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Computer Network Management Optimization Through Big Data Analysis Using Time Series Analysis Method

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ABSTRACT

Efficient management of computer networks is becoming increasingly important in the ever-evolving digital age. With the ever-increasing volume of data in the network environment, sophisticated approaches are needed to analyse and optimise network performance. One promising approach is the use of big data analysis with time series analysis methods. In this context, this research aims to explore the potential application of big data analysis using the time series analysis method in computer network management. By combining the power of big data analysis with time series analysis methodology. One of the main applications of big data analysis in computer networks is security threat detection. By analysing unusual traffic patterns or suspicious behaviour, the system can identify potential attacks or data leaks more quickly and efficiently. In addition, big data analytics can also be used to optimise network performance by identifying bottlenecks, predicting capacity requirements, and improving the efficiency of resource usage by utilising big data analytics in the context of computer networks. However, challenges related to data privacy and security remain a major concern that must be addressed in the application of this technology. Therefore, it is important to develop a framework that takes into account the security and privacy aspects of data throughout the big data analysis process. Through this research, it is hoped that innovative solutions to the challenges of managing complex computer networks in the evolving digital era can be found, as well as provide a solid foundation for further research in this field.

INTRODUCTION

In the ever-evolving digital era, managing computer networks is becoming increasingly important for organizations and enterprises to maintain the performance and security of their IT infrastructure (J. Susanto). As the complexity increases and the volume of data exchanged over the network grows, innovative and efficient approaches are needed to manage a sustainable network infrastructure. Before the advent of big data, decisions were made by relying on data samples. As a result, the decisions taken were not optimal (S. Prahara & I. Ali).

Such inaccurate decisions cover a wide range of fields. One promising approach in applying big data analysis for computer network management is the time series analysis method. This method enables time-based data analysis, which is useful for modeling and predicting future network behavior. By analyzing historical data with time series methods, organizations can identify network performance patterns, predict capacity requirements, and detect anomalies or unusual changes in network behavior (J. Ranjan & C. Foropon). Wireless connections are preferred over wired connections because of what it offers in terms of mobility. Therefore, cellular and Wi-Fi are the most popular connectivity technologies. The degree of freedom (in terms of mobility) varies among wireless technologies, for example, Wi-Fi can provide adequate and flexible data rates. In this ever-changing world, the need for intelligent and adaptive computer network management is becoming increasingly urgent. Organizations no longer only rely on networks to send and receive data, but also as a foundation for innovation, collaboration, and rapid decision-making. However, managing complex computer networks is not easy (R. Zulfauzi, Y. Setyawan, & J. Statistika). Network administrators are faced with increasingly complex tasks, including monitoring ever-increasing network traffic, identifying and addressing performance issues, and securing the infrastructure from rapidly evolving security threats (S. Fachrurrazi, A. Pratama, I. Wirayuda, & Y. Nosari).

In the face of these challenges, big data analysis has become a key element in modern network management strategies (Analisis Data and H. Suhandiana). By leveraging the data generated by the network infrastructure, organizations can gain deep insight into how the network operates, what trends are likely to occur in the future, and how to improve overall efficiency and performance (E. E. Supriyanto, I. Susilo Bakti, M. Furqon, & R). By understanding and applying the principles of time series analysis and big data analysis in computer network management, it is expected that organizations can optimize their network infrastructure to support operational and strategic needs in the

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ever-evolving digital era

LITERATURE REVIEW

Computer network management optimization is a crucial aspect in ensuring the performance and reliability of information systems in organizations. As the amount of data generated by network activities increases, the use of big data and appropriate analysis methods becomes increasingly important. One method that is often used in data analysis is Time Series Analysis. This literature review will discuss various concepts, methods, and research related to optimizing computer network management through big data analysis using the Time Series Analysis method.

