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Hybrid Holt Winter-Prophet method to forecast the number of foreign tourist arrivals through Bali's Ngurah Rai Airport

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Abstract: The Indonesian is an archipelago rich in culture and natural resources. The Government of Indonesia utilizes this wealth by maximizing the tourism potential to earn sizeable foreign exchange. As a major destination, the Indonesian government needs a strategy to ensure foreign tourists continue to increase in terms of health, cleanliness, a sustainable environment and infrastructure. When we can forecast the number of foreign tourists, it is hoped that the government can establish appropriate policies to develop tourism. Based on this, an appropriate forecasting method is needed. This study will use a hybrid model with the Holt-Winter and the Prophet method. The data used is the number of foreign tourists to Bali through Ngurah Rai Airport from January 2009 to December 2019. This study will use stages based on the OSEMN Framework. These stages are Obtain, Scrub, Explore, Model, and Interpret. The result of this study is that the MAPE value for the Hybrid Method is 2.5880%. This result means the Hybrid Holt Winter-Prophet is better than the Holt Winter Method.

Keywords: Forecasting, Hybrid Model, MAPE, OSEMN Framework.

1. Introduction

The Indonesian is an archipelago that is rich in culture and natural resources [1]. The Government of Indonesia utilizes this wealth by maximizing the tourism potential to earn sizeable foreign exchange [2]. The tourism potential in the province or city can be seen from the number of visits by foreign tourists who enter via land, air or sea[3]. In 2019, the government, through the Ministry of Tourism and Creative Economy, targeted the number of foreign tourists at 20 million people [4]. Therefore, tourism is one of the sectors the government prioritizes [5].

The Indonesian government has implemented several policies to help the tourism sector develop. 2011, the Ministry of Tourism issued Government Regulation Number 50 2011 concerning Indonesian tourism development. This policy was created to prioritize tourism development in Bali [5]. As a major destination, the Indonesian government needs a strategy to ensure foreign tourists continue to increase in terms of health, cleanliness, a sustainable environment and infrastructure [6]. In determining these strategies, the government looks at the number of foreign tourists visiting Bali as an indicator of readiness to welcome them [7]. When we can forecast the number of foreign tourists, it is hoped that the government can establish appropriate policies to develop tourism, especially on the island of Bali. Based on this, an appropriate forecasting method is needed.

2. Related Works

In the forecasting concept, if we need the results to be close to the actual data, then we need a method that can capture the time series pattern, which consists of trend, seasonal, and noise [8]. Based on a study from Putu et al. [9], data on the number of foreign tourist visits has a seasonal pattern, which tends to increase in July or August. Therefore, the method used should be able to capture seasonal patterns in the data. One of these methods is the Holt-Winter method[10]. This method was used to forecast the number of foreign tourist visits in Bali using data from January 2015 to April 2018 by Hadiriyanto et al. This study compared the Holt-Winter Method with ARIMA. As a result, the Holt-Winter method can better capture seasonal patterns than the ARIMA method [11].

Although the Holt-Winter method can capture seasonal patterns, it only captures linearity [12]. Linearity is difficult to happen because many influences in the data are unknown [13]. So, we need a method that can not only capture linear patterns but also non-linear ones. One way to do this is to use a hybrid model. This model will combine strategies that can capture the linearity of the data and methods that can capture the non-linearity of the data. A previous study of a hybrid model to predict the number of foreign tourist visits to Bali was carried out by M. Al Haris et al [12] using the Holt Winter-Artificial Neural Network methods. The study results show that the hybrid model produces higher forecasting than the Holt-Winter model.

Based on this, we will use another Hybrid model to forecast the number of foreign tourist visits to Bali via Ngurah Rai Airport. Suppose the previous study combined Holt-Winter and Artificial Neural Network. In that case, this study will combine the Holt-Winter and the Prophet method, which can capture non-linearity patterns in the data. This method was first released by Facebook in 2017 [14]. The use of a hybrid model with the Holt-Winter method and the Prophet method has never been carried out by previous research, so it is hoped that this hybrid model can increase forecasting accuracy compared to Holt-Winter and Artificial Neural Network.

3. Methods and Methodology

In this section, we will discuss the concepts of the methods used for the study and their formulation

3.1. Holt-Winter Method

The Holt-Winter method was first introduced in 1960 by Winters [10], which consists of three smoothing equations containing Level, Trend and Seasonality parameters. Taylor [15] and Taylor [16] later refined the technique submitted by Winters, resulting in double and triple Seasonal Holt-Winter. The improvement made by Taylor is that the method can divide several seasons with different lengths. Apart from that, it can also adjust forecasts and first autocorrelation errors. The Holt-Winter method has two different types, which can be used to change the time series data pattern. There are two Holt-Winter types: Addictive and Multiplicative [10]. The following is the formula for the Holt-Winter equation of Addictive type at time t [17]:

$$\hat{x}_{t+h|t} = l_t + hT_t + S_{t+h-m(k+1)} \tag{1}$$

In Equation (1) l_t is the smoothing Equation for the level which has the formula $l_t = \alpha(x_t - s_{t-m}) + (1-\alpha)(l_{t-1} + T_{t-1})$. h is the number of steps forward from any arbitrary step t. T_t is the smoothing Equation for the trend, which has the formula $T_t = \beta(l_t - l_{t-1}) + (1-\beta)T_{t-1}$. $S_{t+h-m(k+1)}$ is the smoothing Equation for the trend, which has the formula $S_t = \gamma(x_t - l_{t-1} -$

$T_{t-1}) + (1-\gamma)S_{t-m}$. $\alpha, \beta,$ and γ are parameters for level, trend, and seasonal with $0 \leq \alpha, \beta, \gamma \leq 1$. k is the integer part of $\frac{(h-1)}{m}$, where m is the period in the time series data.

Meanwhile, the formula for the Holt-Winter equation of the Multiplicative type at time t is as follows

$$\hat{x}_{t+h|t} = l_t S_{t+h-m(k+1)} + hT_t S_{t+h-m(k+1)} \tag{2}$$

In Equation (2), l_t is the smoothing Equation for the level which has the formula $l_t = \alpha \frac{x_t}{S_{t-m}} + (1-\alpha)(l_{t-1} + T_{t-1})$. T_t is the smoothing Equation for the trend, which has the formula $T_t = \beta(l_t - l_{t-1}) + (1-\beta)T_{t-1}$. $S_{t+h-m(k+1)}$ is the smoothing equation for trend which has formula $S_t = \gamma \frac{x_t}{(l_{t-1}+T_{t-1})} + (1-\gamma)S_{t-m}$.

3.2. Prophet Method

The Prophet method was first released by Facebook in 2017 [14], where this method can capture the separation of seasonal patterns between holidays and Sundays. This method has three main components, namely upward or downward trend patterns, seasonal patterns, and holiday patterns. The Equation that explains the three components is as follows [13]:

$$Y_t = g_t + S_t + H_t + \varepsilon_t \tag{3}$$

Where g_t describes a non-linear upward or downward trend pattern, S_t describes a seasonal pattern, H_t describes a holiday pattern, and ε_t is an error that describes irregular changes the model may not capture.

3.3. Hybrid Method

The Hybrid method is a combination method of statistics and machine learning that interact with each other. This method was first introduced by Zhang P [18], combining the ARIMA and Neural Network models. This combination makes sense because time series data naturally consists of a linear autocorrelation structure and non-linear components. In general, the Equation for the Hybrid method is

$$Y_t = L_t + n_t \tag{4}$$

Where $L_t$shows a linear and n_t shows a non-linear pattern. In this research, the Holt-Winter method will capture linear patterns. So, the residual from Holt-Winter will establish a non-linear relationship [19]. Then, the Prophet method will use the residual as input, which will be used for forecasting to produce$\hat{n}_t$. The results of the hybrid forecasting method are the sum of the effects of linear forecasting using Holt-Winter with the results of non-linear forecasting using the Prophet method. The final result of the Hybrid method is

$$\hat{Y}_t = \hat{L}_t + \hat{n}_t \tag{5}$$

3.4. Model Evaluation

You can use the best model selection criteria to choose the appropriate method to forecast the number of foreign tourists to Bali. The criteria used in this study is MAPE or Mean Average Percentage Error [20]. The formula for MAPE is

$$MAPE = \left(\frac{1}{n} \sum_{i=1}^{n} \left| \frac{\varepsilon_i}{Y_i} \right| \right) \times 100\% \tag{6}$$

In Equation (6), ε_i the residual value is the difference between the actual and predicted values Y_i is the actual value of the data, and n is the amount of data. According to Trimono et al [21], if it has a MAPE value of less than 10%, it means that the forecasting results are said to be very accurate, while the forecasting results are said to be good if it has a MAPE value of 10% to 20%.

