SOSIS SONICE SAPI, KUDA MAS MAKARONI	KUDA MAS STIK	4	48	11.62%	1.00	3.06	Infinity	0.08	1.00		
2	KUDA MAS MAKARONI, JAGOAN NEON	KUDA MAS STIK	3	67	16.22%	0.99	3.01	67.31	0.11	0.99	16.22%	0.99
3	MIE 89, KUDA MAS MAKARONI	KUDA MAS STIK	3	64	15.50%	0.98	3.01	33.66	0.10	0.97	15.50%	0.91
4	SOSIS SONICE SAPI, KUDA MAS MAKARONI, JAGOAN NEON	KUDA MAS STIK	4	49	11.86%	0.98	3.00	33.66	0.08	0.97	11.86%	0.98
5	KUDA MAS STIK, KELAPA MUDA, JAGOAN NEON	KUDA MAS MAKARONI	4	43	10.41%	0.98	3.13	34.38	0.07	0.97	10.41%	0.98
6	MIE 89, KUDA MAS MAKARONI, KELAPA MUDA	KUDA MAS STIK	4	43	10.41%	0.98	2.99	33.66	0.07	0.97		
7	KUDA MAS MAKARONI, KELAPA MUDA,JAGOAN NEON	KUDA MAS STIK	4	43	10.41%	0.98	2.99	33.66	0.07	0.97	10.41%	0.98
8	KUDA MAS MAKARONI	KUDA MAS STIK	2	122	29.54%	0.95	2.89	13.46	0.19	0.93	29.54%	0.95
9	KUDA MAS MAKARONI, KELAPA MUDA	KUDA MAS STIK	3	69	16.71%	0.95	2.89	13.46	0.11	0.93	16.71%	0.95
10	SOSIS SONICE SAPI, KUDA MAS MAKARONI	KUDA MAS STIK	3	80	19.37%	0.95	2.91	13.46	0.13	0.93	19.37%	0.95
11	KUDA MAS STIK, KELAPA MUDA	KUDA MAS MAKARONI	3	69	16.71%	0.95	3.03	13.75	0.11	0.93	16.71%	0.95
12	KUDA MAS STIK, JAGOAN NEON	KUDA MAS MAKARONI	3	67	16.22%	0.94	3.02	11.46	0.11	0.91	16.22%	0.94
13	SOSIS SONICE SAPI, KUDA MAS STIK, JAGOAN NEON	KUDA MAS MAKARONI	4	49	11.86%	0.94	3.02	11.46	0.08	0.91	11.86%	0.94
14	SOSIS SONICE SAPI, KUDA MAS MAKARONI, KELAPA MUDA	KUDA MAS STIK	4	46	11.14%	0.94	2.87	11.22	0.07	0.91	11.14%	0.94
15	MIE 89, KUDA MAS STIK, KELAPA MUDA	KUDA MAS MAKARONI	4	43	10.41%	0.93	2.99	9.82	0.07	0.90		
16	SOSIS SONICE SAPI, KUDA MAS STIK	KUDA MAS MAKARONI	3	80	19.37%	0.92	2.94	8.60	0.13	0.88	19.37%	0.92
17	SOSIS SONICE SAPI, KUDA MAS STIK, KELAPA MUDA	KUDA MAS MAKARONI	4	46	11.14%	0.92	2.95	8.60	0.07	0.88	11.14%	0.92
18	KUDA MAS STIK	KUDA MAS MAKARONI	2	122	29.54%	0.90	2.89	6.88	0.19	0.85	29.54%	0.90
19	MIE 89, SOSIS SONICE SAPI, KUDA MAS STIK	KUDA MAS MAKARONI	4	48	11.62%	0.89	2.85	6.25	0.08	0.84		
20	MIE 89, KUDA MAS STIK	KUDA MAS MAKARONI	3	64	15.50%	0.88	2.81	5.73	0.10	0.83	15.50%	0.94

No	Antecedent	Consequent	Itemset	Freq	Supp	TPQ-Apriori					Apriori Weka	
						Conf	Lift	Conv	Leve	CF	Supp	Conf
21	KELAPA MUDA, JAGOAN NEON	KUDA MAS STIK	3	44	10.65%	0.88	2.69	5.61	0.07	0.82	10.65%	0.88
22	KELAPA MUDA, JAGOAN NEON	KUDA MAS MAKARONI	3	44	10.65%	0.88	2.82	5.73	0.07	0.83	10.65%	0.88
23	MIE 89, JAGOAN NEON	KUDA MAS STIK	3	43	10.41%	0.88	2.68	5.61	0.07	0.82		
24	KELAPA MUDA, JAGOAN NEON	KUDA MAS STIK, KUDA MAS MAKARONI	4	43	10.41%	0.86	2.91	5.03	0.07	0.80	10.41%	0.86
25	MIE 89, TEPUNG WHITE BEAR	GULA PTPN	3	84	20.34%	0.85	1.98	3.81	0.10	0.74		
26	SOSIS SONICE SAPI, JAGOAN NEON	KUDA MAS STIK	3	52	12.59%	0.84	2.57	4.21	0.08	0.76	12.59%	0.84
27	MIE 89, GULA PTPN	TEPUNG WHITE BEAR	3	84	20.34%	0.82	1.99	3.26	0.10	0.69		
28	SOSIS SONICE SAPI, JAGOAN NEON	KUDA MAS MAKARONI	3	50	12.11%	0.81	2.58	3.62	0.07	0.72	12.11%	0.81
29	TEPUNG WHITE BEAR	GULA PTPN	2	137	33.17%	0.80	1.87	2.86	0.15	0.65	33.17%	0.80

From the results of testing the rules in Table 3, the rules produced by the Apriori Weka algorithm are 22. Referring to the specified threshold, namely a minimum support of 0.1 and a minimum confidence of 0.80, the resulting rules are not optimal because there are 7 rules that are not found, although they are slightly better than Fp-Growth Weka because there are 2 additional rules to be found. However, this rule has a different trust value from that produced by TPQ-Apriori; see Table 7 in rows 3 and 20, which are colored orange. Now we prove the correct confidence value. In Table 3, row 3, pay attention to the rule "MIE 89, KUDA MAS MACARONI => KUDA MAS STIK." The total support count or frequency is 64, while Transactions for the Kopegtel dataset of 100% volume is 413 transactions, so the result is 0. We multiply 1549 by 100% to get 15.49%, while to calculate the confidence, we divide 64 by the number of support or frequency of the antecedents "MIE 89, KUDA MAS MAKARONI", The support for the antecedent count "MIE 89, KUDA MAS MAKARONI" in the Kopegtel dataset is 65, so the result is 0.98. Thus, the value of trust in the TPQ-Apriori is correct, while the result of the Apriori Weka is 0.91,which is not quite right when referring to the trust formula. This value is also strengthened by the results of the Fp-Growth Rapid Miner. See Table 1, row 3, where the confidence value is 0.98. For information, the orange color is a rule that was not found, and the green color is a miscalculation of the confidence value. The number of support antecedents "MIE 89, KUDA MASMAKARONI" in the Kopegtel dataset is 65, so the result is 0.98, thus the trust value in TPQ-Aprioriis correct, while the Apriori Weka result is 0.91, which is not quite right when referring to the formula trust.

This value is also strengthened by the results of the Fp-Growth Rapid Miner. See Table 1, row 3, where, the confidence value is 0.98. For information, the orange color is a rule that was not found,d and the green color is a miscalculation of the confidence value. The number of support antecedents "MIE 89, KUDA MAS MAKARONI" in the Kopegtel dataset is 65, so the result is 0.98, thus the trust value in TPQ-Apriori is correct, while the Apriori Weka result is 0.91, which is not quite right when referring to the formula trust. This value is also strengthened by the results of the Fp-Growth Rapid Miner. See Table 1, row 3, where, the confidence value is 0.98. For information, the orange color is a rule that was not found, and the green color is a miscalculationof the confidence value. Because the implementation of the formula used is support 64 divided by 314 and confidence 64 divided by 65.

Table 4. Results of the tpq-Apriori algorithm rule with fp-growth rapidminer for 50% of the Kopegtel dataset

No	Antecdent	Consequent	Freq	TPQ-Apriori						Fp-Growth Rapidminer			
				Supp	Conf	Lift	Conv	Leve	CF	Supp	Conf	Lift	Conv
1	AMARTA COKLAT KACANG	AMARTA CHORY	29	0.10	0.97	8.26	29.43	0.09	0.97				
2	KOPYOR MANGGA	KOPYOR MELON	40	0.13	0.91	5.66	9.33	0.11	0.89	0.13	0.91	5.66	9.23

No	Antecdent	Consequent	Freq	TPQ-Apriori						Fp-Growth Rapidminer			
				Supp	Conf	Lift	Conv	Leve	CF	Supp	Conf	Lift	Conv
3	KOPYOR MELON	KOPYOR MANGGA	40	0.13	0.83	5.66	5.02	0.11	0.80	0.13	0.83	5.66	5.12
4	AMARTA CHORY	AMARTA COKLAT KACANG	29	0.10	0.83	8.26	5.29	0.09	0.81				
5	KUDA MAS MAKARONI	KUDA MAS STIK	37	0.12	0.82	4.24	4.48	0.09	0.78	0.12	0.82	4.24	4.53
6	FRENTA STROBERI	FRENTA ANGGUR	30	0.10	0.81	6.06	4.56	0.08	0.78	0.10	0.81	6.06	4.58
7	TEPUNG BERAS ROSE BRAND	TELER JUMBO	4	0.02	0.00	0.00	0.00	0.00	0.00	0.12	0.90	0.00	0.00
8	TEPUNG WHITE BEAR	TELER JUMBO	8	0.03	0.00	0.00	0.00	0.00	0.00	0.23	0.90	0.00	0.00
9	GULA PTPN	TELER JUMBO	9	0.03	0.00	0.00	0.00	0.00	0.00	0.24	0.89	0.00	0.00
10	GULA PTPN, TEPUNG WHITE BEAR	TELER JUMBO	6	0.02	0.00	0.00	0.00	0.00	0.00	0.14	0.87	0.00	0.00
11	MIE 89, GULA PTPN	TELER JUMBO	5	0.02	0.00	0.00	0.00	0.00	0.00	0.11	0.87	0.00	0.00
12	MIE 89	TELER JUMBO	14	0.05	0.00	0.00	0.00	0.00	0.00	0.31	0.87	0.00	0.00
13	TEPUNG KETAN ROSE BRAND	TELER JUMBO	5	0.02	0.00	0.00	0.00	0.00	0.00	0.11	0.86	0.00	0.00
14	KUDA MAS MAKARONI	TELER JUMBO	8	0.03	0.00	0.00	0.00	0.00	0.00	0.12	0.82	0.00	0.00
15	FRENTA STROBERI	TELER JUMBO	7	0.02	0.00	0.00	0.00	0.00	0.00	0.10	0.81	0.00	0.00
16	SOSIS SONICE SAPI	TELER JUMBO	17	0.06	0.00	0.00	0.00	0.00	0.00	0.23	0.80	0.00	0.00

Table 5. Results of the Tpq-Apriori Algorithm rule with Fp-Growth Weka for 50% of the Kopegtel dataset

No	Antecdent	Consequent	Freq	TPQ-Apriori						Fp-GrowthWeka			
				Supp	Conf	Lift	Conv	Leve	CF	Conf	Lift	Conv	Leve
1	AMARTA COKLAT KACANG	AMARTA CHORY	29	0.10	0.97	8.26	29.43	0.09	0.97				
2	KOPYOR MANGGA	KOPYOR MELON	40	0.13	0.91	5.66	9.33	0.11	0.89	0.91	5.66	7.39	0.11
3	KOPYOR MELON	KOPYOR MANGGA	40	0.13	0.83	5.66	5.02	0.11	0.80	0.83	5.66	4.55	0.11
4	AMARTA CHORY	AMARTA COKLAT KACANG	29	0.10	0.83	8.26	5.29	0.09	0.81				
5	KUDA MAS MAKARONI	KUDA MAS STIK	37	0.12	0.82	4.24	4.48	0.09	0.78	0.82	4.24	4.03	0.09
6	FRENTA STROBERI	FRENTA ANGGUR	30	0.10	0.81	6.06	4.56	0.08	0.78	0.81	6.06	4.01	0.08

Table 6. Results of the Tpq-Apriori Algorithm with Apriori Weka for 50% of the Kopegtel dataset

No	Antecdent	Consequent	Freq	TPQ-Apriori						Apriori Weka		
				Supp	Conf	Lift	Conv	Leve	CF	Supp	Conf	Lift
1	AMARTA COKLAT KACANG	AMARTA CHORY	29	0.10	0.97	8.26	29.43	0.09	0.97			
2	KOPYOR MANGGA	KOPYOR MELON	40	0.13	0.91	5.66	9.33	0.11	0.89	0.13	0.91	5.66
3	KOPYOR MELON	KOPYOR MANGGA	40	0.13	0.83	5.66	5.02	0.11	0.80	0.13	0.83	5.66
4	AMARTA CHORY	AMARTA COKLAT KACANG	29	0.10	0.83	8.26	5.29	0.09	0.81			
5	KUDA MAS MAKARONI	KUDA MAS STIK	37	0.12	0.82	4.24	4.48	0.09	0.78	0.12	0.82	4.24
6	FRENTA STROBERI	FRENTA ANGGUR	30	0.10	0.81	6.06	4.56	0.08	0.78	0.10	0.81	6.06

The test results in Table 4 are a comparison of the rules generated by the Fp-Growth rapidminer and TPQ-Apriori algorithms; the records marked in orange in rows 1 and 4 are rules that were not found by the Fp-Growth rapidminer algorithm. While the records that are colored grayscale are the rules generated by the Fp-Growth rapidminer algorithm, these rules are below the specified minimum support. The data contains 10 rules, but only 2 are displayed, so there are not too many in the displayed table. The rule should not meet the requirements to display. For example, we are calculating support for record 7, the support count from the rule "TEPUNG BERAS ROSE BRAND => TELER JUMBO" is 4, so $Support = \frac{4}{299}$= 0.013 multiplied by 100% the result is 1% even though the minimum support set is 0.1 or 10% of ΣTransactions, 299 is ΣTransactions of the kopegtel dataset for 50% of the volume.

The results of the rule test in Table 8 are a comparison of the rules produced by TPQ-Apriori and Fp-Growth Weka where there are 2 rules not found in Fp-Growth Weka. This is very reasonable because the frequency of the 2 rules that are not found is the rule "AMARTA CHOCOLATE BEANS => AMARTA CHORY" and vice versa is 29 using the formula $Support = \frac{29}{299}$= 0.097 in TPQ-Apriori this value is rounded up to 0.10 or 10% of ΣTransactions. So that this rule appears on TPQ-Apriori. Meanwhile, Fp-Growth Weka has no tolerance for the specified minimum support value.

Table 7. Results of the tpq-Apriori algorithm rule with fp-growth rapidminer for 25% of the Kopegtel dataset

No	Antecedent	Consequent	Freq	TPQ-Apriori						Fp-Growth Rapidminer			
				Supp	Conf	Lift	Conv	Leve	CF	Supp	Conf	Lift	Conv
1	FRENTA ANGGUR, FRENTA LEMON	FRENTA STROBERI	15	0.07	1.00	8.36	∞	0.06	1.00	0.07	1.00	8.36	∞
2	FRENTA STROBERI, FRENTA JERUK	FRENTA ANGGUR	14	0.07	1.00	8.36	∞	0.06	1.00				
3	KOPYOR MANGGA	KOPYOR MELON	19	0.09	0.90	7.56	8.80	0.08	0.89	0.09	0.90	7.56	9.24
4	FRENTA ANGGUR,FRENTA JERUK	FRENTA STROBERI	14	0.07	0.88	7.32	7.34	0.06	0.86				
5	FRENTA STROBERI, FRENTA LEMON	FRENTA ANGGUR	15	0.07	0.88	7.38	7.34	0.06	0.86	0.07	0.88	7.38	7.48
6	FRENTA STROBERI	FRENTA ANGGUR	20	0.10	0.80	6.69	4.40	0.08	0.77	0.10	0.80	6.69	4.40
7	FRENTA ANGGUR	FRENTA STROBERI	20	0.10	0.80	6.69	4.40	0.08	0.77	0.10	0.80	6.69	4.40
8	TEPUNG WHITE BEAR	TELER JUMBO	3	0.01	0.00	0.00	0.00	0.00	0.00	0.15	0.91	1.06	1.63
9	FRENTA COLA	TELER JUMBO	2	0.01	0.00	0.00	0.00	0.00	0.00	0.10	0.91	1.06	1.58
10	GULA PTPN	TELER JUMBO	5	0.02	0.00	0.00	0.00	0.00	0.00	0.21	0.90	1.05	1.38
11	TEPUNG BERAS ROSE BRAND	TELER JUMBO	4	0.02	0.00	0.00	0.00	0.00	0.00	0.16	0.89	1.04	1.36
12	FRENTA LEMON, FRENTA COLA	TELER JUMBO	2	0.01	0.00	0.00	0.00	0.00	0.00	0.07	0.88	1.03	1.22
13	GULA PTPN, TEPUNG WHITE BEAR	TELER JUMBO	3	0.01	0.00	0.00	0.00	0.00	0.00	0.10	0.87	1.02	1.10
14	TEPUNG KETAN ROSE BRAND	TELER JUMBO	5	0.02	0.00	0.00	0.00	0.00	0.00	0.15	0.86	1.01	1.06
15	MIE 89	TELER JUMBO	8	0.04	0.00	0.00	0.00	0.00	0.00	0.21	0.84	0.98	0.92
16	KUDA MAS MAKARONI	TELER JUMBO	4	0.02	0.00	0.00	0.00	0.00	0.00	0.10	0.84	0.98	0.90
17	FRENTA STROBERI	TELER JUMBO	4	0.02	0.00	0.00	0.00	0.00	0.00	0.10	0.84	0.98	0.90
18	TEPUNG BERAS ROSE BRAND, TEPUNG KETAN ROSE BRAND	TELER JUMBO	4	0.02	0.00	0.00	0.00	0.00	0.00	0.10	0.84	0.98	0.90
19	FRENTA LEMON	TELER JUMBO	4	0.02	0.00	0.00	0.00	0.00	0.00	0.10	0.83	0.97	0.86
20	ICE COCO	TELER JUMBO	5	0.02	0.00	0.00	0.00	0.00	0.00	0.11	0.82	0.96	0.80
21	KUDA MAS RUJAK	TELER JUMBO	4	0.02	0.00	0.00	0.00	0.00	0.00	0.09	0.82	0.96	0.79
22	KUDA MAS STIK	TELER JUMBO	5	0.02	0.00	0.00	0.00	0.00	0.00	0.10	0.80	0.93	0.72
23	FRENTA ANGGUR	TELER JUMBO	5	0.02	0.00	0.00	0.00	0.00	0.00	0.10	0.80	0.93	0.72

No	Antecedent	Consequent	Freq	TPQ-Apriori						Fp-Growth Rapidminer			
				Supp	Conf	Lift	Conv	Leve	CF	Supp	Conf	Lift	Conv
24	TELER JUMBO, FRENTA ANGGUR	FRENTA STROBERI	4	0.02	0.00	0.00	0.00	0.00	0.00	0.08	0.80	6.69	4.40
25	FRENTA STROBERI, FRENTA ANGGUR	TELER JUMBO	4	0.02	0.00	0.00	0.00	0.00	0.00	0.08	0.80	0.93	0.72