METHOD

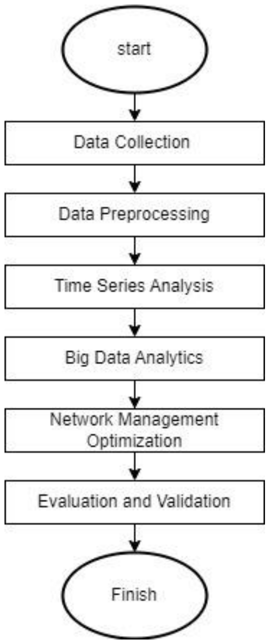

Figure 1. research stages

To gain a deep understanding of the reality under study and answer the research questions posed, this study adopted a comprehensive approach in designing and executing the research methodology. The following steps explain in detail how data was collected, processed, and analyzed to achieve the objectives.

Data collection

Identify relevant data sources, such as server logs, network traffic data, or network performance data (M. Rifka & K). Implement a mechanism to collect data in a structured and organized manner, taking into account the needs of time series analysis.

Data preprocessing

Cleaning and formatting data for analysis, including dealing with missing values or outliers. Perform resampling or interpolation where necessary to adjust for consistent time intervals (Z. Sahwa Chanigia Viqri & E. Kurniati).

Time series analysis

Apply time series analysis methods such as ARIMA (Autoregressive Integrated Moving Average), SARIMA (Seasonal ARIMA) (S. Sulpaiyah, S. Bahri, & L. Harsyiah), or Prophet models to model and analyze network behavior from historical data. Customizing the model by considering trends, seasonality, and other patterns in the data.

Big data analytics

Using big data analysis techniques such as parallel processing or data distribution to address the large volume and complexity of network data (F. Rahmanda, Yulia, A. Dalimunthe, Fachrul, & R. Lubis). Apply big data algorithms and techniques such as MapReduce or Apache Spark to process data efficiently.

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Network Management Optimization

Apply insights gained from time series and big data analysis to optimize network management, including traffic scheduling, resource allocation, and anomaly detection (Zulfikri, A., Putra, F. P. E., Huda, M. A., & Surur, M., 2023). Develop network management strategies and policies based on research findings to improve network performance and security.

Evaluation and Validation

Performing performance evaluation of the developed model using separate test data or cross-validation (H. Hassyddiqy & H. Hasdiana, 2022). Comparing the results of the proposed model with existing network management methods or approaches to assess their effectiveness and relative advantages.

RESULT

The application of big data analysis with time series analysis method in computer network management promises significant benefits. In this research, we have identified several key results that support the contribution of this research to the existing knowledge in the field of computer network management.

Improved Efficiency of Network Management

By analyzing large and complex network data, organizations can identify performance patterns, trends, and anomalies that may be missed with traditional methods. This allows network managers to take the necessary actions to improve network management efficiency and optimize overall performance (S. Yang et al). Improving network management efficiency involves optimizing the use of network resources to ensure maximum performance at minimal cost and it covers various aspects ranging from performance monitoring to automation of routine tasks. With continuous performance monitoring, network administrators can detect and address problems faster, reducing downtime and service interruptions. In addition, the use of analytics and predictive modeling, such as SARIMA, helps in forecasting future workload and capacity requirements, thus enabling better planning and bottleneck avoidance (Putra, F. P. E., Tamam, A. B., Efendi, R. W., & Muim, 2024).

Automation of routine tasks, such as network configuration and security management, also plays an important role in reducing manual workload and reducing the risk of human error. With systems that are more responsive and adaptive to changing needs, networks can operate more efficiently. The use of advanced tools and technologies for network monitoring and management ensures that the network remains healthy, reliable, and ready to face dynamic operational challenges (Y. Zhao, J. Wu, & C. Liu).