3.4. Data Source

The data used in this study is the number of foreign tourists to Bali through Ngurah Rai Airport from January 2009 to December 2019. Data from 2020 to 2022 was not taken because, in 2020 and 2021, there were several months when there were no foreign tourists in Bali. This study focuses on finding methods to increase forecasting accuracy under normal conditions. The data comes from "Badan Pusat Statistik" on the BPS Bali website pages.

3.4. Methodological Description

This study will use stages based on the OSEMN Framework [22], which are as follows

1. **Obtaining** is a stage in obtaining data. The way to carry out this stage is to download the .xlsx format data on the number of foreign tourists who visited Bali from 2009 to 2019.
2. **Scrub** is a stage in cleaning, filtering or extracting the forecasting data obtained. The steps to perform Scrub are
   a. Because the data obtained is the number of foreign tourists who visited Bali via Tanjung Benoa Harbor and Ngurah Rai Airport, we first filtered the data for those who only visited Bali via Ngurah Rai Airport.
   b. We are combining separate data for each year into one variable.
   c. Create a date index so that it becomes time series data.
3. **Explore** is the stage for getting to know the data to be researched. At this stage, we will create data visualizations to identify data patterns. This stage aims to give us the intuition to conduct further forecasting analysis.
4. **Model** is the data modelling stage used to forecast. Before doing Hybrid modelling, first, do Holt-Winter modelling with the following steps:
   a. Divide data into training data and testing data. The training data used is from January 2009 to December 2018, while the testing data used is from January 2019 to December 2019.
   b. Create a Holt-Winter model with several types, namely addictive and multiplicative trend types and addictive and multiplicative seasonal types.

   The next step is to use the Hybrid method using the residual values from the best Holt-Winter model. The steps for the Hybrid method are as follows.
   a. Create a Prophet model using residual testing data from the best Holt-Winter model.
   b. Get forecasting results from the prophet model.
   c. Adding up the best Holt-Winter method forecasting results with the residual forecasting results of the Prophet model to become the final forecasting result
5. **Interpret** is a stage in interpreting the model. This stage will be divided into two stages: interpretation of the Holt-Winter model and interpretation of the Hybrid model. In the Holt-Winter model, interpretation is carried out by identifying the best Holt-Winter model that can be used for the Hybrid method by selecting the smallest MAPE in the testing data. Then, after getting the best model, the residuals from the testing data will be searched for modeling in the Hybrid model. Next, at the hybrid model interpretation stage, the final forecasting results are evaluated to find the MAPE value and compared with the Holt-Winter model evaluation results. We will also compare the visualization of forecasting results using the Holt-Winter model alone with the visualization of forecasting results using the Hybrid Holt-Winter-Prophet model.

4. Results

4.1 Obtain and Scrub

The number of foreign tourists visiting Bali via Ngurah Rai Airport was collected from several files from the Bali Province BPS website. The data structure obtained is

Table 1. Data of The Number of Foreign Tourists Via Ngurah Rai Airport

No	Month	Year	The number of foreign tourists
1	January	2009	173867
2	February	2009	146115
3	March	2009	167954
4	April	2009	188189
5	May	2009	190638
⋮	⋮	⋮	⋮
132	December	2019	451708

Before analyzing using the forecasting method, the Month and Year columns in Table 1 are changed to datetime variables, which are then changed again to indexes to be visualized. The following is a new data structure that is ready to be used to perform time series analysis:

Table 2. Data Time Series of The Number of Foreign Tourists

No	Date	The number of foreign tourists
1	2009 – 01 – 01	173867
2	2009 – 02 – 01	146115
3	2009 – 03 – 01	167954
4	2009 – 04– 01	188189
5	2009 – 05– 01	190638
⋮	⋮	⋮
132	2019 – 12 – 01	451708

4.2 Explore

A time series visualization of the number of foreign tourists visiting Bali via Ngurah Rai Airport can be seen in Figure 1.

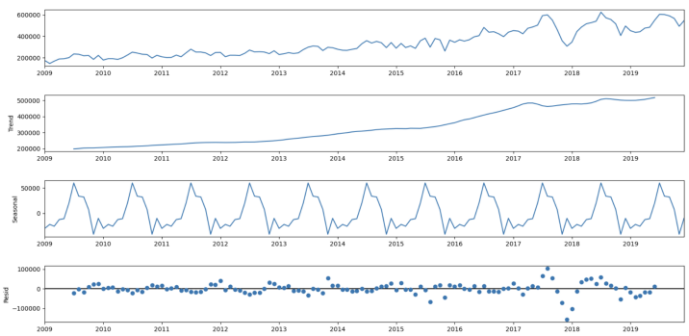

Figure 1. Decomposition of Time Series Plot

The figure shows that the data is increasing yearly, identifying it as having a trend pattern. Apart from that, the seasonal plot shows that each particular period has the same pattern, so it can be said that the data also has a seasonal pattern. Initially, the residual points are around 0 *in the residual plot*, which means that data variability is quite low. However, in the data after 2017, the residuals fluctuate away from 0, which means that the variability in the data is quite high, or it is suspected that the time series data is non-linear. Based on this, a forecasting method is needed to capture trend, seasonal, and non-linear patterns.

Figure 1 is unclear which month has the highest average number of foreign tourists. Therefore, a plot is needed so that the government is alert to the arrival of the largest number of foreign tourists in that month. The following is a plot that can illustrate this:

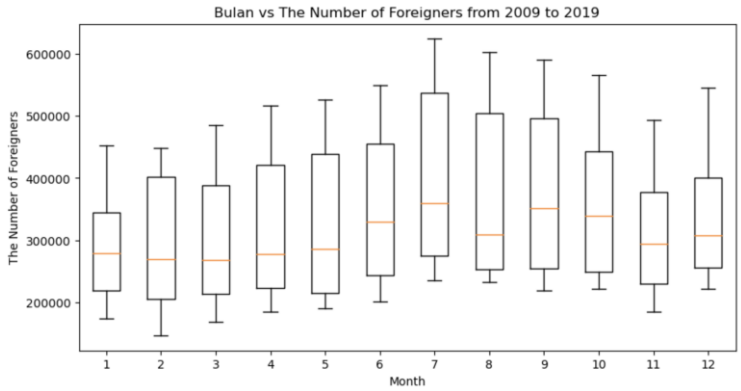

Figure 2. Plot Average of The Number of Foreigners From 2009 to 2019

Figure 2 shows that, on average, throughout the month, the highest number of foreign tourists visiting Bali via Ngurah Rai Airport is in July compared to other months.

4.3. Model and Interpretation

This section will be divided into three stages. The first is modelling and interpreting the Holt-Winter model. The second is modelling and interpreting the Hybrid Holt Winter-Prophet method, and the third is visually comparing the MAPE value. It is from the Holt-Winter model and the Hybrid model.

4.3.1. Modeling and Interpretation of the Holt Winter Model

At this stage, Holt-Winter modelling uses several scenarios to produce parameters and MAPE, as seen in Table 3.