Table 8. Results of the tpq-Apriori algorithm rule with fp-growth weka for 25% of the Koegtel dataset

No	Antecedent	Consequent	Freq	TPQ-Apriori						Fp-Growth Weka			
				Supp	Conf	Lift	Conv	Leve	CF	Supp	Conf	Lift	Conv
1	FRENTA ANGGUR, FRENTA LEMON	FRENTA STROBERI	15	0.07	1.00	8.36	∞	0.06	1.00	0.07	1.00	8.36	13.21
2	FRENTA STROBERI, FRENTA JERUK	FRENTA ANGGUR	14	0.07	1.00	8.36	∞	0.06	1.00				
3	KOPYOR MANGGA	KOPYOR MELON	19	0.09	0.90	7.56	8.80	0.08	0.89	0.09	0.90	7.56	6.16
4	FRENTA ANGGUR,FRENTA JERUK	FRENTA STROBERI	14	0.07	0.88	7.32	7.34	0.06	0.86				
5	FRENTA STROBERI, FRENTA LEMON	FRENTA ANGGUR	15	0.07	0.88	7.38	7.34	0.06	0.86	0.07	0.88	7.38	4.99
6	FRENTA STROBERI	FRENTA ANGGUR	20	0.10	0.80	6.69	4.40	0.08	0.77				
7	FRENTA ANGGUR	FRENTA STROBERI	20	0.10	0.80	6.69	4.40	0.08	0.77				

Table 9. Results of the tpq-Apriori algorithm with Apriori weka for 25% of the Kopegtel dataset

No	Antecedent	Consequent	Freq	TPQ-Apriori						Apriori Weka		
				Supp	Conf	Lift	Conv	Leve	CF	Supp	Conf	Lift
1	FRENTA ANGGUR, FRENTA LEMON	FRENTA STROBERI	15	0.07	1.00	8.36	∞	0.06	1.00	0.07	1.00	8.36
2	FRENTA STROBERI, FRENTA JERUK	FRENTA ANGGUR	14	0.07	1.00	8.36	∞	0.06	1.00			
3	KOPYOR MANGGA	KOPYOR MELON	19	0.09	0.90	7.56	8.80	0.08	0.89	0.09	0.90	7.56
4	FRENTA ANGGUR,FRENTA JERUK	FRENTA STROBERI	14	0.07	0.88	7.32	7.34	0.06	0.86			
5	FRENTA STROBERI, FRENTA LEMON	FRENTA ANGGUR	15	0.07	0.88	7.38	7.34	0.06	0.86	0.07	0.88	7.38
6	FRENTA STROBERI	FRENTA ANGGUR	20	0.10	0.80	6.69	4.40	0.08	0.77	0.10	0.80	7.69
7	FRENTA ANGGUR	FRENTA STROBERI	20	0.10	0.80	6.69	4.40	0.08	0.77	0.10	0.80	7.69

The results of testing the rules in Tables 8 and 9 are a comparison of the rules produced by TPQ-Apriori with Apriori Weka and Fp-Growth Weka, where there are 2 rules not found in Apriori Weka. It's the same with Fp-Growth, which has no tolerance for support values. From the results of Table 7, the results of a comparison of the rules produced by TPQ-Apriori with Fp-Growth rapidminer at TPQ-Apriori yielded the 7 best rules with a minimum threshold support of 0.07 and a minimum confidence of 0.8. A minimum support of 0.07 was chosen because it uses a minimum support of 0.1 on Fp-Growth weka, and Apriori weka do not produce the best rules. Meanwhile, Fp-Growth RapidMiner produced 23 rules, but only 5 of them matched the specified threshold. The rest is the wrong rule, starting from the 8th record to the 25th record, because the support is below the specified minimum support. Table 7 shows the results of testing the rules from TPQ-Apriori with Fp-Growth Weka, where the rules from TPQ-Apriori are 7 rules while the rules from Fp-Growth Weka are only 3 rules. With this result, TPQ-Apriori is more optimal.

Table 9 shows the results of testing the rules from TPQ-Apriori with Apriori Weka, where the rules from TPQ-Apriori are 7 rules and the rules from Apriori Weka are 5 rules. TPQ-Apriori is more optimal, but the rules from Apriori Weka are better than those from Fp-Growth Weka for 25% of the Koegtel dataset volume. From the overall results of testing the rules with good Koegtel datasets for 100%, 50%, and 25% of the total dataset volume, a conclusion can be drawn that

the larger the dataset to be processed, the more optimal the results will be when using the Fp-Growth Rapidminer algorithm, but not optimal if the dataset to be processed is a small dataset. It's different from using the Apriori and Fp-Growth Weka algorithms. Where the resulting rule is less than optimal if the dataset used is large and optimal if the dataset is small. Some rules are not displayed in the algorithms in the Fp-Growth Weka and Apriori Weka algorithms because the two algorithms do not have a tolerance value for the support of the rules that will be displayed. Meanwhile, the method proposed and developed in the form of a tool called TPQ-Apriori is capable of producing optimal and consistent rules for both large and small datasets.

From the results of the analysis of all comparisons of evaluation values for support, confidence, lift ratio, and leverage values, there is no difference, while for conviction there are differences, but the values are close to the same, but they are also the same. But what is unique here is that the conviction value between those produced by the Fp-Growth algorithm in Weka tools is different from the results of the Fp-Growth algorithm in Rapidminer tools. And also, there are rules that are not correctly found or displayed by the Fp-Growth algorithm with RapidMiner tools. Even though this rule has a support value that is very far from fulfilling the minimum support limit that has been set, Thus, it can also be concluded that the rules generated by Fp- Growth RapidMiner are inconsistent. Meanwhile, the rules generated by Fp-Growth Weka and Apriori Weka are slightly more consistent, although sometimes there are a few rules that cannotbe displayed. Overall, they are quite consistent. And finally, the method proposed with the TPQ-Apriori tools is able to produce optimal and consistent rules. Fp-Growth in RapidMiner tools, as well as Fp-Growth and Apriori in Weka tools. To make iteasier, we can see it as shown in Figure 2.

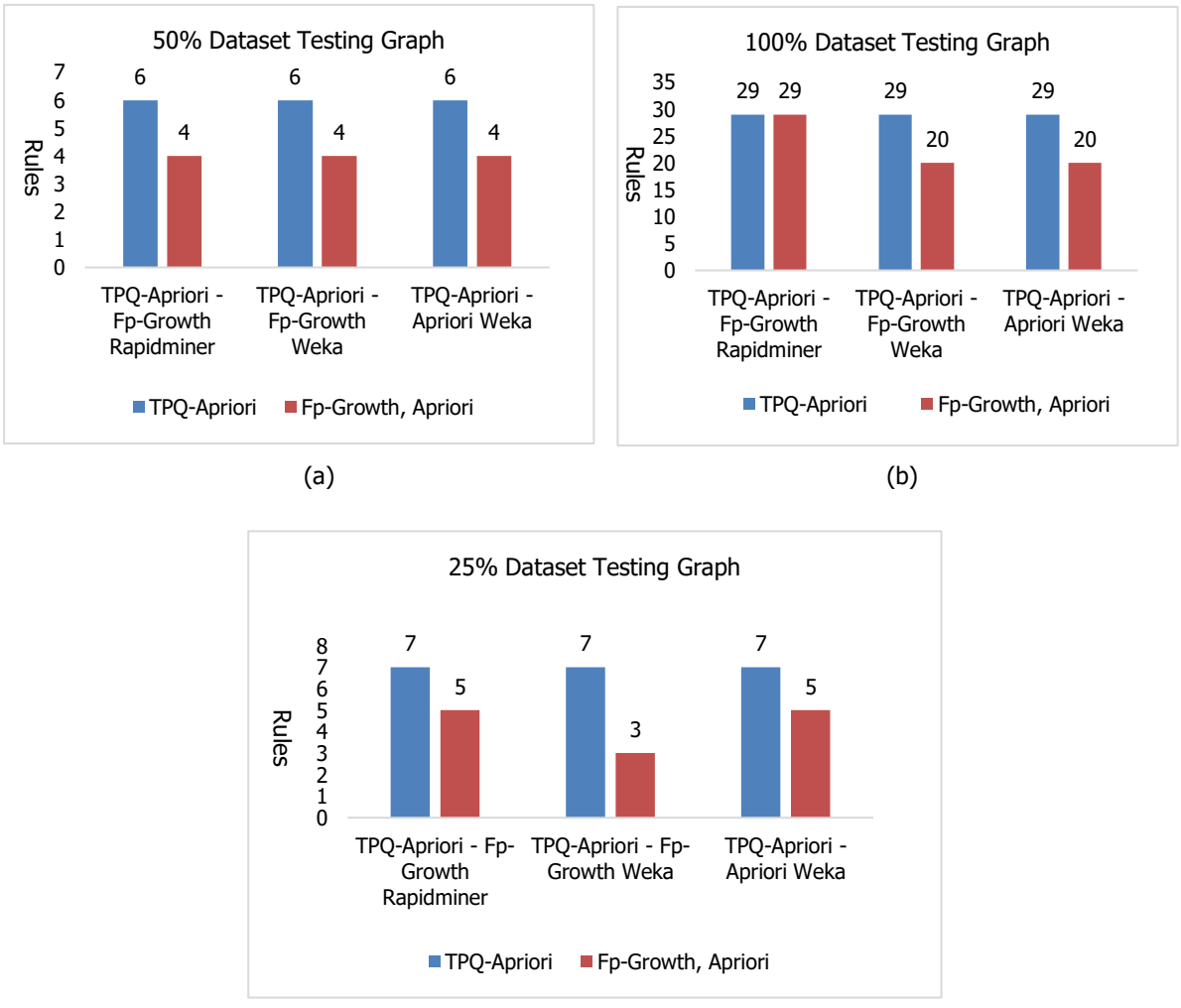

Figure 2. Comparison Chart

We can see the data referred to by the graph; the data depicted in blue are the results from TPQ-Apriori, while the orange ones are the results from Fp-Growth and Apriori from both RapidMiner and Weka tools. While the division of the dataset used is 100%, 50%, and 25%.

Conclusions

The Apriori algorithm is one part of the association rule algorithm with an associative approach. The Apriori algorithm is easy to implement and has the advantage of being able to produce optimal rule combinations. However, the weakness is the very long dataset scan time. Long dataset scans are caused by the process of searching for the frequency of items or support counts in the dataset. Items in the association rule algorithm are attributes or features that will be searched for their frequency or support count. So the bigger the volume, the more items. The length of time the dataset is scanned will have an impact on the amount of memory and processor usage. The priority in this study is to compare three algorithms, namely Apriori, fp-growth, and TPQ-Apriori, with the same dataset to see and ensure the formation of optimal and consistent rules. The test was carried out using the NTB Telkom employee cooperative dataset, which can be downloaded on the Kaggle site.

As for the results of testing the basic rules of the overall results of testing the rules with the Kopegtel dataset both for 100%, 50%, and 25% of the total dataset volume, it can be concluded that the larger the dataset to be processed, the results will be more optimal if using the RapidMiner fp-growth algorithm, but not optimal if the dataset to be processed is a small dataset. In contrast to using the FP-growth Apriori and Weka algorithms, where the resulting rules are less optimal if the dataset used is large and optimal if the dataset is small. The methods used for comparison are the traditional Apriori algorithms fp-growth and TPQ-Apriori, Traditional Apriori, FP-growth, and TPQ-Apriori. For rule testing, the results of the TPQ-Apriori rule were compared to the Fp-Growth algorithm in the Rapidminer and Weka tools and the Apriori algorithm in the Weka tools. From the test results, TPQ-Apriori is able to be more optimal and consistent.

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Library apps to improve the digitization of Sekolah Penggerak Program

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Abstract: Education is a planned means for human development and progress, especially in Indonesia. Education programs in Indonesia have changed from year to year. The first programs were the Rencana Pelajaran Curriculum in 1947, Pendidikan Curriculum in 1975, the Competency-Based Curriculum in 2004, the 2013 Curriculum, and the Merdeka Curriculum 2022 until now. Sekolah Penggerak Program is one of the curriculum implementations that play a role in making operations that suit the learning needs of students at school. One of the interventions in Sekolah Penggerak Program is digitizing schools using various platforms to support student learning and creativity. There are still many Sekolah Penggerak that have not maximized the use of digitalization, one of which is Pelita Kasih Kindergarten. Pelita Kasih Kindergarten is one of the Sekolah Penggerak in Buleleng Regency. Pelita Kasih Kindergarten still uses manual recording to record borrowing books borrowed by students or parents of students. These problems can hamper the learning process and are considered less efficient. Therefore, a system was developed to assist library management and book lending to minimize errors and human errors that could occur. Library system development in this study using the prototype method. The prototype method is used to allow interaction between system developers and system users, it can overcome discrepancies that may occur between developers and users. The results of information system testing using the black box method show that 91% of the functionality is appropriate and it is an indicator of the success of the designed information system.

Keywords: merdeka curriculum, Sekolah Penggerak, prototype, digitalization, black box

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Introduction

Education is a means to advance all areas of human life, both in the social, economic, technological, welfare, cultural, and national progress [1]. In Indonesia, education is a top priority in every government program. This statement is evidenced by the highest state budget (APBN) budget for education amounting to 20% of the APBN according to the mandate of the Constitution UUD 1945 pasal 31 ayat (4) and UU No. 20 of 2003 concerning the National Education System pasal 49 ayat (1) [2].

Various educational programs have been implemented in Indonesia starting from the 1947 Rencana Pelajaran Curriculum, 2013 curriculum improvements, full-day school in 2018, and the 2022 Merdeka belajar curriculum to date [3]. The education program continues to develop and experience improvements to improve the quality of human resources starting from early childhood education. The Minister of Education of Indonesia, Nadiem Anwar Makarim, in 2021 has implemented a new program, namely Sekolah Penggerak Program. Sekolah Penggerak Program is a catalyst for realizing Indonesia's educational vision which focuses on developing student learning outcomes holistically by realizing Pancasila Student Profile [4]. Sekolah Penggerak Program is an effort to realize the vision of Indonesian Education in realizing an advanced Indonesia that is sovereign, independent, and has personality through the creation of Pancasila Students [5].

Sekolah Penggerak Program focuses on developing student learning outcomes in a holistic manner which includes competence (literacy and numeracy) as well as character, starting with advanced human resources (principals teachers) [6]. This program is a refinement of the previous school transformation program. TheMobilization School Program will accelerate schools in all conditions to move 1-2 stages further. The program is carried out in stages and

integrated with the ecosystem so that all schools in Indonesia become the Sekolah Penggerak Program [7]. This is of course a joint commitment in efforts to improve the quality of education in Indonesia.

Sekolah Penggerak program consists of five interventions from the Ministry of Education and Culture in Indonesia that can assist curriculum implementation and are interrelated. The five interventions are as follows [8]:

1. Consultative and Asymmetric Assistance
   The Ministry of Education and Culture through units in each Province as well as Districts/Cities provides assistance and also facilities in carrying out socialization and finding solutions if there are problems during implementation in the field.
2. Strengthening Human Resources in Schools
   The strengthening of human resources carried out by the Ministry of Education and Culture to support the success of the prototype curriculum is by providing intensive assistance (coaching) with expert trainers who have been provided one to one.
3. Learning with a New Paradigm
   In learning with a new paradigm the focus of the Sekolah Penggerak program is to design learning that is differentiated according to the stage of its development.
4. Data-driven planning
   In this intervention, the Ministry of Education and Culture packaged a school-based management system whose planning was based on the results of self-reflection from schools through portrait reports of school quality conditions.
5. Digitizing Schools
   There are lots of digital platforms provided by the Ministry of Education and Culture that can be accessed by teachers, school principals, or various related parties that can be used as references to reduce the occurrence of problems.

One of the interventions is school digitalization by using various platforms to support the Sekolah Penggerak program. In this case, Pelita Kasih Singaraja Kindergarten still uses manual recording to record borrowed books borrowed by students or parents of students. Pelita Kasih Singaraja Kindergarten is one of the PAUD schools registered as the first generation of Sekolah Penggerak Program.

In addition, the school does not yet have a database of the list of books in the Pelita Kasih Kindergarten library. These problems can more or less hamper the learning process and are considered less efficient. Therefore, an information system was developed to assist library management and book lending to minimize human error that could occur. Information systems are organized ways to collect, enter, process, store data, process, and report information in such a way that it becomes valuable information [9]. Library digitization is needed to record all book lending transactions so that the learning process can be fast and efficient. The library program is created using PHP Laravel framework and MySQL database. Laravel is used because this framework emphasizes simplicity and flexibility in its design [10]. The MySQL database is used because MySQL is a popular open-source SQL database management system that is being developed and developers will not infringe on copyright when using a license from MySQL [11]. The digital library is designed to be accessed through websites and mobile phones because of the dynamic design of each gadget.

Various studies regarding the development of library systems have been carried out. Research conducted by Supriyanto Wahyu with the title "Digital Library Service System Development". This study discusses the importance of implementing information technology in library networks because of the many conveniences provided to users to access digital information in libraries [12]. Subsequent research was conducted by Athanasia Octaviani Puspita Dewi with the title "Use of Mobile Libraries for Digital Libraries". This research develops a mobile-based digital librarywith several features such as member registration, circulation, member management, and digitalcollections. With the several conveniences that can be obtained from using this mobile library, itis hoped that the library can consider switching to a digital library for the progress of the library itself and user satisfaction [13].

Research on other library digitization by B. Gavit entitled "Web-Based Library Services". The author explains that the first and foremost function of the library is to provide quality information service to satisfy its users with the right information at the right time. With the help of a library webpage, the library can easily propagate its services and facilities to the academic community worldwide. According to the author, here are some advantages of having a web-based library application: it saves the precious time of the users, a large number of users can be helped simultaneously by using web-based library services, less dependent on the library staff for getting the required information, no need of library staff in large numbers to carry out library works and services, fulfill information requirements instantly, operating costs are minimal, saves considerable storage space and fast publication [14].

Based on this background, a library information system is proposed for Pelita Kasih schools. The information system will help digitize schools to achieve the goals of Sekolah Penggerak program. In addition, the information system will also facilitate the process of borrowing and recording books in schools. In the future, this information system will continue to be developed so that it can reach all Sekolah Penggerak at the national level.

Methodology

The method used in this study is the prototype method. The prototype method is a way of developing the initial device by first designing the initial appearance [15]. The purpose of using the prototype method is to increase interaction between developers and users so that applications can run as expected by users [16]. In addition, if there is an error in the system, the developer can immediately find out and fix the error.