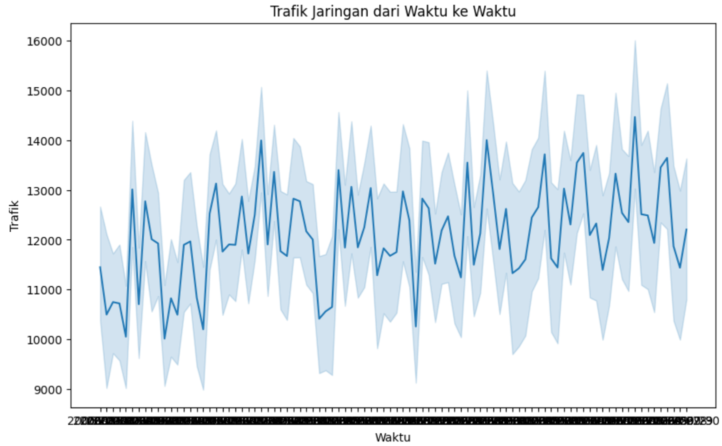

Figure 2. Network traffic over time

Network Performance Prediction

Time series analysis allows organisations to forecast future network performance based on historical patterns. This enables more effective capacity planning, better maintenance scheduling, and prevention of costly failures (A. Zainab, A. Ghrayeb, H. Abu-Rub, S. S. Refaat, & O. Bouhali, 2021). Network performance prediction also uses historical network traffic data to forecast future network conditions and performance. This technique is important in network management to ensure optimal performance, prevent disruptions, and optimise resource usage. By collecting and analysing metrics such as latency, throughput, packet loss, and utilisation, network administrators can use statistical models such as SARIMA (Seasonal Autoregressive Integrated Moving Average) to capture seasonal patterns and long-term trends in the data.

These models are trained with historical data and then used to predict future performance metrics. The results of these predictions help in capacity planning, identification of potential problems, and data-driven decision-making for

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network maintenance and upgrades. Visualisation of the predictions through graphs and time diagrams eases understanding and interpretation, enabling proactive measures to keep the network performance optimised (S. Wajdi).

Anomaly Detection and Network Security

By continuously monitoring network traffic patterns, organisations can quickly detect anomalies that may signal security attacks or performance issues. This enables a quick and effective response to mitigate any possible impact (Eka Mayasari & Agussalim Agussalim). Using manually authenticated anomaly data and historically accumulated black and white list data as a training data set. Since in malicious behaviour discovery network is an inherent data imbalance problem (anomaly data is very rare), extreme imbalance of data samples will impact the final training effect of the model. Therefore, this study uses sampling techniques to reduce the data imbalance problem. Firstly, we reduce the sample size from the normal traffic sample. Secondly, we only sampled URLs from the top-ranked domains (D. Ruhiat, E. S. Masrulloh, & F. Azis).

Then we update the malicious traffic data after manual verification to the blacklist continuously, collecting additional anomaly samples for category data balancing. As traffic data, the above model is implemented in spark mllib for parallel computing and is more suitable for Spark framework (Widiasanti, S. Zahra, A. Najma Sholikha, A. Waluny, M. Acharee Nazhelya Najva, & N. Jakarta). In the algorithm integration, we design a voting mechanism with an adjustable vote threshold, which can be automatically adjusted to the threshold value of the manual verification result. Although the analytical model does not use a deep learning model, we introduce a validation session with manual participation. This approach can meet real-time requirements through rapid model training updates and real-time inference, while reducing the target range and improving the efficiency of manual validation. The algorithm is feasible through in-network framework analysis (I. Khusma & H. Oktaviarosa).

Data-driven Decision Making

By using historical data and big data analysis, network managers can make more informed and informed decisions. This helps reduce uncertainty in network management and increase the responsibility of decision making (R. Saputra, D. Rafael, & S. N. M. P. Simamora). The basic concept of the ARIMA model (Autoregressive Integrated Moving Average)

1. **Autoregressive (AR):** This component takes into account the relationship between the dependent variable at the previous time. The AR(p) model uses previous values (lags) of the dependent variable to predict the value in the present time.
2. **Integrated (I):** This component handles difference or non-stationary time series. A stationary time series is a time series whose statistics do not vary with time. In other words, the mean, variance, and covariance are independent of time. If a time series is not stationary, then we must differentiate it until it becomes stationary. A time series that has been differentiated is called an integrated time series.
3. **Moving Average (MA)**: This component takes into account the prediction error at the previous time to predict the value at the current time. The MA(q) model uses previous values of the prediction error to predict the value in the current time.

In short, ARIMA is a model that combines these concepts in one model to predict time series. The ARIMA (p, d, q) model has three main parameters:

p: The autoregressive order (the number of lags included in the model).
d: The degree of differentiation required to make the time series stationary.
q: Order of the moving average (number of lags of the error included in the model).