Table 3. Parameters and MAPE of Holt Winter Model

Trend	Seasonal	α	β	γ	MAPE
Addictive	Addictive	0,8889	0,0001	0,0247	7,8126%
Addictive	Multiplicative	0,8182	0,0001	0,0303	246,11%
Multiplicative	Addictive	0,8889	0,0001	0,0247	6,0350%
Multiplicative	Multiplicative	0,8182	0,0001	0,0303	4,7910%

Table 3 shows that the best Holt Winter model for forecasting the number of foreign tourist visits to Bali via Ngurah Rai Airport is the Holt Winter modelling with multiplicative trend and multiplicative seasonality. It is because this modelling has the smallest MAPE value of 4.7910%, which means the forecasting results are said to be very accurate. However, using the Hybrid model, we

will try to reduce the MAPE value from the best Holt Winter forecast results. The following are the results of forecasting testing data for 2019 using the best model:

Table 4. The Results of The Best Holt Winter Forecast

Month	$\hat{L}_t$
January	450946.6779
February	441447.0740
March	445112.3561
April	454479.6582
May	454051.0782
June	507845.4492
July	578727.5951
August	547887.4105
September	540101.7547
October	524554.2338
November	465327.0644
December	531575.2760

Table 4 shows the results of forecasting data on the highest number of foreign tourist visits to Bali via Ngurah Rai Airport in July 2019. The result is 578727.5951 or 579 thousand people. This Forecasting is not yet close to the actual value in July of 604310 or 604 thousand people

4.3.2. Modeling and Interpretation of the Hybrid Model

Hybrid Holt Winter and Prophet modelling used residuals from the best Holt Winter. The residual results are then modelled using the Prophet method to produce a predicted value. The residual results of testing and forecasting data using the Prophet method in 2019 are

Table 5. The Residual and Forecasting using The Prophet Method

Month	Residual	$\hat{n}_t$
January	761.3221	6812.5221
February	−5181.0740	10162.1251
March	−3405.3561	13187.5729
April	21624.3418	16537.1759
May	29876.9218	19778.7271
June	41637.5508	23128.3300
July	25582.2453	26369.8813
August	54569.5895	29719.4843
September	49882.24532	33069.0872
October	41411.7662	36310.6385
November	27576.9356	39660.2414
December	13150.7240	42901.7927

From Table 5, you will get the final forecasting results by adding up the best Holt-Winter method forecasting results with the residual forecasting results of the Prophet model. The result is

Table 6. The result of Hybrid Forecasting

Month	$\hat{L}_t$	$\hat{n}_t$	$\hat{Y}_t = \hat{L}_t + \hat{n}_t$
January	450946.6779	6812.5221	457759.2000
February	441447.0740	10162.1251	451609.1991
March	445112.3561	13187.5729	458299.9290
April	454479.6582	16537.1759	471016.8341
May	454051.0782	19778.7271	473829.8053
June	507845.4492	23128.3300	530973.7793
July	578727.5951	26369.8813	605097.4764
August	547887.4105	29719.4843	577606.8948
September	540101.7547	33069.0872	573170.8419
October	524554.2338	36310.6385	560864.8723
November	465327.0644	39660.2414	504987.3058
December	531575.2760	42901.7927	574477.0687

Table 6 shows the results of forecasting data on the number of foreign tourist visits to Bali via Ngurah Rai Airport in 2019 was highest in July. The result is 605097.4764 or 605 thousand people. This forecast is almost close to the actual value in July of 604310 or 604 thousand people.

4.3.3. Comparison of the Holt Winter Method with the Hybrid Method

The Holt-Winter and Hybrid Method can be compared based on MAPE values and visualization between actual and predicted data. The results of the MAPE values obtained by each method are

Table 7. MAPE From Holt Winter and Hybrid Methods

Methods	MAPE
Holt Winter	6,0350%
Hybrid Holt Winter-Prophet	2,5880%

Table 7 shows that the MAPE value for the Hybrid Method is 2.5880%. It means that the MAPE value of this method is smaller than the only Holt Winter method. Therefore, the Hybrid Holt Winter-Prophet method can better forecast the number of foreign tourists visiting Bali via Ngurah Rai Airport than the Holt Winter method. The MAPE results align with the visualization between the actual and predicted values of the Holt-Winter method and the Hybrid Holt Winter-Prophet method, as seen in Figure 3. These figures show that the Hybrid Holt Winter-Prophet (b) method is better because it has an insignificant difference between the actual and predicted data.

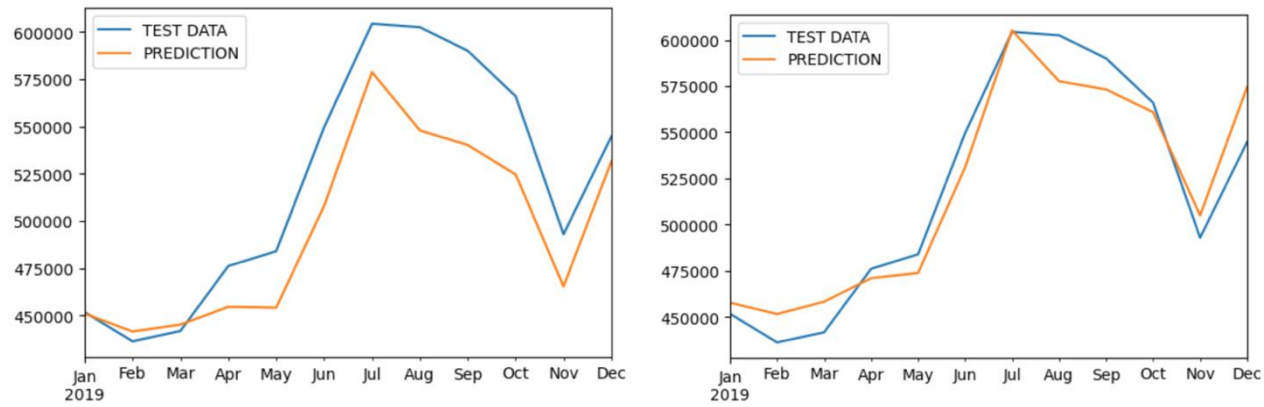

Figure 3. The Visualization of Data Testing and Prediction from (a) the Holt Winter Method and (b) the Hybrid Holt Winter-Prophet Method.

5. Conclusions

The results show that the Hybrid Holt Winter-Prophet method can predict the number of tourists visiting Bali via Ngurah Rai Airport better than the Holt Winter. This method is because it has the smallest MAPE value and a visualization of predicted values closer to the actual values.

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The IT Master Plan Development of Randegan Village

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Abstract: This research focuses on the transformation of Randegan Village into a Smart Village through the integration of digital technology and community empowerment. The main objective of this research is the implementation of e-government in Randegan Village through the design of an IT Master Plan to achieve a smart village. The research design involved a comprehensive analysis of the Smart Village model and literature review by citing insights from the Smart City concept and successful implementation case studies from past research. To help achieve a smart village in Randegan Village, the research team aims to carry out sensing, understanding, controlling, in Randegan Village so that an IT master plan can be created which then has the potential to become a Smart Village Development Master Plan in Randegan Village. The result is that there is a need for cooperation between educational institutions and the community to increase technological literacy. Technology education programs are suggested to overcome challenges of technology adoption. Community involvement is considered very important in developing technology applications, to encourage their acceptance and benefits. The allocation of resources for technology infrastructure is considered important, and it is also important to work with government to ensure financial support and technical assistance. The results of this study are expected to help Randegan Village in determining policies and programs for developing village information systems so that later they can improve the quality of service to villagers, increasing economic growth, and quality of life in randegan village.

Keywords: E-Government; IT Master Plan; Smart Village

1. Introduction

In recent years, the concept of rural development has evolved beyond traditional approaches, integrating technology and innovative strategies to enhance the quality of life for rural communities [1], [2]. The emergence of the smart village paradigm presents a promising avenue for transforming rural areas into digitally empowered and self-sustaining entities. Central to this transformation is the implementation of Information Technology (IT) master plans and e-Government initiatives, which have demonstrated their potential to bridge the rural-urban divide and foster holistic development [3], [4]. This paper delves into the case study of Randegan Village, illuminating the process and outcomes of optimizing rural development through the application of IT strategies and e-Government solutions within the context of the smart village framework. In Indonesia, research on smart villages has been increasingly undertaken by academics and governmental institutions. However, studies specifically focusing on smart rural areas remain relatively scarce [5].