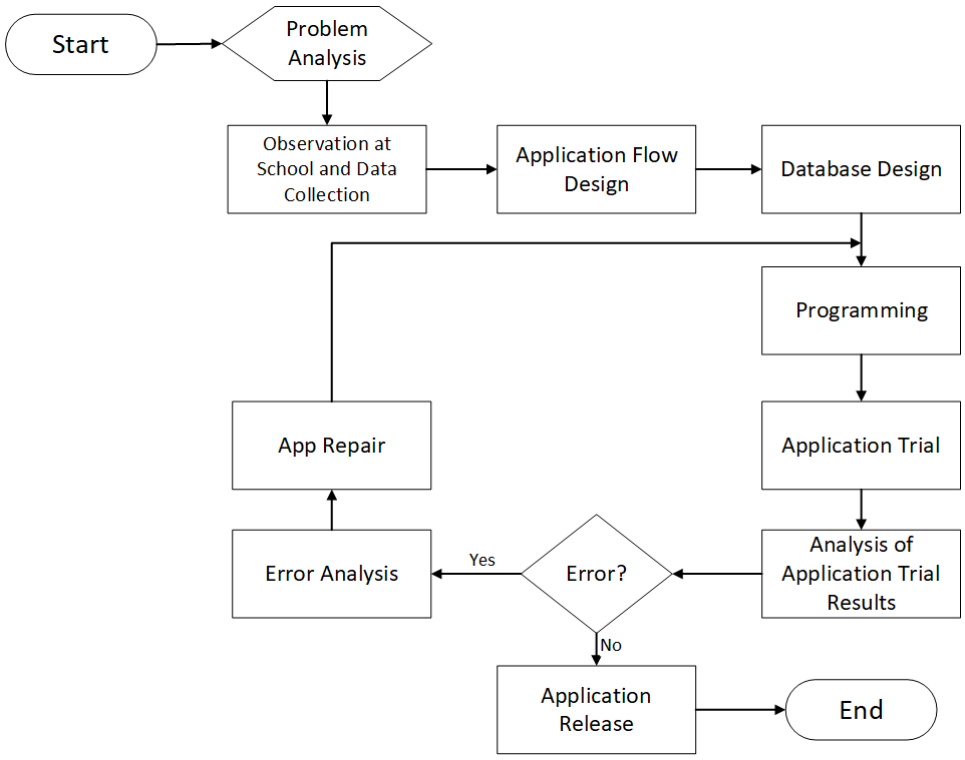

Figure 1. Library app prototype model

Figure 1 is the research process that has been used with the prototype model. The purpose of designing this system is to improve accessibility to library resources and streamline library management. The initial stage of analyzing the problems encountered was then conducting direct observations at the school, namely Pelita Kasih Singaraja Kindergarten. Identify the needs of library information systems by understanding the needs of kindergarten schools, librarians, teachers, and students. Gather information about desired features such as cataloging books, managing borrowing processes, tracking user accounts, and providing an easy-to-use interface.

After observation, it turns out that the process of reporting student learning outcomes and library management still uses manual recording and uses hardcopy reports. Therefore, a digital library application was developed to support the digitization of Sekolah Penggerak program starting from designing the application flow and designing the database design.

After designing the application flow and database, followed by designing a prototype design. Based on the requirements collected, design the structure, interface, and functionality of the library information system prototype, a prototype design was carried out with the following considerations.

1. User Interface Design.
   Designing visually appealing and intuitive interfaces suitable for young children. Use child-friendly colors, icons and fonts and ensure the interface is easy to navigate and understand.
2. Cataloging and Search Functions.
   Designing a system that allows librarians to catalog books based on title, author, genre, and other relevant attributes. Implemented a search function that allows users to easily find books based on different criteria, such as age group or topic.
3. User Accounts and Loan Management.
   Develop mechanisms to create user accounts for students and teachers, enabling them to borrow books. Added features such as book reservations, due date reminders, and tracking borrowed books.
4. Reporting and Analytics.
   Combines features that allow librarians and administrators to create reports on book circulation, popular books, or user preferences. This report can assist in making decisions about resource allocation and library improvement.

The next stage is testing the digital library application. If an error or error occurs during the trial, then the database repair and programming of the application are carried out. The trial process was carried out with the principal of the teaching teacher, and parents of students at Pelita Kasih Singaraja Kindergarten. Testing and evaluation activities need to be carried out to assess the effectiveness of the prototype and gather feedback. Testing involves kindergarten school librarians, teachers, and even children in the testing process. Based on the test, feedback will be obtained about the usability of the system, functionality, and the overall user experience, and then record problems.

The next stage is identifying areas that require further refinement or development. Based on the analysis, repeat the prototyping process by making necessary adjustments and improvements. The final stage is the release of the digital library application which has been started to beused in Pelita Kasih Singaraja Kindergarten. After conducting various trials and improvements tothe application, the digital library application can be used by Pelita Kasih Singaraja Kindergarten,one of the school movers in Buleleng Regency.

Results and Discussions

The research phase begins with problem analysis. there are several problems in the Pelita Kasih Singaraja Kindergarten library so it requires an information system. Pelita Kasih Kindergarten is one of the school movers initiated by the Indonesian Minister of Education which is obliged to digitize the process of borrowing books in the library and student study reports. Furthermore, there are quite a lot of books owned by Pelita Kasih Kindergarten, making it difficult for library staff to search for books. Then the process of borrowing books by students is still doing notebooks which if the notebook is lost then the entire history of borrowing books is also lost.

The next stage was conducting interviews with the school principal to find out the flow of borrowing books at Pelita Kasih Kindergarten and looking directly at the transaction book for borrowing books. The results of these observations serve as the basis for designing a library information system according to the needs of Pelita Kasih Kindergarten.

Figure 2 describes the flow of digital library applications that can be accessed via a browser on a computer or smartphone. There is a library admin entity that can manage book data, school profile data, student data, lists of book loans, and book borrowing history. Admins can add

usernames and passwords for each student so parents can log into the system and borrow books. Library administrators can be 1 or more and are appointed directly by the school principal.

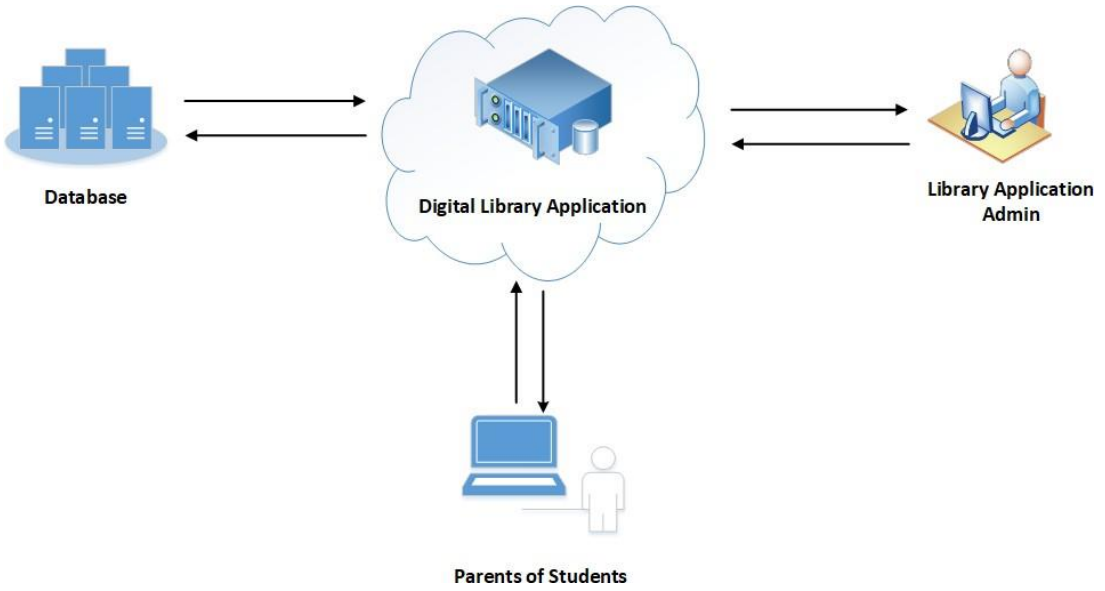

Figure 2. Overview of digital library applications

The student's parent entity displays a list of books that can be borrowed. Parents of students who are logged in can borrow books as needed and return books which will later be updated by the library admin. All transaction processes carried out by the admin and parents of students will enter the system database.

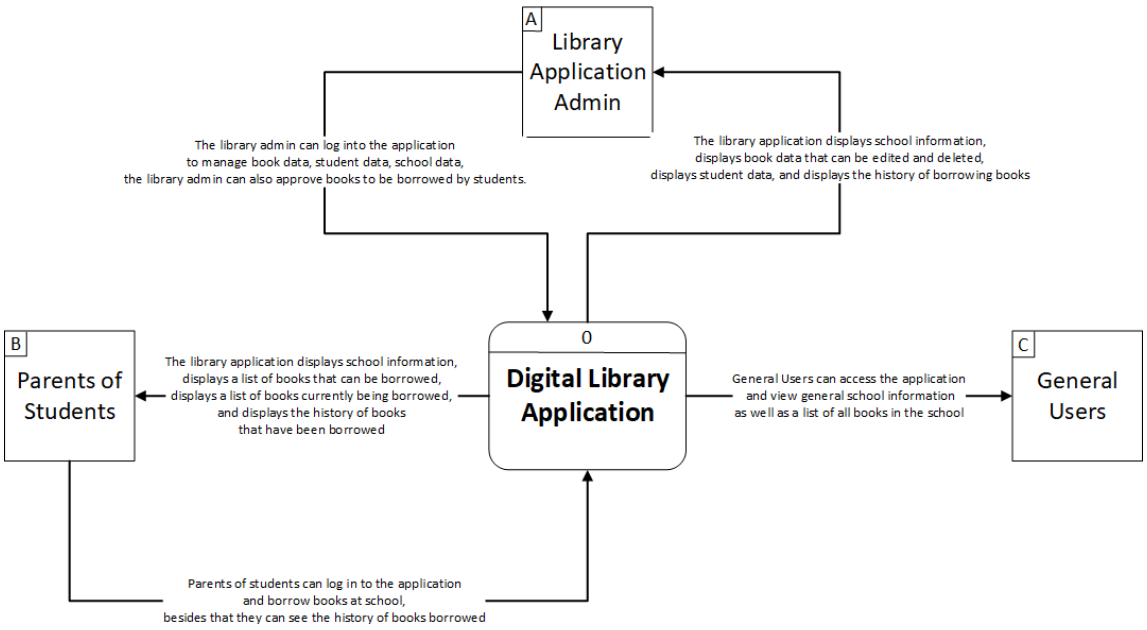

Figure 3. Data flow diagrams

Data flow diagrams (DFD) for digital library applications explain the relationship between entities that can access the system. Data flow diagrams can be seen in Figure 3. In this library application, there are 3 entities namely library admin, parents and general users.

1. The library admin can manage school data such as school profile data, book data, student data, and book loan transactions. School profile data and book data inputted by the admin will appear on the school home page.

2. Parents of students can access the application by logging in first. After logging in, parents of students can borrow books and can read books that are available online.
3. General users can only access the home page of the provided library application. There is some information on the school's home page such as the school's vision and mission, address, social media, and a list of books in Pelita Kasih Singaraja Kindergarten.

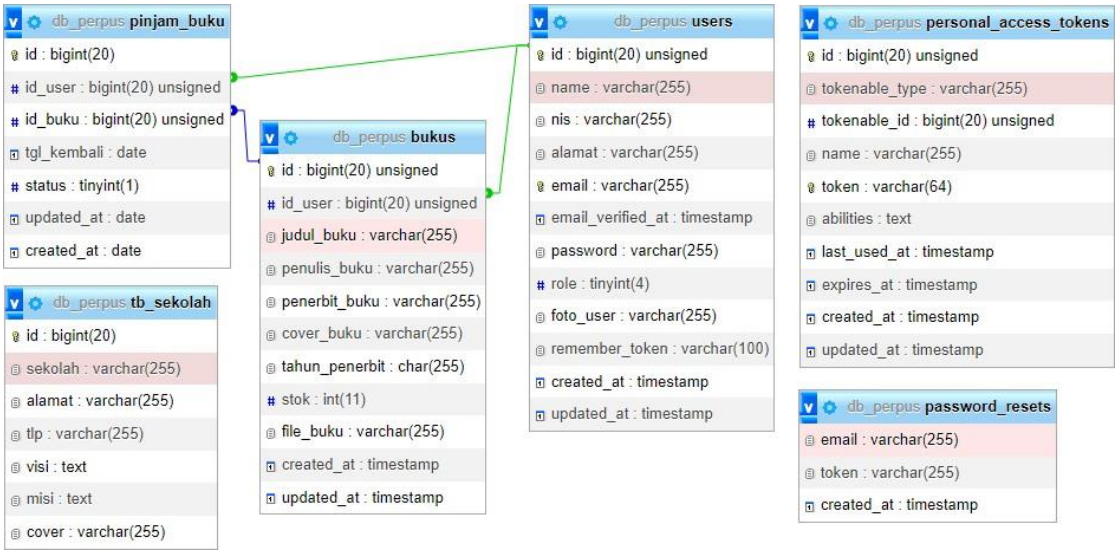

Figure 4. Library apps database

Figure 4 is a library application database schema. There are several tables to store transactions made. The tb_sekolah table contains school data such as address, telephone, vision, mission, and school logo. The users table contains student data, identification number, address, email, photo, username, and password. The bukus table contains book data, title, author, publisher, year of publication, stock, book files, and cover photos. The pinjam_buku table contains transaction data for borrowing books, book return dates, and book status.

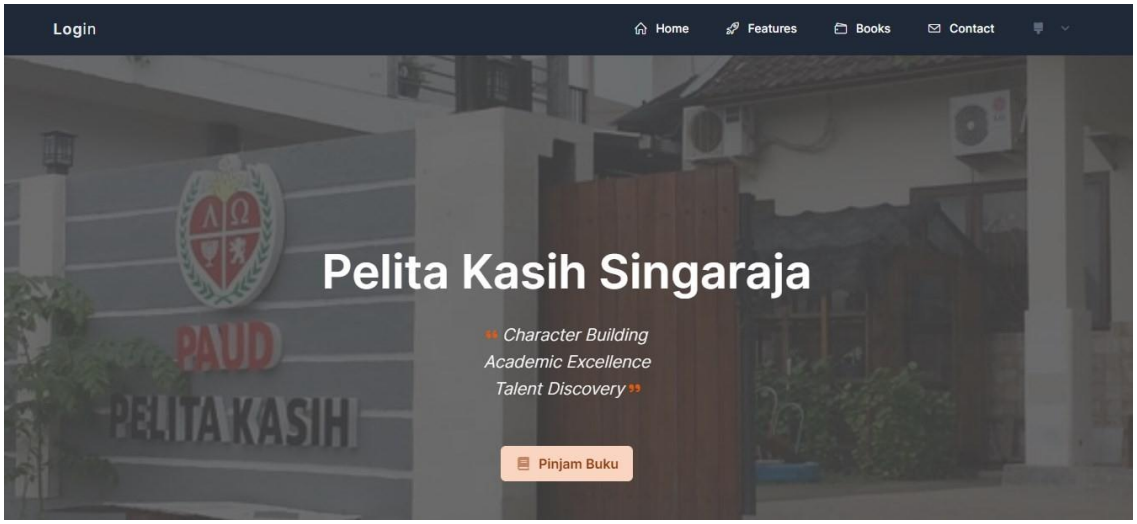

Figure 5. Library app home page

Figure 5 is the initial page of the library application for the Sekolah Penggerak Program (PSP). Users can immediately see a list of books that have been inputted by the library admin and can log into the system.

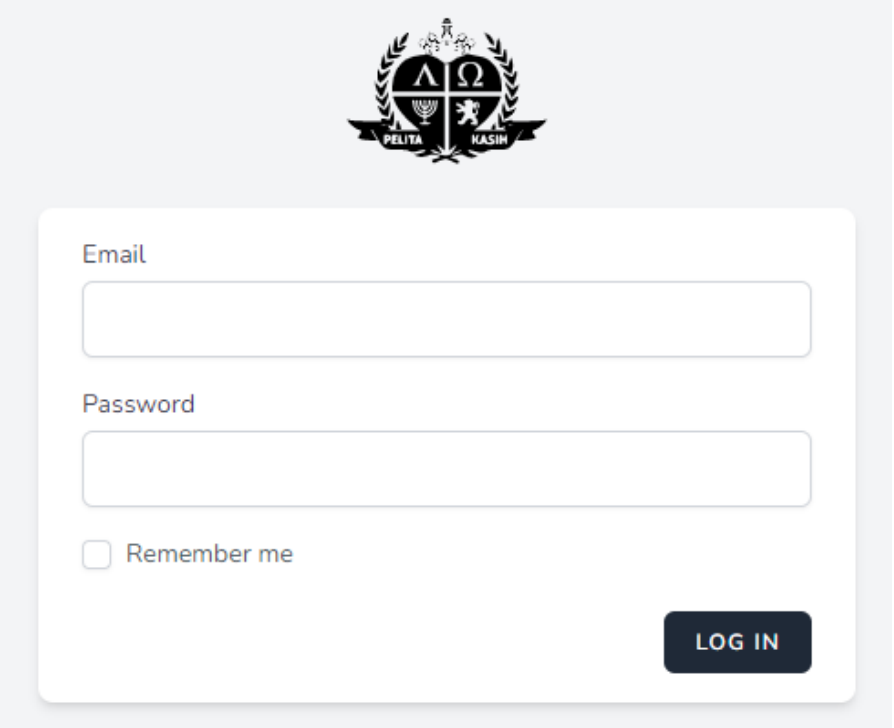

Figure 6. Login page

Figure 6 is the login page to enter the digital library application. Two entities can log in, namely the library admin from the school and parents of students to be able to borrow books.

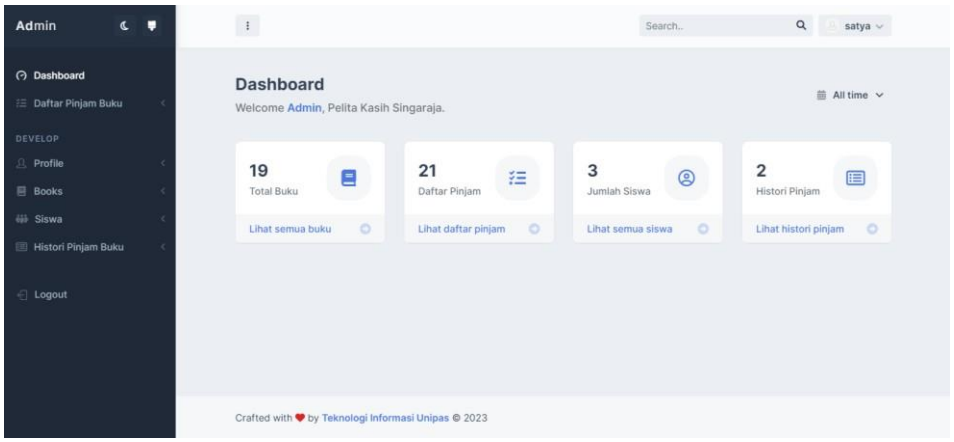

Figure 7. Library admin page

Figure 7 is the display of the digital library admin page. Library administrators can manage various data, namely book data, student data, book borrower data, and book borrowing history. On the dashboard page, the admin can see the amount of each of these data. The admin page is designed with navigation assistance on the left and a search feature on the top right. The design of this feature is to make it easier for admins and librarians to manage all book transactions and prioritize the appearance of the system to ordinary users.

Figure 8. List of book loans on the admin page

Figure 8 is a view of the book borrow list page. Admin can update data on borrowing books borrowed by students. Admin can see the date of borrowing books and the status of borrowing books.

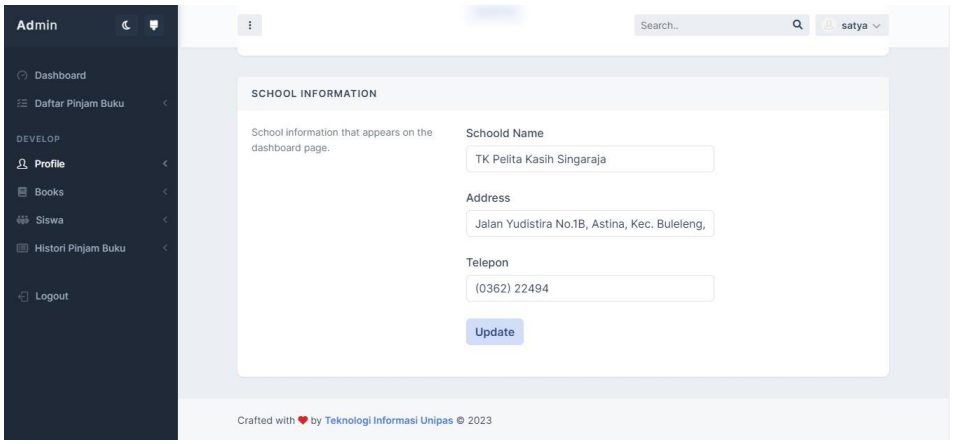

Figure 9. School profile on the admin page

Figure 9 is a school profile page. Admins can manage school profiles such as school name, address, telephone, and school social media.

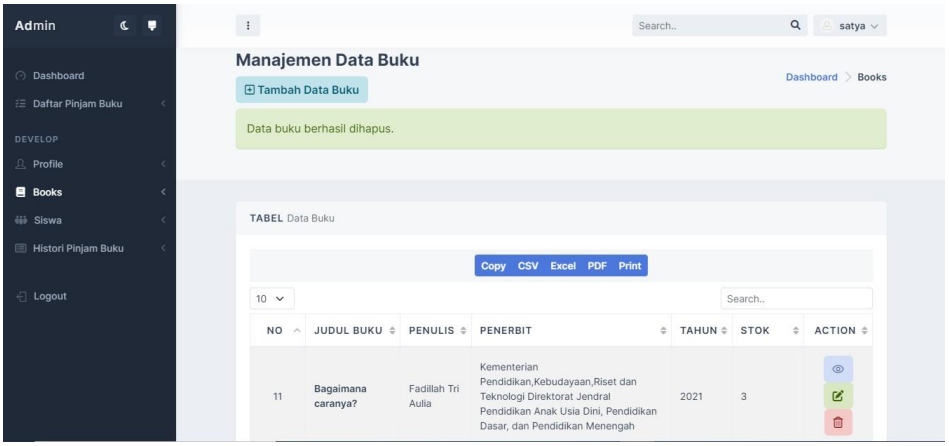

Figure 10. Book data management on the admin page

Figure 10 is a book data page. Admin can manage book data such as adding books, editing book data and deleting books. A list of existing books will appear on the homepage of the digital library application.

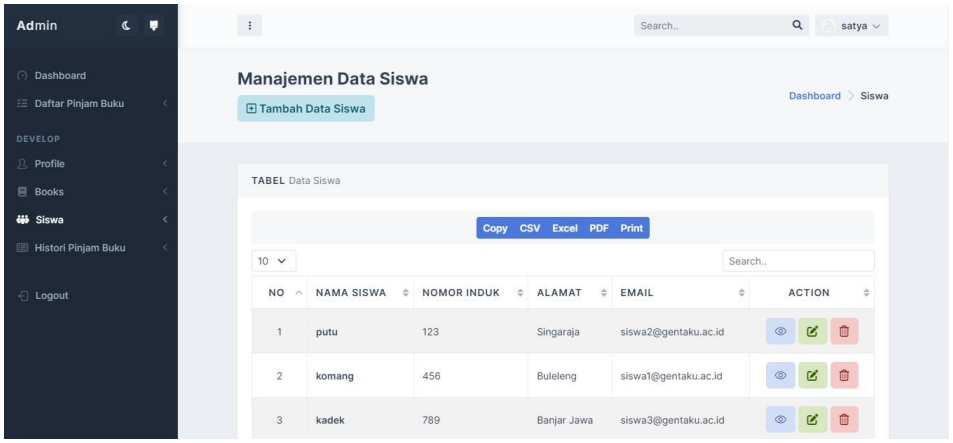

Figure 11. Student data management on the admin page

Figure 11 is a student data page. Admin can manage student data such as adding students, editing student data, and deleting students.

Figure 12. Book borrowing history on the admin page

Figure 12 is the book lending history page. Admin can see students who borrowed books and the total number of books borrowed.

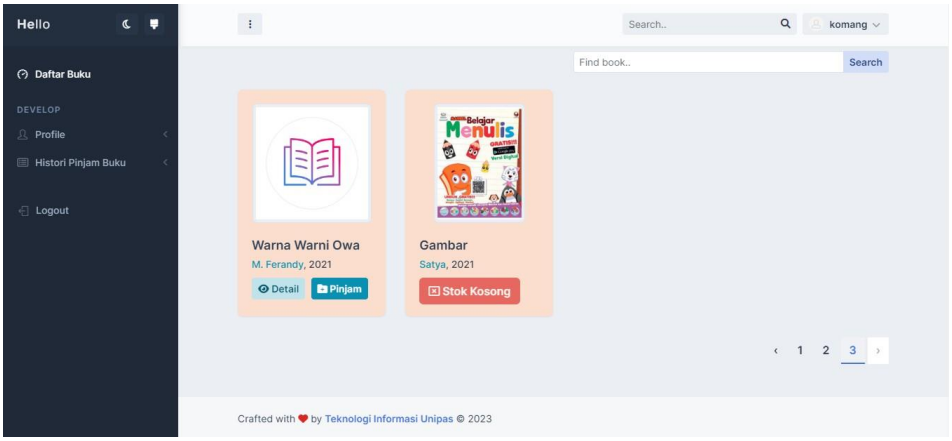

Figure 13. Home page when students log in

Figure 13 is the student's parent page when logging into the digital library application. The student page after logging in displays a list of books that can be borrowed and books that cannot be borrowed because they are out of stock. Students can borrow books by clicking on the Borrow

button. Student pages are visually appealing and child-friendly. This page provides a book search feature to make it easier to find books by title, author, or year of publication.

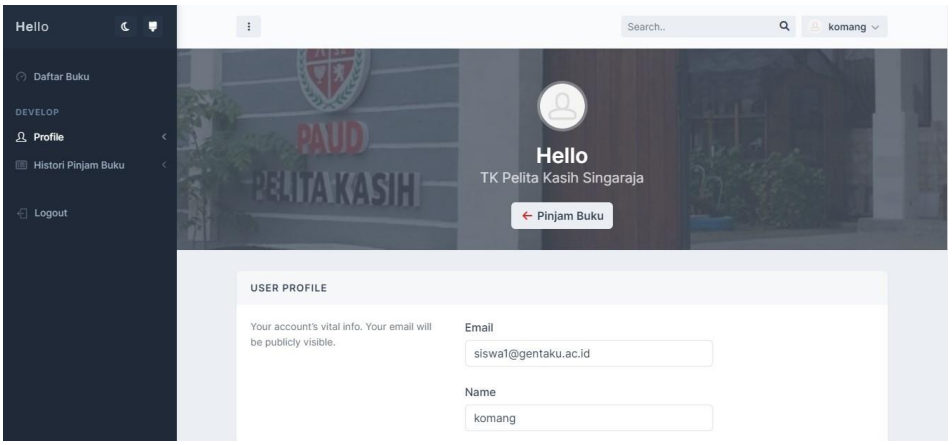

Figure 14. Display profiles on student pages

Figure 14 is a student profile page. On the profile page, students can change data such as name, address, email, and password to log into the application.

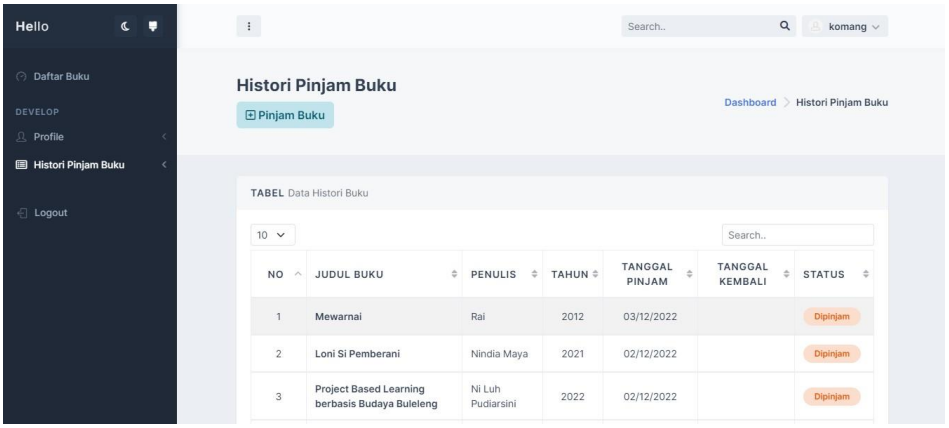

Figure 15. History of borrowing books on the student page

Figure 15 is the history page for borrowing books when students log in. This page displays information on all books that have been borrowed or are being borrowed. If the student has returned the borrowed book, the loan status and return date will be updated automatically.

The test method is done by black box testing. Aspects of testing include system functionality, security, performance, and errors.

Table 1. Testing with black box

Testing Activity	Expected results	Test result	Conclusion
Log in to the system	Users point to the dashboard according to roles and access rights	The login process works as expected and the user view matches the permissions	Appropriate
Click the add book data button	A book data add form appears which contains the book cover, title, author, year of publication, and book stock	The add book data button works as expected with a modal pop up	Appropriate

Click the edit book data button	The book data detail form appears and the latest book data update appears	The book data edit button works as expected	Appropriate
Click the delete book data button	Validation appears before deleting book data	The delete book data button works as expected with validation before the data is deleted	Appropriate
Click the book loan status update button	The appearance of the book loan status form will change to the book has been returned	The book loan status update button works as expected	Appropriate
Click the search book button	All book data will appear according to keywords	The search book button works as expected with search results according to the database	Appropriate
Click the book borrow details button	All book data borrowed by the user appears	The book borrows details button works as expected by displaying all book data that has been borrowed by the user	Appropriate
Download data by clicking the Excel button	Excel data is stored on the computer	The download button works as expected	Appropriate
Online reading button	A new tab appears to read books online with pdf files	Unable to display book files in a web browser	Not appropriate
Access information systems through web devices	The display adjusts to the screen on the computer	The information system prototype display functions as expected in a web browser on a computer	Appropriate
Access information systems through mobile devices	The display according to the size of the smartphone screen	The information system prototype display functions as expected on the smartphone screen	Appropriate

Functional testing is used to ensure that every feature or function in the system can run properly. This test includes login, data input, and the process of borrowing books. Security testing is used to ensure that the library information system is safe from attacks or unauthorized data leakage. This test includes verification that the system has implemented proper access controls and that the system cannot be accessed by unauthorized parties. Performance testing is used to ensure that the information system can handle the workload and can operate efficiently. The system can provide a fast response to the user. Error testing is used to ensure that the information system does not experience errors or bugs that could interfere with the user experience. This test includes verifying that the system can properly identify and handle errors and provide error messages that are clear and easy for users to understand. Black box testing is done with 11 test activities. The information system has not been able to display files in a browser so that users can read books online. Therefore, the black box test gets 91% results with 10 appropriate tests and 1 test that is not appropriate.

Conclusion

Sekolah Penggerak program is a breakthrough that gives students the freedom to be creativeand develop according to their interests. The government's intervention in this program is digitizing schools using various digital platforms. The digitization of the school was carried out by Pelita Kasih Singaraja Kindergarten starting from making library applications to data book management and book lending transactions. The designed library information system can help the management process of borrowing books in schools. This system can be accessed via browser on a computer or smartphone, making it easier for users to make book transactions. This information system has

been tested using the black box method, including testing functionality, security, and system performance. Based on the tests that have been carried out with the blackbox, the test was carried out with 11 test activities where 10 tests were appropriate and 1 test was not appropriate. The test results with the black box are more than the expected results.

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Literature review: visible light communication system business model scheme for telecommunication business in Indonesia

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Abstract: The telecommunication sector mainly comprises operators, vendors, and regulators. In Indonesia, telecommunications operator companies tend to decrease profits from the first quarter of 2017 to the third quarter of 2018. This condition is due to the tight competition of telecommunication service providers, high operational costs, and digital transformation that does not provide substantial revenue for the company. Telecommunications operators need other service options that can expand target market segmentation. It aims to open up a new blue ocean as a new source of income. The world is getting closer to massive communication technology, so high-speed communication is needed. Therefore, telecommunications operators can open new service options based on the visible light spectrum as their communication resources. This option can be integrated with ambient lighting, a wide spectrum ranging from radio waves, and greater bandwidth, making visible light suitable for IoT-5G services. This research aims to design a wireless visible light communication business model. Several frameworks are used, such as the magic triangle of St. Gallen, Osterwalder Business Model Canvas, and PESTLE analysis. The business model design results in a business model with B2B market segmentation being the main focus and B2C market segmentation to acquire retail customers.

Keywords: business model canvas, telecommunication, PESTLE, St. Gallen, visible light communication

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Introduction

The telecommunications business consists of operators, vendors, and regulators. In Indonesia, there are currently four most popular telecommunications operators. However, telecommunication operators in Indonesia must face the existence of over-the-top (OTT) players [1]. These players have taken advantage of delivering huge amounts of data through telecommunication infrastructures owned by telecommunication operators. However, most benefits through application services directly go to OTT, such as high expenditures for building use costs, network maintenance costs, infrastructure development costs, and others. This condition has become one point for telecommunications operators' struggle in the last decade. Operators also must face competing with telecommunication service providers to reach customer loyalty. A price war among telecommunications operators is an effort to increase the number of users and revenue.

Indonesia's internet service market segment has begun to enter a stagnant phase. In the 2021 Indonesian Telecommunications Statistics report, the Central Statistics Agency (BPS) published that the composition of customers in the consumer segment has reached 91.53% [2]. The market penetration of the consumer segment is currently very high, so the space to develop for telecommunications business players, especially operators, in Indonesia, is increasingly limited. Meanwhile, market penetration in other segments, namely the enterprise segment, still reaches 8.45% [2]. This condition shows that the enterprise market segment still has much room for telecommunications businesses to enter.

Along with technological developments, network technology is currently moving towards the era of 5G network technology. Indonesia's telecommunications operator companies can use this momentum to open up alternative income. The alternative is to serve as an enabler of 5G-

based services. The Internet of Things (IoT) is one of the entities of 5G technology that telecommunications operators in Indonesia can utilize. IoT in Indonesia will show a promising prospectus in 2026. The revenue obtained by IoT service provider companies will be 225 million U.S. dollars. The estimated revenue value from IoT services shows that the development of IoT in Indonesia has increased over the past few years [1].

5G-based services must consider aspects that exist in the characteristics of their use case. 5G technology has three use cases, namely enhanced Mobile-Broadband (eMBB), ultra-Reliable and Low Latency (URLLC), and massive Machine-Type Communications (mMTC) [3]. The eMBB use case service on 5G technology allows for communication with very high data rates, up to 20 Gbps, resulting in a better and fast communication experience in large quantities. In addition, the features on the eMBB allow for reliable communication with high mobility, such as on trips at speeds of 500 kilometers per hour. While the use case URLLC allows for a very responsive communication service with less than 1 millisecond latency. Due to its extremely low latency and responsive capabilities, 5G-based communications have a higher relative reliability level than previous generations. In the mMTC use case, the communication services offer massive-scale connectivity of up to 1 million devices per square kilometer. In addition, the features in the mMTC use case must also be efficient regarding energy consumption so that users do not need to recharge the device in large quantities, which takes time [4].

Internet of Things (IoT) technology is one of the entities of 5G technology. IoT-based communication generally uses IoT modules with ISM (industrial, scientific, and medical) frequencies of 2.4 GHz or 5 GHz. Other service options are needed to widen the target market segmentation so that the potential for income increases to open new revenue alternatives for telecommunications operators. However, the visible light spectrum has yet to be widely studied as a communication resource, so the visible light spectrum can be an opportunity to provide communication service options to widen the target market segmentation.

The visible light spectrum has characteristics that support the implementation of 5G communication technology. For example, its use can be integrated with ambient lighting with implications for more efficient energy consumption, making it suitable for mMTC use case services on 5G technology. Based on frequency, visible light in the range of ~400 THz to ~800 THz interferes with visible light and is possible. Radio waves are very small because of their huge difference in the frequency range. Light-based communication seems reliable and suitable for URLLC use case services on 5G technology. The communication bandwidth is also increasing because the visible light spectrum range is very wide. Based on the Shannon-Hartley Theorem, a large bandwidth value makes the channel capacity for communicating larger so that the data rate capability of the communication system can be greater and produce minimum latency [5]. High data rates and minimum latency match URLLC and eMBB use cases in 5G or future technologies.

Based on the visible light spectrum's ability, visible light can be a potential communication resource in 5G technology. 5G and IoT technology (as one of the entities) can be an alternative income option due to the decline in telecommunications operators' income from their main services, telephone, SMS, and internet networks. Therefore, this research proposes a business model design based on wireless visible light communication systems for telecommunications operators in Indonesia to open up new income for telecommunications operators. Currently, visible light communication technology is still in the development stage. There is still room for research in designing business models related to visible light communication technology as a recommendation when the technology is mature and ready to use.

This research aims to provide recommendations for telecommunications business people, especially operators, in applying visible light communication technology based on frameworks of the St. Gallen magic triangle, Osterwalder Business Model Canvas, and PESTLE (Political, Economic, Social, Technology, Law, and Environmental) analysis. St. Gallen's magic triangle framework is useful for designing the main framework of the business model. Followed by the business model canvas framework to build an end-to-end business model. It concludes with a PESTLE analysis to design strategies related to external factors of visible light communication systems.

Methodology

This research considers the qualitative research method using the St. Gallen magic triangle thinking framework, the Osterwalder Business Canvas Model business model framework, and the PESTLE analysis assessment framework. The nature of St. Gallen's magic triangle framework as a business model navigator can be utilized to formulate a basic framework for designing business models. The Osterwalder Business Canvas Model is used to design a business model that is ap-

propriate by considering the focus of the business points of the previous formulation and the data that has been obtained. At the same time, the PESTLE analysis assessment framework is used to determine and anticipate external factors that can interfere with implementing the design business model. Then it ends with the conclusions and recommendations.

In the St. Gallen magic triangle framework, business points are arranged based on articles and papers from previous researchers. The first business model factor, namely "Who is the customer?" [6]. Furthermore, the second business model factor is "What is the customer value proposition? "[7]. Furthermore, the third business model factor is "how to build and distribute the value proposition? " [8]. Finally, the fourth business model factor is "why the business model is financially viable? " [9].

After obtaining business model points, the formulation continues to the Business Model Canvas framework. In this framework, the formulation of business model points from the St. Gallen magic triangle framework is detailed end-to-end. It aims to compile a comprehensive business model, from the target market to its revenue stream. The business model is prepared based on the existing business model of two leading companies in Indonesia, namely PT Telekomunikasi Indonesia and PT XL Axiata, with minor adjustments related to implementing visible light communication technology [10].

The research ends with the PESTLE analysis framework (political, economic, social, technological, law, and environment). This framework has several external aspects that determine the direction of the company's strategy, such as political, economic, social, technological development, law, and environment. Aspects of PESTLE analysis can be beneficial or detrimental to implementing a business model.

Results and Discussions

Analysis of the Magic Triangle Framework of St. Gallen

Table 1 shows the formulation of the business points of the magic triangle of St. Gallen. It presents points arranged to identify the revenue model, the value offered, and the product's value chain (goods/services) for more detail on the Business Model Framework canvas.