Randegan is one of the villages located in the Tanggulangin sub-district, Sidoarjo Regency. The primary potential of this village lies in the fields of agriculture and plantations. In the implementation of information technology to support e-government and ICT governance in rural areas, a comprehensive and well-structured ICT strategic planning is needed. The Strategic ICT Planning in e-government development is used to align the strategic business needs of the village government organization with ICT strategies, thus deriving added value for the governmental organization [6]. The formulation of an ICT Master Plan for village government offices is expected to serve as a guide for city governments in determining policies, strategic plans, ICT work programs, the development of ICT management units, user management, network infrastructure development, ICT infrastructure, information system management guidelines, allowing village government offices to provide rapid and targeted public services and execute the government's vision in realizing good governance.

Based on previous research [7], this study aims to address rural development challenges by employing technology to enhance services, information access, and energy availability. This concept is rooted in local regulations and governance, with the objective of improving community livelihoods and economic conditions. For successful implementation, a robust regulatory framework is crucial, aligned with the Smart City plan in Banyuwangi. Meanwhile in a previous study [8], [9], collaboration between the Ministry of Communication and Information Technology and other ministries is highlighted to initiate a movement towards 100 smart cities. Banyumas Regency was chosen as one of the cities for the smart city project. This paper underscores the necessity of an application that can drive effective, efficient, and participatory smart city development.

2. Related Works

Research related to the Smart Village Concept has been carried out by many previous studies. One such study entitled “Smart Village Concept and Tourism Development in Sumbawa Regency" provides a comprehensive overview of the concept of smart villages and its potential for tourism development in Sumbawa Regency, Indonesia. The paper highlights the need for comprehensive development in rural areas, particularly in terms of infrastructure and technology, to improve public services and address national problems such as poverty, health, clean water, and electricity. Overall, the paper provides valuable insights into the potential of smart village development for promoting

tourism and sustainable development in rural areas. It offers practical recommendations for the development of smart villages in Sumbawa Regency, emphasizing the importance of infrastructure, technology, community empowerment, and stakeholder collaboration [10].

Through the results of research conducted by Widdy Yuspita Wdiyaningrum in the journal article entitled "Strategi Dinas Komunikasi dan Informasi (Diskominfo) dalam Pengembangan dan Pembangunan Master Plan Smart City di Kabupaten Bandung". This article discusses the strategy of the Communication and Information Office (Diskominfo) in the development and construction of the Smart City Master Plan in Bandung Regency. The concept of a smart city is defined as a city that uses technology to improve efficiency, public services, and the well-being of its residents. The article also mentions the use of the SWOT analysis (Strengths, Weaknesses, Opportunities, Threats) in formulating the strategy. The research method used is qualitative research, involving interviews, observations, and document analysis. The article emphasizes the importance of economic, social, and environmental factors in creating a smart city. [11]

In the previous new concept, village development with the smart village concept was first introduced by Indian researchers, N. Viswandham and Townya Vendula. They developed this concept in 2010, elucidating the village ecosystem and mapping integrated design methods for constructing a smart village [7. The smart village concept can be used as a basis for rural development in Indonesia, although this concept cannot be fully applied due to the presence of varying ecosystems in each village [12]. However, village development should not only focus on the utilization of information technology but also comprehensively encompass services, governance, and community life [13]. The objective of this research is the implementation of e-government in Randengan Village through the design of an IT Master Plan to achieve a smart village. Also, this research to explore the potential of the Smart Village concept in improving public services, increasing economic growth, and quality of life in Randegan village.

3. Experiment and Analysis

3.1. Methodology

In preparing a master plan that involves the transformation from a manual system to a computerized system, a systematic approach and methods related to the change process are needed. The research method used is a qualitative method to carry out an analysis of the existing IT systems or devices and the systems needed in Randegan Village. The qualitative method used is as follows. This method facilitates a deep and nuanced understanding of the existing IT systems and devices within Randegan Village, as well as the potential systems required for its advancement. The qualitative approach allows for a holistic exploration of the current challenges, strengths, and gaps in the technological landscape of the village. This, in turn, lays the foundation for the formulation of an effective master plan that aligns with the specific needs and circumstances of Randegan Village.

The stages of the research are carried out as follows [6], [14]:

1. Identifying problems with Randegan Village
2. Conduct a literature study on the village IT master plan and then carry out a field study to Randegan Village.
3. Conduct a study of the profile and strategy of the village of Randegan
4. Analysis of the need for an information system for the village of Randegan

5. Determine the information technology specifications of the Randegan village
6. Compile a management and project portfolio in the village of Randegan
7. Arrange information system governance
8. Create an IT master plan document that contains strategies and steps to implement and build an information system in the village of Randegan, including guidelines, indicators, frameworks, and cost plans.

3.1.1. Literature Study

Literature Study provides a theoretical framework by analyzing literature related to IT Masterplan and best practices in IT strategic plans. The process of conducting a Literature Study serves as a cornerstone in establishing a robust theoretical framework. This framework is constructed through the meticulous analysis of pertinent literature that delves into both the realm of IT Master Plan and the exemplar practices within the broader landscape of IT strategic planning. Literature study was conducted to compare the IT Masterplan which had previously been implemented to support the Smart City program with the IT Masterplan which will be prepared in Randegan Village according to the existing domains. The integration of these three stages will provide a comprehensive understanding regarding the implementation of the IT Masterplan which will be developed in Randegan Village and the potential for improvement and development in the future. This comprehensive review not only contributes to a theoretical underpinning but also serves as a reservoir of insights to guide and inform the forthcoming endeavours.

3.1.2. Observation

The exploration process extends beyond theoretical analysis, encompassing direct observations of the existing IT infrastructure within Randegan Village. Before the IT Master plan was prepared, it was explored first regarding the vision and mission of Randegan Village which would later be adapted to the needs of the village by implementing the existing master plan. The author is shown firsthand how IT infrastructure is used in various aspects of daily activities, including the use of hardware, software and data security both by Randegan village employees and residents in the environment. The practice of direct observation of the existing IT infrastructure in Randegan Village yields a multitude of invaluable benefits that transcend theoretical analysis. This immersive approach brings forth a deeper level of understanding and insight, enriching the process of preparing the IT Masterplan. By immersing themselves in this observational process, the author gleaned insights into the practical applications and utilization patterns of the existing IT infrastructure. This firsthand experience enriched their understanding of how technology threads through various operational facets, ranging from administrative tasks to communal engagements. Observing the utilization of hardware offered a tangible grasp of the tools that facilitate digital processes.

3.1.3. Interview

The interview stages involved the Randegan Village Secretary and the IT team in the village. Interviews were conducted to gain a deeper understanding of their views regarding the IT Master Plan, the costs incurred to adopt the technology, the obstacles encountered, and the solutions provided. In the discourse with the Randegan Village Secretary, invaluable insights were gleaned regarding the overarching vision and strategic alignment of the IT Master plan with the village's developmental goals. The Secretary's perspectives illuminated the intended impact of the plan on the village's overall efficiency, service delivery, and the enhancement of administrative functions.

Additionally, discussions around the financial implications of adopting new technology underscored the Secretary's informed stance on investment, resource allocation, and the anticipated long-term benefits for the community. The primary objective behind these conversations was to delve into a comprehensive understanding of various facets that intertwine with the IT Master plan.

3.2. Results and Discussion

In an effort to prepare an effective IT master plan for Randegan Village, it's important to grasp the concepts of Smart City and Smart Village as foundations. Smart City is the concept of applying digital technology to enhance services and quality of life in urban areas, while Smart Village extends a similar concept to rural areas, focusing on improving public services, economic growth, and technology utilization [15], [16].