The issue raised in this first factor concerns minimal resources to support the business model of visible light communication systems. Resources needed include marketing agents to penetrate the market, technicians to install services and ensure services function properly, service agents customers to accommodate and follow up on customer complaints, and Capex-Opex funding to make investments and infrastructure development operational funding. The next issue is the product. The product is a connectivity solution that can be tailored to the problems of an institution/person. "Customizable" points have a positive appeal because the services provided can be right on target for the problems that customers have.

The second factor in discussing St. Gallen's magic triangle in Table 1 is "Who?". Raising the issue relates to who segments the market from the design business model and the business partners. In determining the market segmentation of a business model, we need to look at the actual conditions of the industry, especially the telecommunications industry in Indonesia. Based on data published by the Central Statistics Agency (BPS), the composition of consumer segment customers has reached 91.53%. This condition means that the consumer market segment in Indonesia has shown signs of stagnating. Therefore, there is a need for an alternative focus on new market segments or also known as the new blue ocean. The business and enterprise market segments can become a blue ocean for telecommunications operators in Indonesia. Based on data from BPS for the composition of enterprise segment customers, it still reached 8.45%. In addition, based on data from Statista, it is predicted that revenue in the enterprise segment on a year-on-year basis will continue to increase [11]. It means that the enterprise market segment

still has much room for growth. The other issue is the business partner needed to support the design business model. There are three crucial things in supporting this proposed business model, namely infrastructure, marketing, and society. Therefore, the business partners include infrastructure provider vendors, marketing and collection agents, and communities to disseminate information related to each other product, service, and business model design.

Table 1. The formulation of the business points of the magic triangle of St. Gallen

Factors	Factor Formulation	Point Formulation
What?	What are the minimum resources required to run the business model?	Marketing agents, technicians, customer service agents, and Capex-Opex.
	What products can be offered to customers?	Connectivity solutions that can be tailored to the problems of an institution/individual.
Who?	Who segments the target market?	Business, Enterprise, and Retail segments.
	Who are the supporting business partners needed?	Vendors of infrastructure providers, marketing-collection agencies, and communities.
Why?	Why are the business products offered profitable for customers?	Able to integrate needs based on customer problems.
	Why should the business model be designed to generate additional income for telecommunications business people?	Because this visible light communication system-based business model not only generates revenue from internet connectivity but also generates new sources of revenue from the digital solution services offered as an implication of the advantages of visible light communication systems.
How?	How to maintain revenue from the technology business model?	Research and development activities in terms of infrastructure and types of services offered.
	How to increase customer interest in using the business products offered?	It is by conducting good customer relationship activities and socialization related to futuristic technology.

The third factor relates to the surplus value of business products and the addition of profits as an effect of increasing income from business services. The advantage of business products offered from this business model is that because the product is a "solution", the business product can integrate needs based on customer problems. Therefore, the new source of income from digital solution services offered to customers has implications for increasing business people's income. Digital solution services will certainly be accompanied by internet connectivity from the same business people so that new sources of income are opened from connectivity internet and those digital services.

The last factor of St. Gallen's magic triangle discussion will lead to maintaining revenue from the design business model and increasing customer interest in relatively new business products. The crucial thing is the existence of research and development activities in terms of infrastructure and the types of services. It is because each technology has its life cycle, and the cycle follows the S-curve theorem [12]. There are four phases in technology development, namely the emerging phase (new technology), the growth phase (rapidly developing technology), the phase maturity (main technology), and the saturation phase (replaceable technology). The importance of conducting research and development related to infrastructure is that business products do not already enter the maturity or saturation phase without any new substitution product ready to replace and create another new S-curve. Currently, visible light communication technology is still emerging, which means it is still classified as a new technology in development. Therefore, increasing customer interest in using these business products to carry out customer relationship activities related to new technology is crucial. It also provides socialization related to the convenience of the business products offered.

Osterwalder Business Model Canvas Framework Analysis

The points obtained from the magic triangle of St. Gallen are then used in formulating business models using the Osterwalder Canvas Business Model framework to formulate a business model comprehensively. The aspects start from partners, activities, and selling points to expenses and income channels. This model design adopts the existing I.T. solution service business model in telecommunications companies (PT Telekomunikasi Indonesia and PT XL Axiata) in Indonesia [10]. Detailed questions and components of each aspect are listed in Table 2.

Table 2. Components of each aspect

Aspects	Questions	Components
Key partners	What are your key partners to get a competitive advantage?	Electronic vendor provider, network hardware vendor, frontline agent, community, infrastructure management service provider
Key Activities	What are the key steps to move ahead with your customers?	Sales activation, marketing & promotion, RnD services, fulfillment & service assurances, channel activation (community, marketing partner, etc.), retention, loyal program activation
Key resources	What resources do you need to make your idea work?	Company employee, sales & marketing agent, community marketing agent, assurance & fulfillment technician, customer care agent, CAPEX & OPEX
Key propositions	How will you make your customers' life happier?	Customizable I.T. solution for business, enterprise, and retail
Customer relationships	How often will you interact with your customers?	Customer interaction, social media giveaways, loyalty program activation, retention program activation
Channels	How are you going to reach your customers?	Digital advertising, customer care, sales & marketing agent, website landing page, digital community agent, mobile apps
Customer segments	Who are your customers?	Business segment, enterprise segment, retail segment
Cost structure	What are the CAPEX and OPEX used for?	Infrastructure investment (CAPEX), asset investments (CAPEX), human resources cost (OPEX), general affair cost (OPEX), Marketing cost (OPEX), operational & maintenance cost (OPEX)
Revenue stream	How much are you planning to earn in a certain period?	Digital service revenue, analytic service revenue, OTC or recurring infrastructure charge

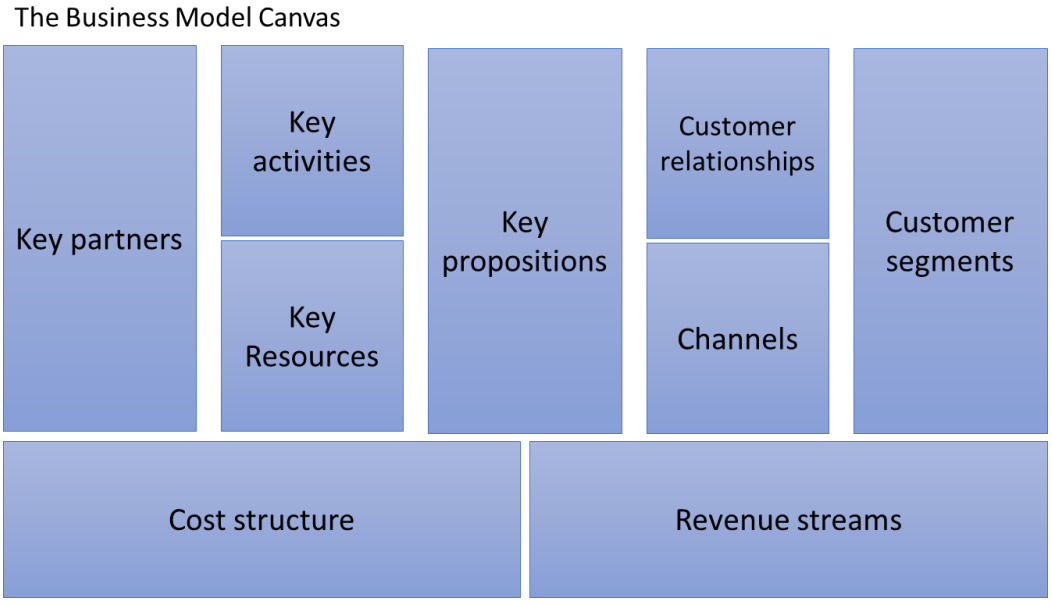

Figure 1. Business model canvas - visible light communication system

Figure 1 shows aspects of designing a business model of a visible light communication system for telecommuni-cations businesses in Indonesia. Market segmentation in an industry can be categorized into several groups, such as based on business scale, type of business, or geographical location. Market segmentation categories based on business scale can be divided into business size classifications, for example, small, medium, and large businesses. At the same time, the market segmentation category based on business type can be divided into business type classifications, such as home market or businessto consumer (B2C) and business to business market (B2B). Market segmentation based on geo-graphical location can be divided into market location classifications, whether in mountains, low-lands, or urban areas.

Applying market segmentation based on business type would be more appropriate in the telecommunications industry. By classifying markets based on the type of business, telecommunications business people can adjust the services offered to the capabilities of the intended market. According to data from the 2021 Indonesian Telecommunications Statistics report published by the Central Statistics Agency (BPS), the composition of customers in the home market segmentation has reached 91.53% [2]. The penetration of B2C market segmentation is already very high, so Indonesia's space to develop telecommunications businesses, especially operators, is increasingly limited. Meanwhile, market penetration in other segments, namely the enterprise segment, still reaches 8.45% [2]. It means that the enterprise market segment still has a very large growth room for telecommunications business players to enter the market.

Regarding the propositions, based on information from Indonesian Telecommunication Statistics from BPS in 2021 regarding customer composition, the best market segmentation for the business model is in the segment enterprise (B2B). The characteristic of enterprise segment customers is that they have varied problems. Unlike the home segment (B2C), the products offered to the B2B segment also differ from B2C, whose products are uniform. Product offerings for the B2B segment must lead to solving the problems of each institution, namely in the form of adaptive I.T. solutions based on digital technology. The solutions offered can be more targeted and increase service rates based on customer needs.

With light-based communication products through visible light communication systems, new technology applications will be open because of the need for high communication speed. The visible light spectrum range is very wide, and the communication bandwidth that can be utilized is also getting bigger. Based on the Shannon-Hartley Theorem, a large bandwidth value makes the channel capacity for communicating larger so that the data rate capability of the communication system can be greater and produce minimum latency [5]. High data rates and minimum latency suit URLLC and eMBB use cases in 5G communication technology or future technologies.

According to Osterwalder, service distribution channels have five distinct phases. Each such distribution channel may contain one or more phases. The five phases include awareness (interacting by providing information to customers), evaluation (interacting by requesting product or service evaluations from customers), purchase (how customers make transactions), delivery (how to deliver products or services to customers), and after-sales (post-transaction service) [13].In addition, the method of applying service distribution channels is also divided into two types, namely direct (interacting directly) and indirect (interacting through intermediaries or third parties) [13].

In the design of this business model, six distribution channels can be utilized to channel the five phases. The six channels include digital marketing, customer care, marketing agencies, web pages, community agencies, and applications. Digital marketing channels, customer care, web pages, and applications fall into the direct type. Meanwhile, marketing agent channels and community agents are included in the indirect type. The types of channels have their advantages and disadvantages, both direct and indirect. Indirect channels have a smaller margin value when compared to direct channels but are suitable if you want to do a major expansion. Conversely, direct channels can have a larger margin value but require more capital to carry out the same amount of expansion compared to indirect canals [13].

Today, business competition requires us to approach customers in various ways. One way is through digital marketing. Advertising is the most effective digital marketing strategy to build a product image and develop its business to be better known by its target market. Therefore, digital marketing channels contain one of the phases referred to by Osterwalder, namely, building awareness of the target market related to the product. In addition, through digital advertising, it can also directly invite the target market to make transactions. If digital advertising can be utilized optimally, digital marketing channels also contain a purchase phase.

The second channel to be maximized is the customer care (CC) division. The CC division is

one of the most important channels in this business model because it contains all five phases to become a complete channel. When there is a target market contact, the CC division has the authority to explain the most suitable product to be used as a solution. This function makes the CC division contain one of the channel phases, namely awareness. The CC division can also receive criticism or ask for opinions directly from customers to contain the next phase of the channel, namely evaluation. After the target market is satisfied with the information provided, the target market will enter the next phase facilitated by the CC division, namely purchase. The purchase phase will be continued with the delivery phase, where the CC division functions as an intermediary between the customer and the technician team to install the service. The last function owned by the CC division is the after-sales phase, where the CC division can function as a center for receiving service complaints against disruptions or damage for immediate follow-up.

Marketing agencies and community agents are indirect channels for large and short expansion. These agents can spread product awareness to the target market by jumping in and meeting it directly. Just like in CC channels, through marketing agencies and community agents, if the target market feels sufficiently informed and feels the right product to be used as a solution. Then it will proceed to the purchase phase. After the purchase phase, the agents will contact the engineering team to perform the installation. Another secure web channel can be a digital channel for conveying official information spread awareness about new products or the latest promos. This web page aims to build engagement between business people with the target market and customers who have subscribed. Tar-get markets can also make transactions by submitting products from the web page.

Unlike a web page, an application is more personal and addressed to the product's customer. The application can contain content in the form of other available product and service information to increase customer awareness. Customers can use these other service products to apply for additional services as desired. In addition, businesses can enter a feedback column in the application channel to get customer suggestions and evaluations. In the after-sales phase, customers can also use the application to report disruptions or damage without contacting the CC team. The customer connection contains ways to communicate with customers so that customerscan still feel comfortable subscribing. There are various ways to maintain customer interaction. This business model proposes four types of customer relationships: customer interaction, giveaways, customer loyalty programs, and customer retention programs.

Maintaining good customer relationships is important in doing business to create subscription sustainability. One of them is by conducting customer interactions. Customer interaction can touch all aspects of business, from marketing and sales to customer service. With a good customer interaction relationship, it will result in increased customer satisfaction in subscribing.

Customer interaction related to marketing can be obtained through how business people can convey information/advertising through social media and get responses from customers or potential customers. In addition, another example is the participation of business customers at a business event to increase engagement. Customer interaction in marketing can also be built by always updating relevant packages and promos in the community.

Customer interaction in other aspects, such as sales, is how businesses can leverage the voice of the customer to improve the quality of sales. For example, customers contact frontline agents to get information quickly and accurately. Customers can also do this in another way, namely by accessing the web page of the business person.

Customer relationships are related to the phases of the channel. As in customer interaction in the aspect of customer service, ways for business people to interact with customers to obtain an evaluation phase. For example, businesses provide a way for customers through various platforms to provide criticism and product suggestions. The results of the evaluation can improve service quality and product quality. The cycle will continue continuously until the customer experience improves.

Customer loyalty is a major factor in earning sustainable revenue. Customer loyalty can be improved with several activities. These activities can be done by always connecting with customers and offering benefits to make customers remember their products. Customer loyalty programs can also be synergized with customer retention programs. For example, providing fine relief for selected customers experiencing financial problems, giving giveaways, giving souvenirs to customers' acquisitions, etc. Customer loyalty programs aim to reduce the number of customer churns.

The most important part of a business is the profit scheme from the income earned. There are three additional revenue streams for businesses when implementing this business model. These revenue streams include revenue from digital services, analytics as a service, and one-time

or recurring rate schemes for supporting infrastructure. Revenue from digital services can be understood as a new source of revenue derived fromenabled digital services due to the presence of visible light communication systems. For example,smart services (smart office, smart home, etc.), smart energy harvesting services as an alternative energy source, and communication system services between vehicles and vehicles to minimize accidents. These sources can be utilized to add revenue to business people because, basedon customer segments, the enterprise market has a direction toward providing I.T. solution services. The second revenue stream source is analytics services, such as Analytics as a Service (AaaS). Data center market predictions in Indonesia projected by the end of 2022, the value of revenue from the market will reach USD 2.84 billion. In addition, it is also shown that the compound annual growth rate (CAGR) based on revenue from 2022 to 2027 is predicted to touch 5.03% or 2027, amounting to USD 3.63 billion [14].

AaaS is designed to process and manage information in massive sizes. AaaS is becoming important in a competitive industry due to a shift in focus from business-centric to customer-centric. Getting accurate and quality state findings can have implications for better decision-making, improving customer experience, and others. However, the complexity challenges of data processing are getting higher. In addition, it is also necessary to pay attention to data security from business customers so as not to fall into unwanted parties.

The third source of revenue stream is from one-time charges or recurring infrastructure charge schemes. Both schemes offer customers the choice of the desired scheme for using visible light communication system devices. The one-time charge scheme is like business people also sell visible light communication system devices to customers so that customers can enjoy I.T. solution services from business people. Meanwhile, the recurring charge scheme is like a business person implementing a monthly device rental policy for customers to enjoy I.T. solution services from business people. Both the one-time charge scheme and the recurring charge scheme are certainly beneficial for business people. It is because businesses can capitalize on devices to increase their revenue stream.

Key resources are important resources to support business activities. This business model has six key resources: employees, marketing agencies, community marketing agencies, technicians, customer care agents, and funds for expenses in Capex and Opex. All key resources owned by the company will be meaningless without a manager. Therefore, business employees have an important role in managing these products. Managing, developing, and being responsible for the entire product marketing cycle. The product marketing cycle covers how services are produced to how services are marketed to customers.

Sales and marketing agents are the "spearhead" in penetrating the market. Sales and marketing agents such as account managers are one of the resources that employees need to manage. Things that need to be managed start regarding operational activities, productivity, and field constraints. If previously sales and marketing agents were from internal resources, there need to be additional resources from external so that the market penetration movement is more massive. Community marketing agencies are external resources to penetrate more strategic markets. However, to activate the resources of this community marketing agency, there needs to be an approach from employees to make partnerships. It is intended to create a mutually beneficial relationship.

Apart from sales and marketing, there are other aspects for business employees to pay attention to: technicians. Technicians are included in important resources because they are the "spearhead" in installing and maintaining infrastructure. The technician team must be ensured and monitored for its performance by business employees to serve and prioritize the best customer experience.

In a telecommunications business, it is not enough to pay attention to aspects of marketing and sales. There also needs to be special attention to customers through customer care agents. CC agents are needed to handle customer complaints related to disruptions, infrastructure maintenance, to the submission of additional services.

One of the most important resources in a business model is funding. Funding in a business can be divided into capital expenditure (Capex) and operating expenditure (Opex). Capex is a source of funding for a business to invest in adding asset value to increase profits in the future. Meanwhile, Opex is a source of operational funding to maintain the continuity of these assets so that business activities can run well. Managing Capex and Opex can affect the sustainability of a business. Therefore, the role of business employees is needed to manage Capex and Opex wisely.

The key activities aspect is activities to support business activities that are eight key activities, namely sales activation, marketing and promotion, product development, technical mainte-

nance, channel activation, program retention, and customer loyalty programs. A sales activation is an activity to convert a prospect into a customer [15]. Efforts in activating sales can be done with marketing campaigns aimed at the target market. The strategy for doing this campaign is with 4P mixed marketing [16]. According to Kotler, mixed marketing is a mixture of marketing variables that an institution can control to achieve a certain level of sales in the target market [17]. McCarthy describes the concept of 4P mixed marketing as "Product", "Promotion", "Price", and "Place" [18].

The four factors are crucial in benefiting because the products offered to the target market must be by their wishes. A need will arise when the target market already wants products from business people. When the needs of the target market are by the pricing and promotions applied, business people will have the potential to acquire target markets into their customers. Place marketing can also help business people in marketing because, in addition to opening physical marketing places, business people can also use online marketing to expand market penetration.

In 2020, Boston Consulting Group released a list of the 50 most innovative companies in the world. The ten companies are Apple, Alphabet, Amazon, Microsoft, Samsung, Huawei, Alibaba Group, IBM, and Sony. These companies have one thing in common, namely, ICT service providers. Companies in the technology field generally rely heavily on their research and development teams to continuously develop their products to remain competitive in the competitive market [19]. The results of product development from the research and development team of each company will have implications for the emergence of new products with various types of innovations applied. New products will create a new competitive market, also known as a new blue ocean, so that the sustainability of an institution can be maintained.

After the creation of marketing activities, of course, infrastructure installation and maintenance activities by technicians are needed. Therefore, technicians are important in this business process because they can deliver services from business people to customers. In addition, technicians also spearhead infrastructure maintenance so that it can always be delivered to customers properly.

In the basic flow of business processes, operational activities can run when sales activation, marketing, and infrastructure installation and maintenance activities have been running. Furthermore, market expansion activities are required to develop business models. One of them is by activating marketing channels. Marketing with multichannel or omnichannel techniques can drive sales results significantly [20]. In its published article, McKinsey informs that in some use cases, there has been a 20% increase in marketing efficiency for marketing agencies [20]. It is planned that customers can need the necessary information without the presence of a marketing agency. Marketing channels in this business model can be websites, chatbots, communities, and call centers.

The networking activities of new customers will be meaningless if the subscriber subscription period is not as expected. Therefore, the retention program is an important activity to pay attention to because implementing a good retention program will produce loyal customers. Retention programs can be done in various ways, such as customer education programs related to products, using positive testimonials, spreading positive content on social media, Good and consistent communication with customers, etc.

After the retention program is successful, loyal customers will begin to grow. The last step is to make customers more comfortable using the service by carrying out customer loyalty program activation. Customer loyalty activities can also be interpreted as a form of appreciation from business people to customers for their loyalty in using services. According to a McKinsey survey, 50% of loyal customers will be more likely to recommend used services to others, and 31% will be more willing to pay more to stick with the services used [21]. Loyalty programs such as points-based and tiered loyalty programs can be activated. An example of a points-based program is activating a point redemption program for certain benefits, such as price deductions or certain souvenirs worth some points accumulated. At the same time, examples of tiered loyalty programs are grouping customers into a category based on transaction frequency or subscription duration. The higher the level of customer categories, the more benefits customers get.

In the key co-worker aspect, related parties support business activities. There are five partners in this business model, namely providers of electronic equipment supporting visible light communication systems, providers of connectivity supporting hardware, managing partners' device and infrastructure maintenance, frontline agents, and communities. The main factor that needs to be ensured for this business model's sustainability is network connectivity services. Network connectivity is required to connect customers with services from internet servers. If internet servers can be provided for customers to use, then the integration of visible light com-

munication infrastructure is carried out to enable high-speed I.T. solution services. Building a comprehensive visible light communication infrastructure requires electronic components. These electronic components include LEDs as signal transmitters, photodiodes as receivers, and operating systems to process signals. The existence of vendor partners providing these electronic components will be an advantage for this business person because vendor partners can enable mutually beneficial cooperation schemes for both parties.

Distributing services from the central office to customers requires a connectivity medium to be an intermediary. These mediums use devices such as Gigabit Passive Optical Network (GPON) devices to provide connectivity services, Optical Line Termination (OLT) for the starting point for distributing connectivity services, and Optical Network Terminal (ONT) for signal receiving endpoints from connectivity services. The specifications of these devices are crucial in providing optimal service quality. Therefore, the cooperation of partners in providing network hardware will make it easier for business people to ensure and determine the quality of the desired device.

After the electronic components and supporting hardware of the service infrastructure are available, partners are needed to ensure that the service infrastructure is always available optimally. Not only ensuring its availability but also ensuring its maintenance when a disturbance can be handled quickly. Partners in terms of infrastructure maintenance are needed so that disruption handling becomes more focused.

In businesses engaged in telecommunications, there are two main things to focus on business. These two things include in terms of infrastructure and terms of marketing. Business focus in terms of infrastructure has been discussed in the importance of having partners for providing electronic components, hardware supply, and infrastructure maintenance. Furthermore, the business focus in terms of marketing will be discussed through frontline agents and communities.

Marketing activities not only market penetration must be considered, but also customer retention needs to be considered. A frontline agent can help to handle both of these things. When carrying out market penetration activities, although the role of an account manager can also be used to do customer retention, frontline agents, such as customer care, are also needed to capture customer complaints. In addition, customer care is also needed to carry out activities in terms of customer relationships to maintain customers. External parties, such as communities, can also conduct market penetration activities. Thecommunity strongly influences the dissemination of information because it is massive and widelyconnected. If business people can empower the community, then business people will benefit inthe form of rapid and widespread dissemination of product information and open up the potentialof new marketing channels.

The cost structure of this business model is divided into two types: Capital Expenditure (Capex) and Operational Expenditure (Opex) costs. Capex costs are incurred by business people when there is a need for investment in adding asset value to support activities in increasing profits in the future. Meanwhile, Opex costs are a source of operational funding to maintain the continuity of these assets so that business activities can run well. Capex in this business model is divided into two main categories: infrastructure investment and asset investment. Meanwhile, Opex is divided into four categories: H.R. costs, general purpose costs, marketing and sales costs, and operational maintenance costs.

The cost of expenses so business activities can run is an investment in Capex. The first Capex cost in this business model is infrastructure investment such as fiber optic networks, visible light communication system networks, and other supporting infrastructure. In addition, Capex costs also include asset investment, such as technical tools and equipment to maintain or repair infrastructure and leasing or purchasing locations to place network support devices.

Furthermore, infrastructure and asset investment costs are necessary for operations after infrastructure and asset investment. This business model has four Opex cost categories: human resource compensation, general affairs, marketing, and maintenance. Human resource compensation costs include employee payroll costs, employee insurance costs, recruitment costs, and others. Furthermore, the cost of general affairs includes the cost of electricity, water costs, the cost of gasoline generators, and other general needs. In marketing costs, the costs in question include producing brochures and catalogs, subsidizing costs to issue promos and other costs to encourage sales of business products. Finally, maintenance costs include, among others, infrastructure repair costs, asset damage costs, and other operational costs.

PESTLE Framework Analysis

After obtaining a business model based on the previous framework, the next discussion is external factors that can benefit and harm the business model. Business people can prepare for the anticipation of adverse factors and take advantage of beneficial factors in operations. These

factors are designed using the PESTLE framework (political, economic, social, technological, law, and environment). Table 3 lists external factors that influence the development of visible light communication systems.

Table 3. PESTLE analysis of visible light communication system

Politics	Economics	Social	Technology	Legal	Environment
US-China semiconductor chip war	Potential world recession conditions in 2023	"New Normal" Behavior	Not maximized semiconductor production	Chips and Science Act Bill – USA	Green Technology
China-Taiwan geopolitical conditions	Potential spike in global inflation	Digital Divide	Safer communication networks	Potential "Price Fixing" regulation from the government	
			VLC technology is still in the development stage		

The first factor in the PESTLE analysis is politics, one of which is the US-China semiconductor chip war. Today, the United States (U.S.) and China are waging a technological war. The United States government exercises export controls by targeting China. These controls include cutting off access to certain types of semiconductor chip manufacturing with equipment from the United States. The Chinese government responded by entering into a cooperation agreement with South Korea to integrate the semiconductor industry between the two countries. China reinvested funds in the semiconductor industry's stock exchange in South Korean industries, such as Samsung and S.K. Hynix, and Chinese industries, such as Semiconductor Manufacturing International (SMI) Corp. and Montage Technology [22].

The impact of the chip war is the decline in world semiconductor production. As the world's largest chip market, China experienced a decrease in imports of I.C. units in September 2022 by 12.8% year-on-year (YoY). Therefore, the number of Chinese semiconductor chips also decreased by 10%. This decrease in the number of semiconductor chip circulation in the world market can cause a reduction in the supply of semiconductor chips worldwide, potentially resulting in a scarcity of these components to produce tools and electronics [23].

Apart from the semiconductor chip war between the United States and China, another potentially hindering factor in semiconductor supply is the geopolitical conditions between China and Taiwan. Taiwan is the world's largest producer of semiconductors. Tensions between China and Taiwan are suspected of political conflicts in which China mobilizes its military force to reclaim Taiwanese territory. This condition will certainly threaten the electronics industry in Indonesia, where the main material is semiconductors. The threat could arise because the logistics route between Taiwan and Indonesia generally goes through the South China Sea. Indonesia has a dilemma because if Taiwan sides with the United States and imports semiconductors from Taiwan or the United States, it will certainly disrupt the stability of Indonesia's trading partners, where the United States and China are on the list of the top 10 largest investor countries in Indonesia [24].

The second factor in the PESTLE analysis is the economy, where the main influencing factor is the condition of a potential recession. From the country's internal point of view, challenges related to public health due to the Covid-19 pandemic remain unresolved. Meanwhile, from the country's external point of view, geopolitical pressures between Russia and Ukraine do not contribute positively to the global economic recovery. Both points of view increase global energy and food prices and trigger inflation [25]. The impact of inflation on the entire industry. Including the electronics and telecommunications industries is the increase in prices of production materials, thereby increasing production costs and investment value. The third factor in the PESTLE analysis is social, where social factors that influence the telecommunications business, especially visible light communication systems, are "new normal" behavior and The existence of the Digital Divide. The Covid-19 pandemic has forced public life toutilize digital platforms daily. Today the world has entered the digital era, where technological advances continue to increase, and the need for online activities increases [26]. Therefore, I.T. solution services based on light communication systems seem to be an attractive technological solution for integrating technology needs.

In Indonesia, rapid technological development is not matched by technology penetration, especially in the 3T (frontier, outermost, and underdeveloped) regions. This digital divide is an imbalance in the growth of information and communication technology in an area. Based on the digital divide value index (DIDIX), Indonesia has an index value between 19.39 and 25.49 [27].

The fourth factor in the PESTLE analysis is technology, where things related to technology affect the technical development of visible light communication systems. Considerations related to the technology include not maximizing semiconductor production, safer communication networks, and visible light communication system technology is still in development. The threat of not maximizing semiconductor production due to the semiconductor chip war between the United States and China makes the main components in producing electronic devices increasingly limited. Visible light communication systems require electronic devices, such as LEDs, photodiodes, and microcontrollers, as their main components.

However, currently, the visible light communication system is still in the development stage. The development of visible light communication systems has reached the stage of making dongles, but it has not yet been commercialized. This visible light communication system is attractive because of its advantages: high security, speed, and energy efficiency. High safety due to the nature of light that cannot penetrate thick objects. In addition, it is high in speed because the frequency of light is very high, so referring to Shannon's Theorem allows higher communication bandwidth to radio communication [28]. Meanwhile, the advantages of high energy efficiency are related to environmental factors in the PESTLE analysis because its function can be integrated with ambient, general, and room lighting.

The fifth factor in the PESTLE analysis is legal, where matters related to legal provisions, both domestic and foreign, can affect the application of visible light communication systems. From the provisions of foreign law, there is a phenomenon of semiconductor chip warfare between the United States and China which has been drafted in the Chips and Science Act Bill bythe United States so that it has the force of law. Furthermore, from domestic legal provisions, there is the possibility of service pricing regulations, such as in the Omnibus Law, where the government sets the lower and upper limits of telecommunications services in Indonesia. It can positively or negatively impact the business model of visible light communication systems. Pricingcan positively impact keeping market conditions healthy when the market is saturated. Meanwhile, when the market is still not saturated, pricing can have a negative impact because itcan limit the profit margins of business people, so it takes longer to break even points or even record their first profit.

Conclusion

This research found that the business model design by implementing visible light communication systems results in a business model with B2B market segmentation being the focus for increasing revenue. Meanwhile, the B2C market segmentation should be kept acquiring retail customers. The main player of the support system is the I.T. solution which is very important in integration and transformation from the current condition to emerging VLC. By all its advantages, visible light communication technology can open new applications with high-speed and reliable communication characteristics.

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The empirical study of Joomla CMS map extension and location performance

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Abstract: Thousands of extensions can be installed on the Joomla CMS with various functions. One of them is the map and location extension, which is useful for meeting the needs of content that display information in the form of visual maps and locations. The Phoca Maps and MX Maps extensions are two of the many map and location extensions available on the Joomla Extension Directory website, downloadable and widely used. This study aims to provide a reference for Joomla CMS users in terms of managing content related to maps and locations through empirical studies of the performance of Phoca Maps and MX Maps extensions. In measuring extension performance, Google Lighthouse is used to audit all quality aspects that support the performance of a web application. The research results found that, in general, the desktop and mobile performance of the Phoca Maps and MX Maps extensions was unsatisfactory. This can be seen from the performance testing results for First Contentful Paint, Speed Index, Largest Contentful Paint, Time to Interactive, Total Blocking Time, and Cumulative Layout Shift.

Keywords: CMS Joomla, extensions, google lighthouse, Phoca Maps, MX maps

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Introduction

In its use, a website has a very potent role in conveying various information sourced from various agencies, educational institutions, companies, and other organizations. The purpose of the information provided can be various, such as information for communication, entertainment content, and trade, such as offering services, introducing company profiles, marketing, and selling products, providing news, or just sharing tips and tricks. Access to public information is given without distance and time limitations so that whenever and wherever everyone can access it. Not only limited by one type of device, but various devices such as smartphones, tablets, laptops, and personal computers can access it.

Many factors make website information content convey well to visitors. These factors include various aspects such as internet network infrastructure support, device specifications, browser applications, to good website quality. One way of assessing the quality of a good website is through its performance. Good website access speed performance means that visitors don't need a long time to see the entire page content. On the other hand, performance is one of the reasons for consideration for visitors to visit a website [1]. Because web application performance plays a key role in satisfying end users [2], organizations must think of effective and efficient ways to build high-performance websites.

Today the development of programming languages is increasingly encouraging website programmers to create various applications that are safer and easier to use by personal and organizational users. The application accommodates the needs of users who have different backgrounds needs. One of the popular products resulting from the website application development is Joomla. Joomla is a free, open-source application that can be used as a content management system (CMS) to publish website content [3]. Through Joomla, website developers are given a lot of convenience in managing content because it has good features for managing content [4]. With a CMS, the website development workflow becomes simpler without having to require previous experience and knowledge [5], having special technical knowledge [6], and without the

need to worry about having abilities in terms of coding [7]. Complex website development processes will be simplified, significantly reducing development time.

Developers can add many extension options to a Joomla CMS-based website. No less than 4800 extensions [8] for various needs can be downloaded and installed on the website. Among the many extensions is the map and location extension (Maps & Locations). This category type is used specifically for the needs of processing map content and locations. One of the benefits is that it allows Joomla users to place markers on the map on each article or page of a website. By embedding maps and locations on the website, developers can expand the functions of the website to be built. The map is useful for making it easy to share information about a business or office's location, see routes, or explore roads virtually.

Many factors will be considered in designing a website based on maps and locations to produce a quality website. In this case, Joomla developers need to consider the most appropriate extension. One of the benchmarks is the accuracy in selecting extensions with good performance. Extensions must be able to run with maximum performance both through mobile and desktop access.

In this regard, in this study, the authors will conduct an empirical study regarding the map extension's performance and the Joomla extension's location. The method to be used in this research consists of three stages: extension data collection, performance testing, and analysis of performance testing results. This research aims to explore and find out the performance of the map and location extensions used in the Joomla CMS. At the same time, the research results are expected to be a reference for Joomla website developers to choose and determine which map extension and location are more appropriate to use.

Methodology

The research stages shown in Figure 1 provide a function as a reference for achieving research objectives. This stage consists of four stages: literature study, observation and extension data collection, performance testing, and analysis of performance testing results.

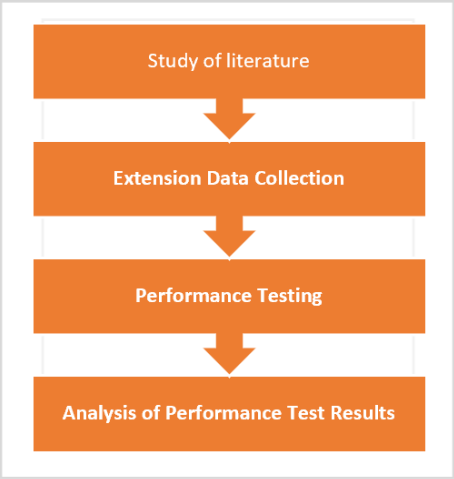

Figure 1. The research stages

Study of literature: At this stage, a search for materials and information relevant to the research problem is carried out to serve as a guideline for problem-solving approaches. Literature sources used as references in this study are electronic journals and technical documents from extension providers that will be used.

Extension Data Collection: At this stage, data is collected regarding each extension regarding requirements specifications (map support and Joomla compatibility), features (multimap), licenses, extension types (components, modules, plugins), and technical documentation support. Data regarding extensions are needed to support the stage of the performance testing process.

Performance Testing: At this stage, performance testing uses Google Lighthouse. The test results will be displayed in the form of a matrix to show measurements of First Contentful Paint (FCP),

Speed Index, Largest Contentful Paint (LCP), Time to Interactive (TTI), Total Blocking Time (TBT), and Cumulative Layout Shift (CLS). Performance measurement tests will be carried out more than once and use aggregation values because the results of single-run tests can be misleading and not representative [9].

First Contentful Paint (FCP)

FCP marks the time when text or images were first recorded [10]. FCP captures performance related to how quickly visitors can view content from a website [11]. FCP equals the time in milliseconds until the first element is drawn on the white screen that is first displayed in the browser [12]. The FCP Score in Table 1 below shows this performance variable's assessment.

Table 1. FCP score

FCP Time in Second	Color Code
0 – 1.8	Green (fast)
1.8 – 3	Orange (moderate)
Higher than 3	Red (slow)

Scores with a duration of 1.8 seconds or less (represented by a green color code) mean fast performance and good value. Scores with a duration of more than 1.8 seconds and less than 3 seconds (depicted by the orange color code) mean that the performance is moderate and needs improvement. A score with a duration higher than 3 seconds (depicted by a red color code) means poor performance, so improvement is needed [10].

Speed Index

Speed Index shows how fast the page content appears to be filled or the content is displayed visually during page load. The Speed Index is a gauge of how quickly a website shows information visually during page load [13]. It is done by recording a video of the page loading in the browser and then calculating the visual progress between frames [10]. Assessment of speed performance is shown through the Speed Index Score in Table 2 below.

Table 2. Speed index score

Speed Index in Second	Color Code
0 – 3.4	Green (fast)
3.4 – 5.8	Orange (moderate)
Higher than 5.8	Red (slow)

Scores with a duration of 3.4 seconds or less (depicted by a green color code) mean fast performance. Scores with a duration of more than 3.4 seconds and less than 5.8 seconds (depicted by the orange color code) have a moderate performance meaning. At the same time, a score with a duration higher than 5.8 seconds (depicted by a red color code) means poor performance [10].

Largest Contentful Paint (LCP)

The LCP is Another indicator that influences a site's performance [14]. It has a special role in research because it complements the FCP by measuring the perceived loading speed when the main content of a page has loaded [15]. The LCP marks and measures the time interval [16], the time that the largest text or image was printed [17] when the user enters the web [18]. The largest image or block of text visible in the viewport is will be reported for its render time from the first time it is loaded. Websites with LCP times below 2.5 seconds or less will provide a good user experience, while it will be bad if the value exceeds 4.0 seconds.

Time to Interactive (TTI)

TTI is the amount of time it takes for a page to load [19] until the page is fully responsive to interactions [20]. TTI measures website responsiveness when the website loads a website page [10]. Assessment of TTI performance is shown through the Time to Interactive Score in Table 3 below.

Table 3. Time to interactive score

TTI in Second	Color Code
0 – 3.8	Green (fast)
3.9 – 7.3	Orange (moderate)
Higher than 7.3	Red (slow)

Scores of 3.8 seconds or less (represented by a green color code) mean fast performance. Scores with a duration of more than 3.8 seconds and less than 7.3 seconds (depicted by the orange color code) have a moderate performance meaning. At the same time, a score with a duration higher than 7.3 seconds (depicted by a red color code) means poor performance [10].