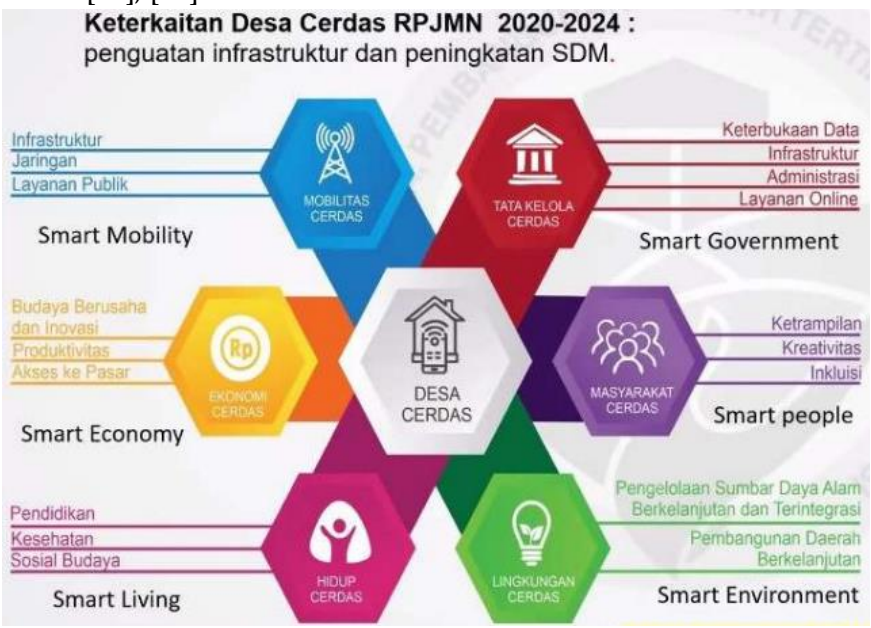

Figure 1 Six Pillars of Smart Village

There are 6 pillars in implementing a smart village, smart people, smart living, smart environment, smart economy, smart mobility, and smart government. Figure 1 shows the relevance of the 6 pillars smart village with *Rencana pembangunan Jangka Panjang dan Menengah Nasional* (RPJMN) 2020-2024 [17]. This refers to strengthening infrastructure and increasing Human Resources (HR). The purpose of having a smart village is as a form of transformation in the use of digital technology which is expected to encourage an increase in the quality of basic services and village development based on sustainable community empowerment. Digital technology has a role in realizing this smart village. Furthermore, to realize the development of a smart village, it is necessary to go through several stages, i.e., planning, implementing and monitoring.

Through the integration of digital technology, as seen in the Smart Village concept in Banyuwangi, Indonesia, the potential to enhance public services, stimulate rural economic growth, and support the tourism sector becomes more evident. Banyuwangi's approach to becoming a Smart Village is influenced by local policies, needs, and opportunities that shape such initiatives in a contextual manner. Utilizing diverse sources of income, including Village Original Revenue, General Allocation Fund, and Grants, provides a strong foundation for investing in smart technology.

To successfully transform into a Smart Village, it's important for Randegan Village to allocate a portion of its budget for the implementation and maintenance of Information Technology and Information Systems (IT/IS). This opens the pathway for the integration of technologies such as IoT devices and data analytics, resulting in the augmentation of public services and the quality of governance. Additionally, harnessing the inherent potential within the village's robust agriculture sector provides a unique opportunity to not only bolster this sector but also attract crucial investments that can catalyze the growth of intelligent and technology-driven agricultural practices. By infusing smart technology into agriculture, Randegan Village can optimize resource management, enhance crop yields, streamline distribution channels, and ensure sustainable farming practices. This not only elevates the economic prospects of the village but also contributes to the broader goal of fostering a technologically empowered and sustainable smart village ecosystem [18].

Parallel to the information from the IT master plan, Banyuwangi's evolution as a Smart Village aligns with key principles. The proposed Smart Village model, encompassing dimensions of Governance, Technology, Resources, Village Services, Life, and Tourism, can serve as a guideline for strategies tailored to Randegan Village's unique characteristics and challenges [7]. This model also reflects the necessity of considering technology-based solutions to address economic issues and enhance productivity and competitiveness in the industrial sector. This model exemplifies the vital importance of incorporating technology-driven solutions to effectively tackle economic challenges. Particularly, it underscores the significance of harnessing technology to elevate productivity and enhance competitiveness within the agriculture sector, which happens to be a dominant strength of Randegan Village. By integrating smart technology applications into agricultural practices, the village can optimize resource allocation, streamline supply chains, and implement precision farming techniques. These initiatives lead to increased crop yields, reduced waste, and improved overall efficiency. Such advancements not only bolster the economic prospects of the village's agriculture but also position Randegan Village as a beacon of innovation in the broader regional context. As a result, the transformation into a smart village becomes a strategic endeavor that not only empowers the local community but also drives sustainable rural development through technology-enabled solutions.

In effective IT master planning, lessons can be drawn from the need for regulatory frameworks, as Smart Village approaches are reliant on local policies. The interdisciplinary collaboration evident in the Banyuwangi Smart Village project can serve as a model for developing Banyumas as a smart city, emphasizing efficient workflow management and user-centered design. This experience underscores the importance of considering economic, social, and environmental factors in Smart Village creation. Thus, for Randegan Village, similar considerations need to be factored in when planning the journey towards becoming a Smart Village.

In the context of Randegan, allocating a portion of available financial resources to implement and maintain IT/IS infrastructure can be a fundamental initial step. Focusing on harnessing industrial sectors in line with Randegan's potential strengths, similar to Banyuwangi, provides opportunities for economic revitalization. Collaborations with governmental bodies, private entities, and other stakeholders will be crucial for accessing expertise and funding for smart village initiatives.

Moreover, the comprehensive Smart Village model approach presents an adaptable framework that can readily be implemented in Randegan. By tailoring strategies to the specific dimensions of

Governance, Technology, Resources, Village Services, Life, and Tourism, this approach ensures a holistic transformation that aligns with the village's distinct needs and opportunities. Drawing inspiration from the successful journey of Banyuwangi's Smart Village initiatives and guided by the principles outlined in the IT master plan, Randegan can chart its course towards becoming a thriving Smart Village, promoting sustainable development, enhancing public services, and improving overall quality of life for its residents.

Incorporating the model's Governance dimension entails establishing efficient decision-making processes, fostering local leadership, and engaging the community in shaping the village's technological evolution. Through strategic collaborations with local stakeholders, Randegan can ensure that its technology-driven endeavors are rooted in the needs and aspirations of its residents. By embracing the Technology aspect, the village can leverage digital tools, such as IoT devices, to modernize agricultural practices, optimize resource allocation, and enhance connectivity. This not only boosts productivity but also opens doors to innovative solutions that cater to the challenges faced by rural communities.

The Resources dimension involves effectively utilizing the village's existing assets, such as financial resources and human capital, to fuel its smart transformation. By investing in skill development and education, Randegan can cultivate a tech-savvy workforce capable of driving the implementation of digital solutions. Village Services encompass the digitalization of public services, facilitating seamless interactions between residents and local authorities. Through digital platforms, citizens can access essential services, fostering a more transparent and efficient administrative process.

The Life dimension emphasizes improving the overall quality of life for Randegan's inhabitants. By incorporating technology into healthcare, education, and social services, the village can enhance well-being and promote inclusivity. Lastly, Tourism holds potential for economic growth, where Randegan can promote its unique cultural and natural heritage through digital platforms, attracting visitors and generating revenue.

By adopting this multidimensional approach, Randegan can align itself with the principles of a Smart Village, capitalizing on its strengths in sectors like agriculture while embracing modern technology. The Smart Village model provides a roadmap for sustainable development, efficient governance, and enhanced living conditions, enabling Randegan to flourish as a shining example of technological progress in a rural context.

Meanwhile, the provided instruments such as services, applications, security, business processes, SPBE organizer, Network, hardware, software, and data and information reveal weaknesses in the application and SPBE organizer domains in Randegan Village. These weaknesses span across both the application domain and the SPBE organizer domain. The challenges are compounded by the scarcity of skilled human resources in IT management within the village. Moreover, the local residents' limited familiarity with technology further exacerbates the situation. The underutilization of the existing applications aggravates the issue, making it imperative to take strategic measures. With limited skilled human resources in IT management and the villagers' lack of understanding of technology, coupled with minimal implementation of existing applications, steps to enhance human resource capabilities, educate the community, and facilitate application adoption need to be central in the IT master plan for Randegan Village.