Total Blocking Time (TBT)

TBT measures how much time is blocked in response to user input [20], such as keyboard presses, mouse clicks, and screen taps or keyboard taps [21] on the device during page loading [11]. TBT evaluates task responsiveness by quantifying how long a page is non-interactive until it becomes reliably interactive [22]. Total TBT is calculated by adding the blocking portion of all long tasks between TCP and TTI. TBT measures task responsiveness, as it helps measure the severity of how non-interactive a page is before it becomes reliably interactive. In other words, TBT measures the time between FCP and TTI [15]. The TBT score table can be seen through the Total Blocking Time Score in Table 4 below.

Table 4. Total blocking time score

TBT in Second	Color Code
0 – 200	Green (fast)
200 – 600	Orange (moderate)
Higher than 600	Red (slow)

Scores with a duration of 200 seconds or less (represented by a green color code) mean fast performance. Scores with a duration of more than 200 seconds and less than 600 seconds (depicted by the orange color code) have a moderate performance meaning. At the same time, a score with a duration higher than 600 seconds (depicted by a red color code) means poor performance [10].

Cumulative Layout Shift (CLS)

CLS measures the movement [10] or shifts in the layout of visible elements within the field of view on the page when the website loads [11]. CLS can occur between when the page starts loading and when its lifecycle state changes to hidden [23]. The CLS variable was introduced in content analysis because it measures layout visual stability [24] and provides a decision of the analyzed page in terms of the frequency of unexpected display changes [15]. The score is considered good if the value is below 0.1, and the score is considered bad if the value is above 0.25 [11].

Analysis of Performance Test Results: This stage is the final stage, where an analysis will be carried out on performance testing results for desktop and mobile devices.

Results and Discussions

The following is information on the feature comparison of each extension based on data collected via the Phoca Maps [25], MX Maps [26], and the official Joomla Extension site [27]. Table 5 below shows information regarding the feature Comparison of Phoca Maps and MX Maps Extensions.

Table 5. Comparison of phoca maps and MX maps extensions

Information	Phoca Maps	MxMaps
Map Support	Google Maps, OpenStreetMap	OpenStreetMap
Joomla compatibility	Joomla Versions 3 and 4	Joomla Versions 3 and 4
Multiple Maps and Locations	Yes	Yes
Map Style	No	Yes (9 Maps Styles)
License	GPLv2 or later version	GPLv2 or later version
Paid Version	No	Yes
Extension Type	Components & Plugins	Module
Documentation	Yes	No
Technical Support	Yes	Yes

The performance testing of the Phoca Maps and MX Maps extensions is carried out under the following conditions:

1. Hardware specifications using AMD A10 -5745M APU with Radeon HD Graphics 2.10 GHz processor, 8 GB RAM, and 256 GB SSD.
2. Windows 10 Pro Edition operating system software, Joomla Version 3.9, Google Chrome browser application Version 105, and Google Lighthouse Version 100.
3. Internet uses a wireless connection with a downstream speed of 17.4 Mbps and an upstream of 19.9 Mbps (connection speed is measured using https://speedtest.cbn.id/).
4. Webserver Apache 2.3.47 (win32), PHP 5.6.40, and Database Server MariaDB 10.1.37.
5. CMS Joomla version 3.8 with additional template styles.
6. The map extension is placed into an article and uses five map markers (OpenStreetMap).

So that empirically the results of performance measurement get representative results, the performance test is carried out five times [9]. Performance testing is carried out in several stages, namely testing Phoca Maps for desktop and mobile performance, then proceeding with testing MX Maps for desktop and mobile performance. Phoca Maps testing for desktop performance is shown in Figure 2 below.

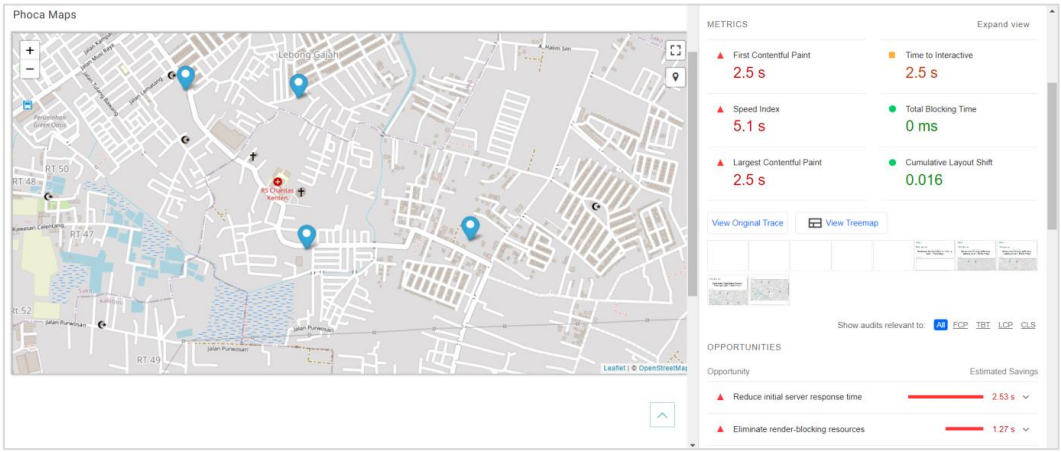

Figure 2. Phoca Maps Desktop Performance Testing

The detailed results of the Phoca Maps desktop performance test are shown in Table 6 of Pho-ca Maps Desktop Performance Testing below.

Table 6. Table of phoca maps desktop performance testing

PERFORMANCE TESTING	Test result					Average
	P1	P2	P3	P4	P5	
First Contentful Paint	2.5 s	1.7 s	5.8 s	6.6 s	4.2 s	4.2 s
Speed Index	5.1 s	5.1 s	6.6 s	7.4 s	6.2 s	6.1 s
Largest Contentful Paint	2.5 s	1.8 s	5.9 s	7.4 s	4.2 s	4.4 s
Time to Interactive	2.5 s	2.5 s	5.9 s	6.6 s	4.6 s	4.4 s
Total Blocking Time	0 ms	100 ms	0 ms	20 ms	360 ms	96 ms
Cumulative Layout Shift	0.016	0.014	0.008	0.006	0.008	0.010
SCORE	67	75	49	47	38	55.2

Phoca Maps testing for mobile performance is shown in Figure 3 below.

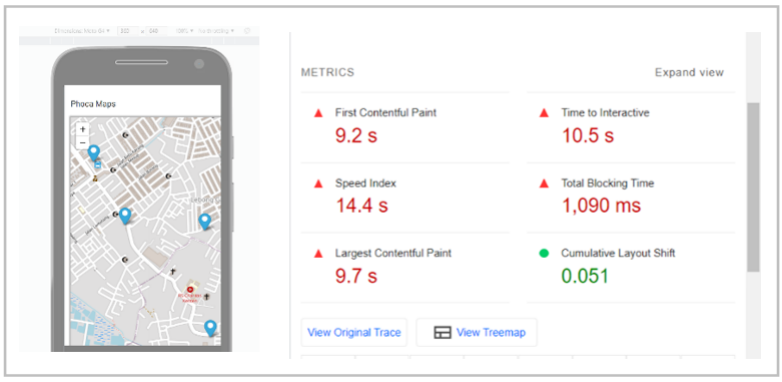

Figure 3. Phoca maps mobile performance testing

The detailed results of mobile Phoca Maps performance testing are shown in Table 7 of Phoca Maps Mobile Performance Testing below.

Table 7. Table of phoca maps mobile performance testing

PERFORMANCE TESTING	Test result					Average
	P1	P2	P3	P4	P5	
First Contentful Paint	4.8 s	5.0 s	6.9 s	4.9 s	4.4 s	5.2 s
Speed Index	14.2 s	14.7 s	13.0 s	14.1 s	12.9 s	13.8 s
Largest Contentful Paint	4.9 s	5.0 s	6.9 s	4.9 s	4.4 s	5.2 s
Time to Interactive	9.6 s	11.6 s	8.6 s	9.9 s	10.3 s	10.0 s
Total Blocking Time	1.850 ms	4.530 ms	1.420 ms	1.880 ms	2.590 ms	2.4540ms
Cumulative Layout Shift	0.05	0.05	0.05	0.05	0.05	0.05
SCORE	29	24	25	29	30	27.4

Figure 4 below shows testing MX Maps for desktop performance.

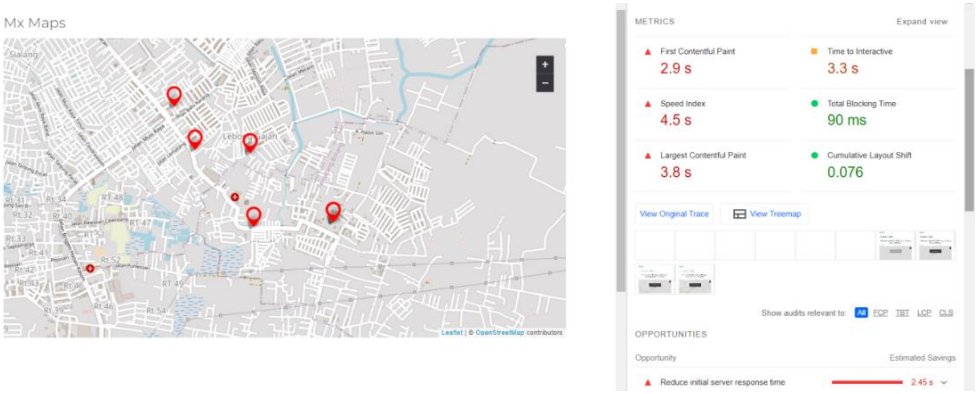

Figure 4. MX maps desktop performance testing

The detailed MX Maps desktop performance test results are shown in Table 8 of MX Maps Desktop Performance Testing below.

Table 8. Table of MX maps desktop performance testing

PERFORMANCE TESTING	Test result					Average
	P1	P2	P3	P4	P5	
First Contentful Paint	13.1 s	9.1 s	7.9 s	11.1 s	7.9 s	9.8 s
Speed Index	23.0 s	17.5 s	17.1 s	19.3 s	15.0 s	18.4 s
Largest Contentful Paint	13.1 s	9.1 s	8.7 s	11.1 s	8.1 s	10.0 s
Time to Interactive	22.3 s	16.2 s	15.3 s	19.6 s	13.8 s	17.4 s
Total Blocking Time	7.390 ms	5.680 ms	5.670 ms	7.340 ms	3.410 ms	5.898 ms
Cumulative Layout Shift	0.052	0.051	0.051	0.051	0.051	0.051
SCORE	15	16	16	15	17	15.8

Testing MX Maps for mobile performance is shown in Figure 5 below.

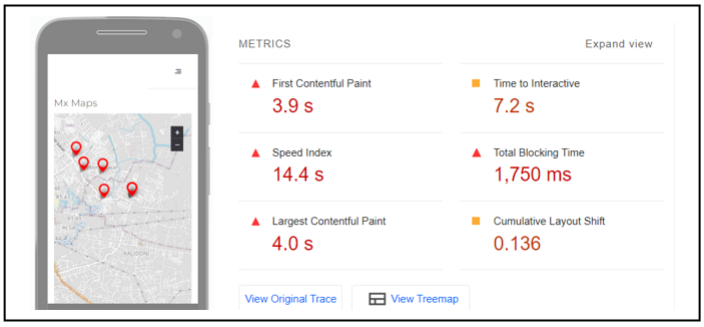

Figure 5. MX maps mobile performance testing

The detailed results of mobile MX Maps performance testing are shown in Table 9 of MX Maps Mobile Performance Testing below.

Table 9. Table of MX maps mobile performance testing

PERFORMANCE TESTING	Test result					Average
	P1	P2	P3	P4	P5	
First Contentful Paint	3.9 s	6.9 s	5.0 s	7.0 s	6.9 s	5.9 s
Speed Index	14.4 s	12.2 s	12.7 s	14.5 s	13.3 s	13.4 s
Largest Contentful Paint	4.0 s	7.5 s	5.5 s	7.6 s	7.1 s	6.3 s
Time to Interactive	7.2 s	8.9 s	8.7 s	8.9 s	11.8 s	9.1 s
Total Blocking Time	1750 ms	1060 ms	2380 ms	1120 ms	4050 ms	2072 ms
Cumulative Layout Shift	0.136	0.044	0.043	0.044	0.043	0.062
SCORE	29	27	26	26	19	25.4

Analysis of the performance test results for FCP, Speed Index, LCP, TTI, TBT, and CLS for desktop Phoca Maps performance testing is shown through Results of Phoca Maps Desktop Performance Analysis in Table 10 below.

Table 10. Results of phoca maps desktop performance analysis

Performance Testing	Average Score Test Results	Performance Conclusion
First Contentful Paint	4.2 s	Slow
Speed Index	6.1 s	Slow
Largest Contentful Paint	4.4 s	Bad
Time to Interactive	4.4 s	Moderate
Total Blocking Time	96 ms	Fast
Cumulative Layout Shift	0.010	Good

Based on the performance test of Phoca Maps Desktop, it can be concluded that FCP has a slow performance because it has an average score of 4.2 seconds. This score is at the lowest score position in the performance assessment table, which is higher than 3 seconds. Speed Index has a slow performance because it has an average score of 6.1 seconds. The score is at the lowest score position, which is higher than 5.8 seconds. LCP has a bad performance with an average score of 4.4 seconds because it exceeds the lowest limit score of 4 seconds. TTI has moderate performance with an average score of 4.4 seconds. The score position is in the medium performance score range, which is between 3.9 seconds and 7.3 seconds. TBT has fast performance with an average score of 96 microseconds. This score is at the highest score position with a duration of less than 200 seconds. CLS has good performance with an average score of 0.010. This score is in a good performance assessment position with a value of less than 0.1.

Analysis of the results of testing the performance of FCP, Speed Index, LCP, TTI, TBT, and CLS for Phoca Maps mobile performance testing is shown through the results of Phoca Maps Mobile Performance Analysis in Table 11 below.

Table 11. Results of phoca maps mobile performance analysis

Performance Testing	Average Score Test Results	Performance Conclusion
First Contentful Paint	5.2 s	Slow
Speed Index	13.8 s	Slow
Largest Contentful Paint	5.2 s	Bad
Time to Interactive	10.0 s	Slow
Total Blocking Time	2454 ms	Slow
Cumulative Layout Shift	0.05	Good

Based on the Phoca Maps Desktop performance test, it can be concluded that FCP has a slow performance because it has an average score of 5.2 seconds. This score is at the lowest score position in the performance assessment table, which is higher than 3 seconds. Speed Index has a slow performance because it has an average score of 13.8 seconds. The score is at the lowest score position, which is higher than 5.8 seconds. LCP has a bad performance with an average score of 5.2 seconds because it exceeds the lowest limit score of 4 seconds. TTI has a slow performance with an average score of 10 seconds. The score position is in the lowest performance score position, which is higher than 7.3 seconds. TBT has slow performance with an average score of 2454 microseconds. This score is at the lowest score position with a duration of more than 600 seconds. CLS has good performance with an average score of 0.05. This score is in a good performance assessment position with a value of less than 0.1.

Analysis of the performance test results of FCP, Speed Index, LCP, TTI, TBT, and CLSfor MX Maps desktop performance testing is shown through the results of MX Maps Desktop Performance Analysis in Table 12 below.

Table 12. Results of mx maps desktop performance analysis

Performance Testing	Average Score Test Results	Performance Conclusion
First Contentful Paint	9.8 s	Slow
Speed Index	18.4 s	Slow
Largest Contentful Paint	10.0 s	Bad
Time to Interactive	17.4 s	Slow
Total Blocking Time	5898 ms	Slow
Cumulative Layout Shift	0.051	Good

Based on the MX Maps Desktop performance test, it can be concluded that FCP has a slow performance because it has an average score of 9.8 seconds. This score is at the lowest score position in the performance assessment table, which is higher than 3 seconds. Speed Index has a slow performance because it has an average score of 10 seconds. The score is at the lowest score position, which is higher than 5.8 seconds. LCP has a bad performance with an average score of 17.4 seconds because it exceeds the lowest limit score of 4 seconds. TTI has a slow performance with an average score of 10 seconds. The score position is in the lowest performance score position, higher than 7.3 seconds. TBT has a slow performance with an average score of 5898 microseconds. This score is at the lowest score position with a duration of more than 600 seconds. CLS has good performance with an average score of 0.051. This score is in a good performance assessment position with a value of less than 0.1.

Analysis of the results of testing the performance of FCP, Speed Index, LCP, TTI, TBT, and CLS for MX Maps mobile performance testing is shown through Results of MX Maps Mobile Performance Analysis in Table 13 below.

Table 13. Results of MX maps mobile performance analysis

Performance Testing	Average Score Test Results	Performance Conclusion
First Contentful Paint	5.9 s	Slow
Speed Index	13.4 s	Slow
Largest Contentful Paint	6.3 s	Bad
Time to Interactive	9.1 s	Slow
Total Blocking Time	2072 ms	Slow
Cumulative Layout Shift	0.062	Good

Based on the MX Maps Mobile performance test, it can be concluded that FCP has a slow performance because it has an average score of 5.9 seconds. This score is at the lowest score position in the performance assessment table, which is higher than 3 seconds. Speed Index has a slow performance because it has an average score of 13.4 seconds. The score is at the lowest

score position, which is higher than 5.8 seconds. LCP has a bad performance with an average score of 6.6 seconds because it exceeds the lowest limit score of 4 seconds. TTI has a slow performance with an average score of 9.1 seconds. The score position is in the lowest performance score position, which is higher than 7.3 seconds. TBT has a slow performance with an average score of 2072 microseconds. This score is at the lowest score position with a duration of more than 600 seconds. CLS has good performance with an average score of 0.062. This score is in a good performance assessment position with a value of less than 0.1.

The following summarizes the desktop and mobile performance test results of the Phoca Maps and MX Maps extensions shown in Table 14, the Performance Conclusion Summary Table.

Table 14. Performance conclusion summary

Performance Testing	Objective	Performance Conclusion			
		Phoca Maps		MX Maps	
		Desktop	Mobile	Desktop	Mobile
First Contentful Paint	Measures the speed of visitors in viewing web content.	Slow	Slow	Slow	Slow
Speed Index	Measures the speed of the web in displaying information visually during page loading.	Slow	Slow	Slow	Slow
Largest Contentful Paint	Measures the time interval text and images are printed when a user enters the largest web.	Bad	Bad	Bad	Bad
Time to Interactive	Measures website responsiveness when the website loads a page.	Moderate	Slow	Slow	Slow
Total Blocking Time	Counts how long it takes a non-interactive page to become reliably interactive.	Fast	Slow	Slow	Slow
Cumulative Layout Shift	Measures the movement or shift of the layout of visible elements within the field of view on the page when the website loads.	Good	Good	Good	Good

Conclusion

Google Lighthouse makes it easy to measure the performance of extensions on Joomla CMS-based websites. The ease of use indicates this, the interface display, along with the information displayed. Desktop performance for First Contentful Paint, Speed Index, and Largest Contentful Paint extension Phoca Maps on Joomla CMS has unsatisfactory results. Performance Time to Interactive has moderate performance, Total Blocking Time has fast performance, and Cumulative Layout Shift has good performance. On the mobile performance side, the results of First Contentful Paint, Speed Index, Largest Contentful Paint, Time to Interactive, and Total Blocking Time had unsatisfactory results. Meanwhile, good results are obtained only from the performance of the Cumulative Layout Shift. Desktop performance for First Contentful Paint, Speed Index, Largest Contentful Paint, Time to Interactive, and Total Blocking Time for the MX Maps extension on CMS Joomla had unsatisfactory results. There is one good performance, namely in Cumulative Layout Shift. Meanwhile, on mobile performance, the results for First Contentful Paint, Speed Index, Largest Contentful Paint, Time to Interactive, and Total Blocking Time had unsatisfactory results. There is one good performance, namely the Cumulative Layout Shift.