To address these challenges comprehensively, the forthcoming IT master plan for Randegan Village should primarily focus on augmenting the capabilities of the available human resources. This entails providing training and skill development opportunities to enhance IT management proficiency. Simultaneously, an essential aspect will be to initiate community-wide technology literacy programs. By enlightening the villagers about technology's benefits and operations, the barriers to adoption can be effectively lowered. A concerted effort to facilitate the integration of existing applications is also vital, necessitating a holistic approach that encompasses education, training, and ongoing support mechanisms.

In the endeavor to design an IT Master Plan for a Smart Village in Randegan, several strategic recommendations have been identified.

1. The first priority is Human Resource Enhancement, focusing on training and development in the IT field. Collaboration with educational and training institutions around the village is expected to enhance the population's ability to manage technology more effectively.
2. Technology Education program needs to be implemented for village residents to address confusion regarding new applications and technologies. This initiative can include training sessions, workshops, and informative sessions to improve the community's technological understanding.
3. Community Participation is also deemed essential in technology application development and usage. By encouraging active involvement, acceptance and understanding of technology can be improved.
4. The aspect of IT Infrastructure must not be overlooked. Therefore, it is recommended to allocate specific funds from the village budget to meet the needs of purchasing, operating, and maintaining the required IT hardware and software.
5. Strategic partnerships with the central government, private sector, and other relevant parties are also suggested recommendations. These partnerships are expected to provide access to resources, technical support, and funding that support technology development.
6. In application development, an emphasis on User-Friendly design with easy-to-use interfaces and clear guidelines should be highlighted. This is crucial to support village residents who are not accustomed to technology.
7. Lastly, Monitoring and Evaluation become crucial steps. It's recommended to establish performance indicators that measure the effectiveness of application and technology usage. Regular evaluation and improvement based on user feedback are considered necessary to ensure the success of technology implementation in Randegan Village.

4. Conclusions

Based on the results of the analysis and discussion above, the development of Randegan Village to become a Smart Village is an important and strategic step to improve the quality of life of the people, advance the economy of the Randegan village, and improve public services. The Smart Village concept, which combines digital technology with community empowerment, has great potential to realize these goals. Through discussions on the concepts of Smart Cities and Smart Villages, as well as implementation case studies in Banyuwangi, Indonesia, several recommendations and principles have been found that can be adopted by Randegan Village on its

way to transforming into a Smart Village. This research provides valuable insights into how digital technologies can be applied to improve public services and economic growth in rural areas.

Several factors such as human resource development, active community participation, and strong technological infrastructure are key elements in realizing the vision of a sustainable Smart Village. Then implement a comprehensive and directed IT Master Plan in realizing this vision. The IT Master Plan is the main guide in managing strategic steps in integrating digital technology, developing human resources, and building the infrastructure needed to create a sustainable Smart Village. By integrating these components holistically, Randegan Village has a real opportunity to undergo a positive transformation into a smart, innovative and sustainable entity in the digital era.

To achieve change towards a successful Smart Village, Randegan Village needs to take strategic steps. First, collaboration with educational and training institutions needs to be increased in order to improve human resource capabilities in managing technology. Second, a technology education program is needed that provides understanding to villagers regarding new applications and technologies. Third, involving the community actively in the development and use of technology will accelerate the acceptance and effectiveness of implementation. With these steps, as well as the allocation of funds and strategic cooperation, Randegan Village has the potential to become a successful example in realizing a smart and innovative future. As well as being able to assist Randegan Village in determining policies and programs for developing village information systems so that later they can improve the quality of service to villagers.

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Strategic Insights into Educational Assessment: The Implementation and Constraints of SIMCPM in Monitoring Student Outcomes

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Abstract: In response to the evolving challenges in educational institutions, the Ministry of Education and Culture emphasizes the crucial role of effective information systems in achieving optimal educational objectives. This study introduces the Student Learning Achievement Information System (SIMCPM) as a strategic solution for systematically monitoring and evaluating student performance. The research explores the implementation of SIMCPM, focusing on its role in functional testing within educational environments. With a user-centric approach, the study investigates how SIMCPM can be integrated as an innovative tool for monitoring student learning achievements, specifically in displaying grade and attendance data. The methodology outlines the comprehensive approach to SIMCPM's development, emphasizing the use of Laravel 8 for backend infrastructure and HTML, CSS, and JavaScript for UI/UX development. Data visualization development is highlighted, showcasing the integration of ApexCharts.JS for effective communication of educational metrics. Functionality testing ensures the reliability of the system, encompassing testing scenarios, integration testing, load and performance testing, and mobile and tablet functional testing. Results and discussion present the outcomes of SIMCPM's implementation, including data simulation, dashboard rendering, and functionality testing. The study introduces dashboard features for students, lecturers, and the Head of Study Program, emphasizing speed, efficiency, and data visualization quality. Functionality testing results confirm the robustness of the system. The subsequent section interprets the results, addressing implications, strengths, limitations, and potential improvements in the SIMCPM system. The conclusion recommends continuous testing with real-time data, user feedback integration, and potential enhancements such as predictive analytics and personalized learning recommendations to ensure sustained effectiveness in supporting academic processes. Overall, SIMCPM emerges as a promising tool for efficient academic management, subject to continuous refinement and innovation.

Keywords: Student Learning Outcome; Information System; Functional Testing; Education Asesement; Laravel, PHP

1. Introduction

In the dynamic landscape of educational institutions, the development of an effective and efficient information system emerges as a critical response to the unique challenges faced in monitoring and evaluating student learning outcomes. Recognizing the pivotal role of education in societal advancement, the Ministry of Education and Culture (2019, Article 16 paragraph 1) underscores the importance of ensuring that educational objectives are optimally achieved. To meet this imperative, the Student Learning Achievement Information System (SIMCPM) has been conceived as a strategic solution[1]. Functioning as an effective and efficient tool, SIMCPM is meticulously designed to systematically and integratively monitor and evaluate student performance[2].

The research questions guiding this investigation delve into the extent of SIMCPM's implementation in providing additional insights into the literature on the functional testing of information systems in educational environments[3]. With a user-centric approach, the study aims to explore how SIMCPM can be seamlessly integrated as an innovative tool for monitoring student learning achievements, particularly in the nuanced contexts of displaying grade and attendance data[4]. This exploration extends beyond the immediate academic environment, probing into the potential for SIMCPM to pave the way for the development or enhancement of similar information systems in diverse educational institutions. While the research seeks to unravel the possibilities and benefits inherent in SIMCPM, it acknowledges certain constraints that delineate its scope. The study is intentionally confined to three primary user applications—students, faculty members, and program coordinators—to ensure a nuanced understanding of their specific needs within the educational realm. Furthermore, recognizing the symbiotic relationship with the existing academic system, SIMCPM is positioned as an additional or supportive component. This deliberate approach aims to augment the functionalities of the established academic infrastructure without imposing a complete overhaul[5].

The limitations of the research are intricately tied to the focus on specific features within SIMCPM, specifically the visualization of student data related to grades and attendance[6]. By delving deeply into these components, the study intends to provide an in-depth examination of their impact on the holistic monitoring of student learning achievements[7]. In essence, this introduction sets the stage for a comprehensive exploration of SIMCPM, balancing the promises it holds for educational advancement with the pragmatic considerations that guide its.

2. Methodology

The methodological anchor of this study, providing a comprehensive overview of the approaches, techniques, and processes employed in the implementation and evaluation of the SIMCPM system.

2.1. Application Development

The application development process involves a comprehensive approach to ensure the creation of a functional and efficient educational assessment system[8]. Laravel 8, chosen as the development framework, facilitates the systematic organization of the project by providing a set of

tools and conventions. The development team will leverage Laravel's capabilities for routing, database management, and templating to create a robust back-end infrastructure[9]. The PHP programming language, known for its versatility, will be employed to implement the business logic, ensuring seamless interactions within the application. The choice of MySQL as the database management system further supports data storage and retrieval requirements. This integrated approach aims to establish a cohesive and scalable foundation for the educational assessment system, emphasizing the importance of a well-structured application development process in achieving the research goals[10].

The user interface (UI/UX) development phase is pivotal in shaping the overall user experience and visual appeal of the educational assessment system. HTML and CSS are employed to craft an intuitive and visually engaging front-end interface. Leveraging the capabilities of JavaScript, particularly with the integration of ApexChars.JS for charting, enhances the interactivity and data visualization aspects of the user interface. The combination of these technologies ensures a seamless and responsive user experience across various devices. By implementing a user-centric design philosophy, the UI/UX development focuses not only on aesthetic aspects but also on creating an interface that promotes user efficiency and comprehension. The incorporation of ApexCharts.JS for dynamic charting contributes to effective data communication, aligning with the research objective of emphasizing visualized educational data. This subchapter underscores the significance of thoughtful UI/UX design in enhancing the overall usability and accessibility of the educational assessment system.

2.2. Data Visualization Development

The subchapter on Data Visualization Development [11] constitutes a critical phase in the implementation of the educational assessment system. Beginning with the identification of relevant data sets, this phase aims to translate raw information into meaningful insights through the application of visual elements. ApexCharts.JS is instrumental in this process, providing a powerful toolset for creating dynamic charts and diagrams. The selected visualizations are strategically designed to communicate educational data effectively, catering to diverse audiences. The integration of these visual components not only enhances the aesthetic appeal of the system but also facilitates a more intuitive understanding of complex educational metrics. By combining the identified data with visually impactful representations, this subchapter emphasizes the pivotal role of data visualization in making the educational assessment system accessible and comprehensible for users, thereby contributing to the overarching objectives of the research.

2.3. Functionality Testing

Functionality Testing is a crucial stage in ensuring the reliability and effectiveness of the educational assessment system. This subchapter encompasses a series of rigorous tests designed to evaluate the application's various functionalities. Beginning with Testing Scenarios, key use cases are systematically examined to validate that the system behaves as expected under different conditions. Integration Testing follows, verifying the seamless interaction between different components to ensure a cohesive and well-integrated system. Load and Performance Testing are integral to assessing the application's responsiveness and stability under varying levels of user activity. Mobile and Tablet Functional Testing ensures that the system's interface remains responsive and functional across diverse devices. By employing a comprehensive set of testing methodologies, this subchapter aims to validate the robustness and reliability of the educational assessment system, emphasizing its capability to meet the intended objectives and user expectations.

3. Result and Discussion

This chapter delves into the heart of the study, presenting the results obtained from the comprehensive implementation and evaluation of the SIMCPM system. This chapter serves as a detailed exposition of the outcomes derived from various phases, including data simulation, dashboard rendering, and functionality testing.

3.1. Result Presentation

The comprehensive implementation of the SIMCPM system is presented, enriched by a diverse set of dummy data generated using FakerPHP v1.23.0. The simulation spans across six academic semesters, resulting in a dataset comprising 12,192 rows of information. The dataset encompasses key elements, including student IDs, course details, assigned faculty, academic years, semesters, attendance, examination status, and performance metrics such as pre-test scores (Pre Test 1-4), midterm (UTS), and final (UAS) exam grades, overall course grades, and corresponding letter grades. It is noteworthy that all values in the dataset are customized within the range of 40 to 100. Further details and a visual representation of the dataset can be found in Fig 1.

The dummy data, meticulously crafted to emulate the intricacies of a dynamic educational environment, enables a thorough exploration of the system's functionality and its impact on diverse user experiences. The utilization of FakerPHP ensures a realistic and diverse representation of student and course interactions within the simulated academic context.

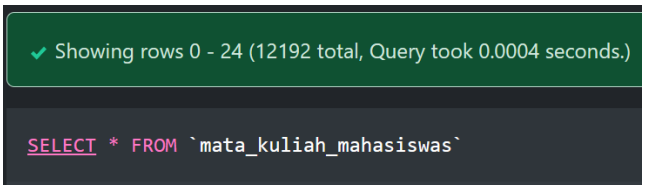

Figure 1 Data

In the development of SIMCPM, we introduce a dashboard feature specifically designed for students, providing contextual visualization based on the current academic year, semester, and the student's ID. The algorithm's success in rendering the visual dashboard in a short time, averaging 0.3 seconds, ensures fast and efficient access to student data. Comprehensive details regarding this data can be found in Table 1.

Table 1 Average Page Load Speed

Page	Average Page Load Speed
Student Dashboard	0,3
Student Course	0,3
Lecturer Dashboard	0,4
Head of Study Program Dashboard	0,4
Head of Study Program Course	0,6

This feature not only offers speed but also delivers relevant information. The student dashboard display includes crucial elements such as the course name, assigned faculty, semester, and academic year. The data generated from this feature is clearly documented in Fig. 2, illustrating a concrete

visualization of the student dashboard view. Thus, students can easily track their academic progress and plan their studies more effectively. The data visualization in the table and image provides a profound understanding of the excellence and added value of this dashboard feature.

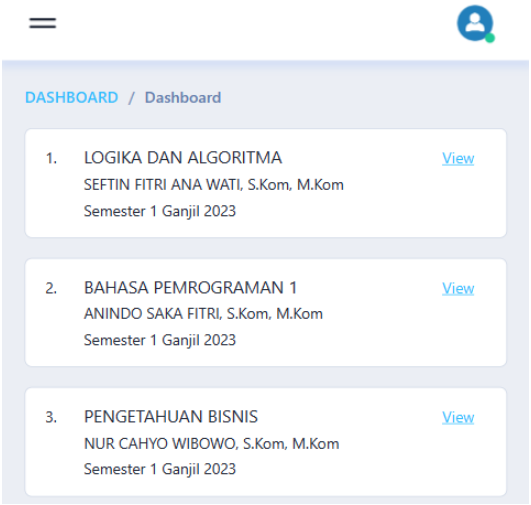

Figure 2 Student Dashboard

A student course dashboard feature specifically tailored for students, displaying visualizations based on the current academic year, semester, and the selected course, along with the student's ID. The implemented algorithm successfully renders the visual dashboard with an average time of 0.5 seconds, ensuring quick and efficient access to student data. All detailed information regarding this data can be referenced in Table 1.

This feature goes beyond providing a general overview; it delves into more comprehensive details concerning students' grades, attendance, and the course materials covered. The selection of this feature aims to offer a more profound understanding of students' academic progress within a specific course. The data visualization is presented distinctly in Fig. 3, providing a concrete representation of the course dashboard feature. With this feature, it is anticipated that students can easily monitor their academic development, make informed decisions, and enhance their overall learning experience.

Moreover, the tracking of grades and attendance serves as a reminder for students to remain focused on their coursework, ensuring that final grades and attendance records remain favorable. This feature acts as a valuable tool, prompting students to prioritize their academic commitments and contributing to a more successful and engaged learning journey.

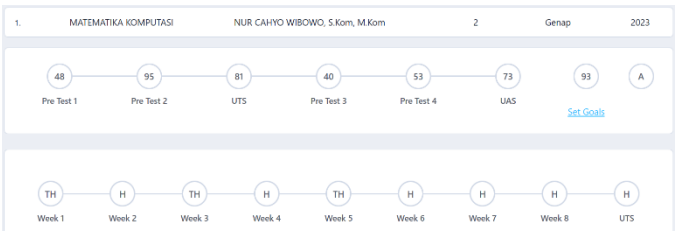

Figure 3 Student Course Dashboard

A dashboard feature specifically designed for Lecturer, displaying visualizations based on the courses they teach, considering the current academic year, semester, and the instructor's ID. The algorithm's success in rendering the visual dashboard with an average time of around 0.3 seconds ensures quick and efficient access to instructor-related data. All detailed information regarding this data can be accessed in Table 1.

Figure 4 Lecturer Dashboard

This feature goes beyond providing a general overview; it also presents key information that facilitates instructors' analysis of student performance. The feature includes a list of the five highest and lowest grades obtained by students in the respective course. Additionally, there is a pie chart summarizing the percentage of student grades with customized colors for each grade: green for Grade A, blue for Grade B, cyan for Grade C, orange for Grade D, and red for Grade F. As a complement, a stacked column chart for student attendance is displayed, using purple for present students and gray for absent ones. All these features are clearly depicted in Figure 4, providing a more comprehensive representation of the course dashboard feature for instructors. With this feature, it is expected that instructors can easily analyze and understand student performance, make informed decisions, and manage classes more efficiently.