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Optimizing transaction data performance in database management systems

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Abstract: One indicator of the quality of an information system is the speed of data processing. A database's most common data processing operations are adding, displaying, changing, and deleting data. The amount of data stored in the database significantly impacts the performance of data processing and, therefore, the performance of information systems. The update command changes some or all of the data in a table. The update command works by retrieving the data in the table to be changed, entering the new data in a form, and then sending it back to the database. The update command is often combined with a condition specifying which data rows must be changed. This research is an experimental study that compares the use of the update command with a stored procedure to the use of the update command without a stored procedure. The results showed that the average processing time for the update command with the stored procedure was 348.896 milliseconds for the minimum data category, 266.462 milliseconds for the medium data category, and 279.543 milliseconds for the maximum data category. The average processing time for the update command without a stored procedure was 297.132 milliseconds for the minimum data category, 747.670 milliseconds for the medium data category, and 1256.273 milliseconds for the maximum data category. These results suggest that the update command with a stored procedure is more efficient than the one without a stored procedure. This is because the stored procedure can pre-compile the SQL statement, which reduces the time it takes to execute the statement.

Keywords: database, stored procedure, update

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Introduction

The database is a collection of related. The database is the rules set for processing data into information to be useful for information system users according to their needs [1], [2]. The information generated from the database is obtained from several interconnected data [3]. There are several benefits of using a database, namely 1) Ease of storing data, 2) Minimizing data redundancy, 3) Data accuracy, 4) Availability of data according to user needs, 5) Data Security, 6) Availability of user sharing, 7) Providing data completely [4]. An application called the Database Management System is used to process data in the database, including MySQL, PostgreSQL, Ms. Access, SCL Server, and others [5], [1]. The database and database management system cannot be separated from each other and form a single unit called the database system. There are several database system components, namely 1) hardware, 2) operating system, 3) database, 4) database management system, 5) users, and 6) application interface [6], [7].

Database design and implementation, application design and implementation, and administrative procedures influence information systems [8]. Database design is the first factor that influences information systems. This means that a good database structure will greatly affect the performance of information systems. Nine aspects need to be considered in designing a database: the ability to be integrated, reach, level of detail, correctness, consistency, relevance, completeness, minimalism, and readability [9].

Several factors affect database performance, namely 1) response time, which is the duration of the database in processing a given command; 2) throughput, which is the ability of hardware and software to process data; 3) resources, hardware and software, 4) memory, the amount of memory used in completing the given command [10]. The amount of data to be processed by the database will help application performance if optimization is carried out [11].

Database optimization can be done by adjusting the hardware with the software and configuring the database application, but this method requires more expensive resources. Another method is optimizing the database design, which can only be done at the beginning of application development. Database optimization can also be done by optimizing database queries/commands used in applications [12]. In addition to database performance objectives, as mentioned earlier, optimization is also carried out for data security purposes to prevent interface exploitation of the database [13]. Communication errors between the application interface and the server will cause security holes in the stored data. This is called SQL injection. SQL Injection takes advantage of invalid data errors entered into the database through the application interface [14]. One method to optimize database security is by embedding data encryption algorithms in the application, resulting in stored data being different from the inputted data. This is done to minimize data misuse [15].

Generally, the most frequently performed data processes in the database are adding, displaying, changing, and deleting data. The large amount of data stored will greatly affect the performance of data processing and, of course, the performance of information systems. In the information system design process, there are database design stages. Understanding data flow, procedures, and organizational mechanisms for processing data is crucial in designing database systems. The basic data is designed in such a way as to meet the information needs of its users. Generally, database design is done using Entity Relationship Diagram (ERD). The designed ERD is then transformed into a table relation.

One aspect that influences the successful implementation of information systems is the design of tables in the database [16]. Using the right data types, using keys, and applying some table constraints will guarantee data quality. One benchmark for data quality is the absence of data duplication, whether it occurs within the same table or across different tables. Data duplication can lead to data inconsistencies, resulting in information discrepancies [17]. Applying normalization to tables will also affect data quality. Insert anomaly, delete anomaly, and update anomaly can be minimized by applying normalization rules. Management and data processing in the database can be done by running several commands. Structured Query Language (SQL) is a command for managing and processing database data. The SQL language is grouped into several categories, namely Data Definition Language (DDL), Data Manipulation Language (DML), and Data Control Language (DCL).

Insert, update, and delete commands are included in the DML category. Insert is used to add data to the table. Delete is used to delete some or all of the data in the table, while the update command is used to change some or all of the data in the table. The update command works by retrieving data in the table to be changed, entering it in the form, and then sending it back to the database; generally, the update command is combined with a condition where the data rows to be changed are by the specified conditions. This study aims to test the update command using a stored procedure in the database. The stored procedure is a subroutine that makes it possible to execute SQL statements that have been prepared [18]. There are several benefits of using stored procedures, including 1) effectively used for commands that are executed many times, 2) using stored procedures, the load on resources will be divided, and 3) better security [19].

Methodology

This research is experimental research. Experimental research is a type of research conducted by testing several conditions [20]. This research was conducted on a database containing tables, which have a number of rows of data. These data rows will be changed using the update command without a stored procedure and the update command using a stored procedure. Testing is done by running each command using the terminal/command prompt. The amount of data used is 30000, 70000, and 100000 data, while the research flow can be seen in Figure 1 below:

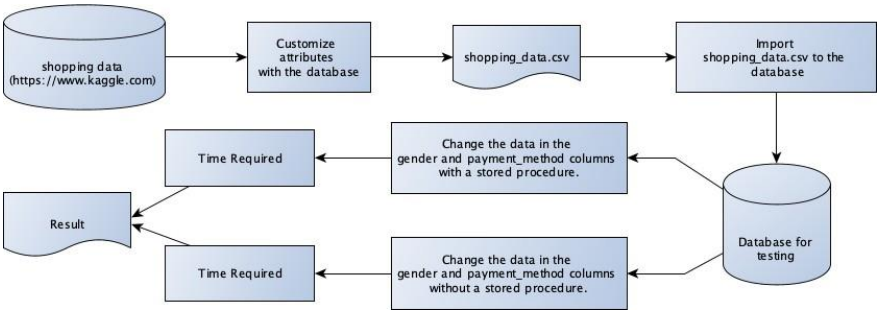

Figure 1. Research flow

The data used in this research is customer shopping data downloaded from Kaggle (https://www.kaggle.com/datasets/mehmettahiraslan/customer-shopping-dataset). It needs to be adjusted before testing some of the attributes in the data. The test was performed 10 times by running the update command with a different amount of data. Each test will record the processing time, and the results will then be averaged.

Testing is carried out by changing the data in the database with different command methods, namely using stored procedures and without using stored procedures with different amounts of data, namely the minimum amount of data with a total of 30,000 data, the amount of medium data with a total of 70,000 data and the maximum number data with a total of 100000 data. Before making changes to the data, creating a database and table structure to store data needs to be done. The structure of the test table used in this study is shown in Table 1 below:

Table 1. Table structure for testing

Field	Type Data/Length	Constraint
invoice_no	Character (10)	Primary Key
customer_id	Character (10)	Not Null
gender	Variable Character (7)	Not Null, Check (Male, Female)
age	Integer	Not Null
category	Variable Character (25)	Not Null
quantity	Integer	Not Null
payment_method	Variable Character (15)	Not Null, Check (Cash, Debit Card)
invoice_date	Date	Not Null
shopping_mall	Variable Caharcter (45)	Not Null

Table 1 above shows the structure of the test table, and it can be seen that there are 9 columns/fields with data types and constraints that are adjusted to the test data.

The next step in this research is to enter data into the table that has been made. Then the testing; the first test is carried out on minimum category data, then medium category data, and maximum category data. Before entering data into the table, it is necessary to make data adjustments. The data adjustments change all data in the gender column to 'Male' and data in the payment_method column to 'Cash'. After that, testing is carried out by executing updated data with a stored procedure and updating data without a stored procedure. The two commands will change the data in the gender column, which previously had the value 'Male', to 'Female', and the data in the payment_methode column, which previously had the value 'Cash', to 'Cash'. Debit Card'. The stored procedure commands used in testing can be seen in Figure 2.

```
CREATE OR REPLACE FUNCTION update_data (
    data_gender VARCHAR(7),
    data_payment_method VARCHAR(15)
)
RETURNS void AS $$
BEGIN
     UPDATE data_shopping SET
     gender = data_gender,
     payment_method = data_payment_method;
END;
$$ LANGUAGE plpgsql;
```

Figure 2. Stored procedure update

As for the command to change data without a stored procedure, it can be seen in Figure 3 below:

```
UPDATE data_shopping SET
    gender = 'Female',
    payment_method = 'Debit Card';
```

Figure 3. Update without stored procedure

In contrast to changing data with a stored procedure, changes without a stored procedure can be executed immediately, whereas to execute data changes with a stored procedure, it is necessary to call the previously created stored procedure, as shown in Figure 3. The calling commands can be seen in Figure 4 below:

```
SELECT update_data
     ('Female', 'Debit Card');
```

Figure 4. Calling command stored procedure

Suppose the command in Figure 4 is executed. In that case, it will execute a stored procedure called update_data where in the stored procedure update _data, there are commands to change the data in the gender and payment_method columns; the values 'Female' and 'Debit Card' are new values that will replace the old values. Namely 'Male' and 'Cash'.

Results and Discussions

Experimental research trials were conducted on both hardware and software systems with the following specifications: 1) Intel Core i5 dual-core 2,3 GHz, 2) RAM 8 gigabytes, 3) Solid State Drive 128 gigabyte, 4) Intel Iris Plus Graphics 640, 5) Operating System: Mac OS Ventura, 6) PostgreSQL Version 14.8. The first trial was carried out by running the update command with the stored procedure; the command execution was performed 10 times for each amount of data. Next, run the update command without a stored procedure and do it 10 times. The results of testing the minimum data category with a total data of 30,000 can be seen in Table 2 below:

Table 2. The result from the minimum data category

Experiment To -	Update with Stored Procedure (milliseconds)	Update without Stored Procedure (milliseconds)
1	327,442	304,699
2	339,585	308,567
3	343,934	306,887
4	384,772	308,828

5	352,058	278,808
6	321,442	290,663
7	393,636	339,163
8	328,377	296,573
9	375,645	279,559
10	322,076	257,582

The graph of the experimental results for the minimum data category can be seen in Figure 5 below:

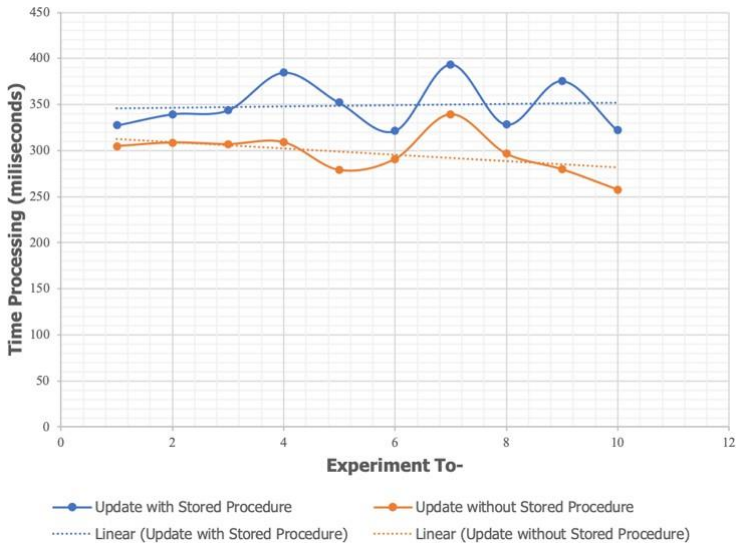

Figure 5. Graph result in minimum data category

The test results for the medium data category with a total data of 70,000 can be seen in Table 3 below:

Table 3. The result from the medium data category

Experiment To -	Update with Stored Procedure (milliseconds)	Update without Stored Procedure (milliseconds)
1	326,921	774,549
2	239,468	713,015
3	323,322	750,009
4	251,495	768,340
5	259,701	729,498
6	224,897	727,768
7	251,202	770,247
8	263,754	764,007
9	250,137	723,504
10	273,726	755,772

The graph of the experimental results for the medium data category can be seen in Figure 6 below:

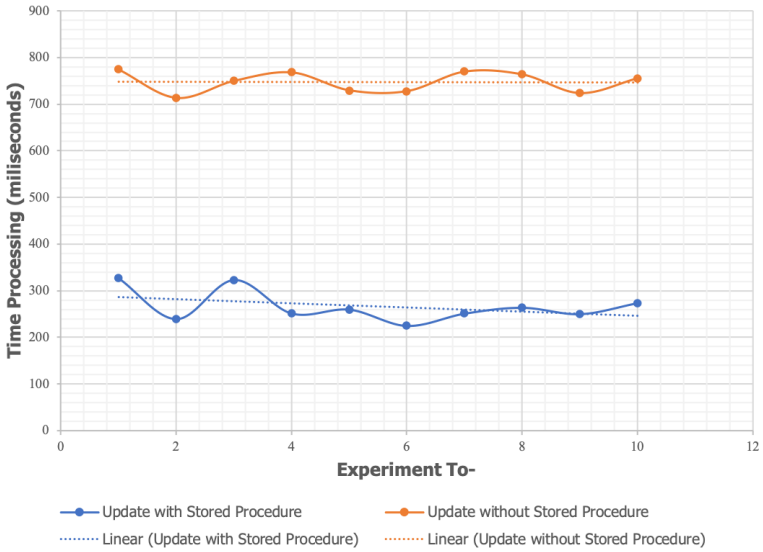

Figure 6. Graph result in medium data category

Figure 5 shows that changing data with a stored procedure is better than changing data without using a stored procedure in the medium data category with a total of 70,000 data. The experimental results for the maximum data category with a total data of 100000 can be seen in Table 4 below:

Table 4. The result from the maximum data category

Experiment To -	Update with Stored Procedure (milliseconds)	Update without Stored Procedure (milliseconds)
1	254,917	1156,595
2	297,792	1005,891
3	250,609	1007,575
4	228,304	1380,146
5	258,102	1101,780
6	540,740	1067,539
7	233,316	1695,356
8	255,274	1051,303
9	223,324	1116,453
10	253,055	1980,094

The graph of the experimental results for the maximum data category can be seen in Figure 7 below:

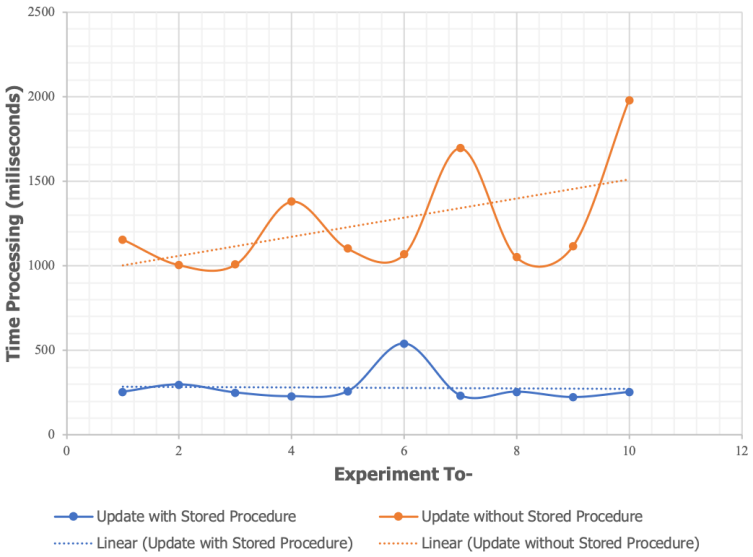

Figure 7. Graph result in maximum data category

Figure 7 shows that changing data with a stored procedure is faster than changing data without a stored procedure in the category maximum with 100000 data. Data changes using stored procedures were better in the medium and maximum data categories of the three experiments conducted in this study. Table 5 displays the outcomes concerning the percentage representation of data modification process time when employing stored procedures, while Figure 8 illustrates the graphical depiction of the comparative average data modification process time using stored procedures versus data modification without the utilization of stored procedures:

Table 5. Percentage of Data Modification Process Time with Stored Procedure

Experiment To -	Minimal	Medium	Maximum
1	9%	12%	9%
2	10%	9%	11%
3	10%	12%	9%
4	11%	9%	8%
5	10%	10%	9%
6	9%	8%	19%
7	11%	9%	8%
8	9%	10%	9%
9	11%	9%	8%
10	9%	10%	9%

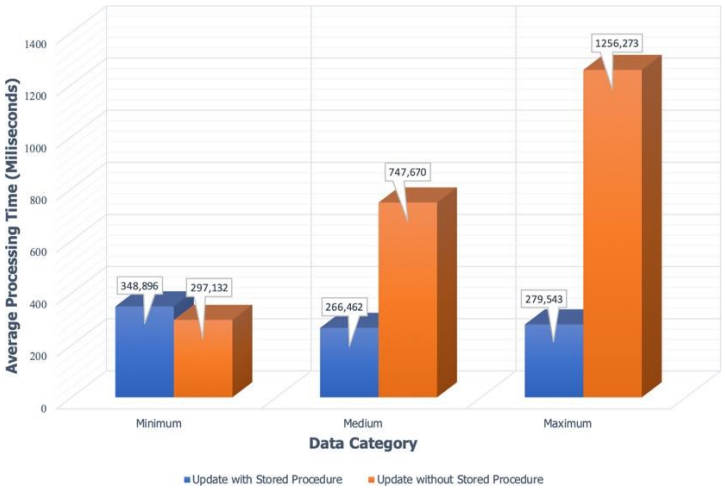

Figure 8. Average processing time based on data category

Table 5 presents the percentage of data modification process time using stored procedures. The table indicates that as the percentage value decreases, the data modification process time becomes faster. Figure 8 shows the average processing time of the three data categories. It can be seen that for the minimum data category with the amount of data 30000, the use of updating data without stored procedures resulted in an average processing time of 297.132 milliseconds, while for the medium and maximum data categories with the amount of data 70000 and 100000 the use of updating data without stored procedures produced an average processing time of 747.670 milliseconds and 1256.273 milliseconds. The test results show that the use of updating data with stored procedures is better used in the medium data category with an amount of data of 70000 with an average processing time of 266.462 milliseconds and the maximum data category with an amount of data 100000 with an average processing time of 279.543 milliseconds.

Conclusion

This study is an experimental research that compares data conversion methods using stored procedures and without stored procedures. The data used is categorized based on the amount of data, namely the minimum, medium, and maximum data categories. The results showed that changing data using a stored procedure was better for the amount of data in the medium and maximum categories while changing data without a stored procedure was better for the minimum data category. This implies that the utilization of stored procedures to optimize the performance of data transactions is more suitable for data quantities falling within the categories of medium and maximum. The results of this study are very useful for developing applications that use data conversion with large amounts of data.

This research is limited to the comparison of query processing times. It is highly recommended for future research to not only compare processing time but also investigate how queries function to identify the underlying factors contributing to the slow processing time of stored procedures with minimum data category. The researcher realizes that this research is still far from perfect because the researcher's understanding still needs to be improved, and the researcher's time is limited. For further research, researchers suggest testing on a larger amount of data and directly implementing it in the application.

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