A dashboard feature specifically designed for the Head of Study Program displaying visualizations based on the current semester within the current year. The algorithm successfully renders the visual dashboard with an average time of around 0.4 seconds, ensuring quick and efficient access to Head of Study Program related data. Detailed information regarding this data can be accessed in Table 1.

This feature goes beyond providing a general overview; it also includes links to a list of courses that allow the Head of Study Program to explore further details. The dashboard view also incorporates information on the lowest, average, and highest grades for each course. These links are designed to facilitate the Head of Study Program in gaining more insights into each course, while the grade distribution provides a comprehensive overview of the progression of each course. With this feature, it is anticipated that the Head of Study Program can easily manage and monitor the educational progress at the program level. The associated data can be viewed in Figure 5. Additionally, for the bar chart, the color representation is as follows: orange represents the lowest grades, blue represents the average grades, and green represents the highest grades.

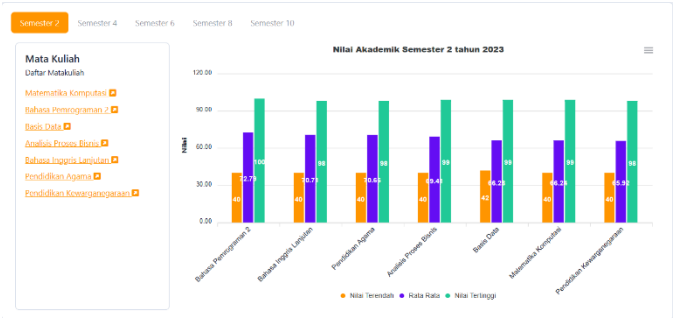

Figure 5 Head of Study Program Dashboard

A dedicated dashboard feature for the Head of Study Program displaying visualizations based on the selected courses. The algorithm successfully renders the visual dashboard with an average time of around 0.6 seconds, ensuring quick and efficient access to Head of Study Program Course-related data. All detailed information regarding this data can be accessed in Table 1.

This feature goes beyond providing a general overview; it also offers specific details related to the courses being supervised. The dashboard view includes information on the name of the instructing faculty, a line chart depicting the progression of grades (highest, average, lowest) for each course per academic year. The color representation in this chart distinguishes the highest grades with green, average grades with blue, and lowest grades with orange. Additionally, there is a pie chart summarizing the percentage distribution of grades in that particular course. The feature also presents a tabulated list of grades and attendance for all enrolled students in that course.

With this feature, it is anticipated that the Head of Study Program Course can easily analyze and monitor student performance in each supervised course. The information provided, ranging from grade progression to grade percentage summaries, is designed to offer a deeper understanding and facilitate the management of the curriculum and academic progress of the study program. The associated data can be viewed in Figure 6.

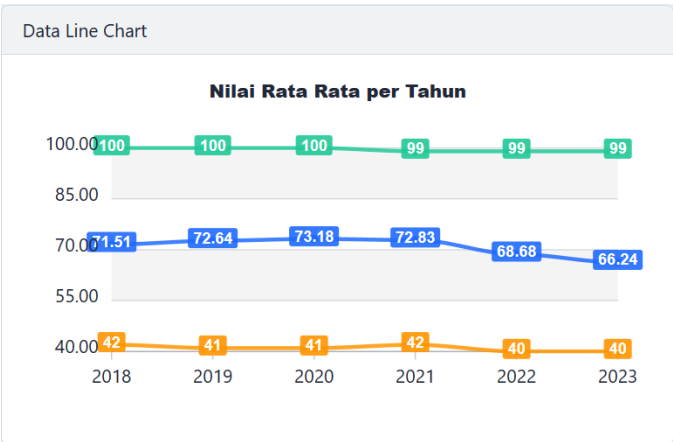

Figure 6 Head of Study Program Course Dashboard

3.2. Functionality Testing Results

- Data Simulation Process

We employed the FakerPHP v1.23.0 software to generate dummy data, incorporating diverse scenarios that mimic a range of academic situations. The simulation process involved selecting appropriate parameters for each data element and adjusting value ranges to align with the academic

context. Throughout this section, we provide a detailed account of the data simulation process, outlining the steps taken to produce a dataset that authentically reflects various academic scenarios. The utilization of the FakerPHP v1.23.0 software allowed us to simulate scenarios involving value variations, attendance situations, and exam scenarios, ensuring a comprehensive representation of academic contexts. This involved selecting suitable parameters for each data element and adjusting value ranges to accurately capture the intricacies of diverse academic situations.

- Dataset Details and Performance Metrics

In this subchapter, we present comprehensive details of the dataset generated during the simulation, including key parameters such as student IDs, course details, faculties, academic years, semesters, as well as performance metrics like pre-test scores, midterm grades, and final exam grades. Additionally, we describe how all values in the dataset were customized within a specific range to provide realistic variation.

- Dashboard Rendering Speed

We evaluate the performance of the algorithm that renders visual dashboards for students, lecturers, and the head of the study program. The average rendering speed, measured in seconds, is recorded for each user type. This evaluation ensures fast and efficient access to student data and understanding the system's response to dashboard rendering demands.

- Data Visualization Quality

Focusing on data visualization aspects, this subchapter discusses the quality of the dashboards produced by the system. We evaluate how well visualizations provide clear and useful information to users. Aspects such as graph clarity, data presentation, and interpretability are the focus of evaluation in this subchapter.

- Functionality Testing

This subchapter covers the overall functionality testing of the system. We test various features, ranging from the student dashboard to the head of the study program dashboard, to ensure that each function operates as expected. The results of functionality testing serve as the basis for assessing the success of the SIMCPM implementation in providing useful and responsive features.

3.3. Results and Discussion

This section serves as an extensive exploration of the data simulation process, encompassing key parameters and scenarios. Utilizing FakerPHP v1.23.0, diverse dummy data is generated, mirroring a spectrum of academic situations. The detailed process involves parameter selection, value range customization, and a focus on aligning simulated data with real-world academic contexts. The comprehensive overview extends to the presentation of the generated dataset, highlighting key performance metrics such as student IDs, course details, academic years, semesters, and exam scores. It also delves into assessing the rendering speed of dashboards for various user types, gauging system responsiveness. With a specific focus on data visualization, the section evaluates dashboards' quality in terms of clarity, interpretability, and overall effectiveness in conveying information. Furthermore, user responses regarding implemented dashboards are analyzed to measure effectiveness and user satisfaction. A crucial aspect covered is the functionality testing results, ensuring each system feature operates as intended. These outcomes contribute to the overall assessment of the system's success in providing useful and responsive features. The section culminates in interpreting the presented results, offering insights into their implications, strengths, limitations, and potential areas for improvement in the SIMCPM system.

4. Conclusions

The development and implementation of the SIMCPM system have been thoroughly examined and presented in this study. The utilization of FakerPHP v1.23.0 for data simulation has provided a robust foundation for testing the system's functionality under various academic scenarios. The comprehensive dashboard features for students, lecturers, and Head of Study Program demonstrate the system's versatility in catering to diverse user roles and needs.

The speed and efficiency of the dashboard features, as indicated by the average page load speeds, showcase the system's responsiveness and user-friendly design. The incorporation of detailed data visualizations, such as charts and graphs, enhances the interpretability of academic information for both students and instructors.

Based on the findings, several recommendations can be made for further improvements. Firstly, continuous testing and validation with real-time data are essential to ensure the system's reliability and accuracy in a live academic environment. User feedback should be actively sought and integrated into the system's updates to enhance user experience and address any emerging needs.

Additionally, expanding the system's features to include predictive analytics and personalized learning recommendations could contribute to a more proactive and adaptive educational environment. Integrating machine learning algorithms to analyze patterns in student performance and engagement could assist in identifying early indicators for academic challenges.

In summary, the SIMCPM system, with its simulated data and functional dashboard features, lays a solid foundation for an efficient academic management tool. Continuous refinement and innovation, guided by user feedback and emerging technological advancements, will be crucial in ensuring the system's sustained effectiveness in supporting academic processes.

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