In addition to ARIMA, there is also a variant called SARIMA (Seasonal ARIMA) which takes into account the seasonal component in the time series, characterised by additional parameters for seasonality (P, D, Q, m). The SARIMA (p, d, q)(P, D, Q, m) model handles seasonal patterns in time series data (Y. He, F. R. Yu, N. Zhao, H. Yin, H. Yao, & R. C. Qiu).

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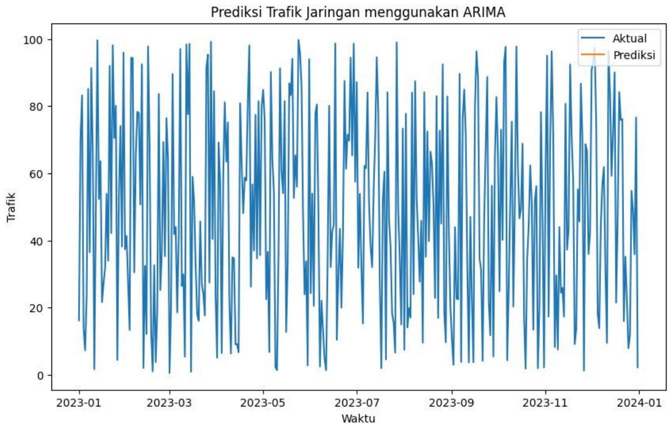

Figure 3. ARIMA prediction

SARIMA (Seasonal Autoregressive Integrated Moving Average) is an extension of the ARIMA model that takes into account the seasonal component in time series data. This model is particularly suitable for data that shows seasonal patterns, such as monthly sales data, annual weather data, or network traffic that shows seasonal variations (Ruth Elizabeth & S. Sitorus).

The basic concepts of SARIMA include:

1. **Autoregressive (AR):** This component uses past values of the same variable to predict current values. For example, in an AR(p) model, the current value is predicted using the previous p values.
2. **Integrated (I):** This component is used to make the data stationary by differencing. Differencing is the process of subtracting the current value from the previous value. In the I(d) model, differencing is performed d times to achieve stationarity.
3. **Moving Average (MA):** This component uses the prediction error from the past to predict the current value. In the MA(q) model, the current value is predicted using q previous prediction errors.
4. **Seasonal Components:** In addition to AR, I, and MA components, SARIMA also has seasonal components:
   - Seasonal Autoregressive (SAR): Uses repeated past values with seasonal periods.
   - Seasonal Integrated (SI): Uses differencing on the seasonal period.
   - Seasonal Moving Average (SMA): Uses the prediction error in the seasonal period.
   - Seasonal Period (s): The length of the seasonal period (e.g., 12 for monthly data with an annual pattern).

The SARIMA model is denoted as SARIMA(p, d, q)(P, D, Q, s), where:

p, d, q: Non-seasonal parameters for autoregressive, differencing, and moving average.

P, D, Q: Seasonal parameters for autoregressive, differencing, and moving average.

s: The length of the seasonal period.

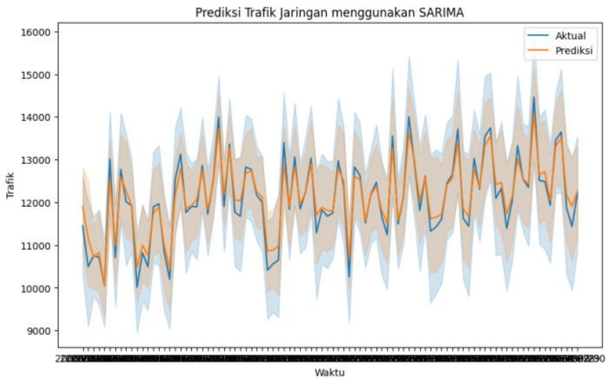

Figure 4. SARIMA prediction

Improvement and Compliance

By continuously monitoring and analysing network data, organisations can ensure compliance with relevant security standards and regulations. This helps protect sensitive data and maintain the organisation's reputation. Improvement and compliance in computer network management optimisation through big data analysis using the time series analysis method involves several important aspects. The time series analysis method enables time-based data analysis, which helps in modelling and predicting future network behaviour. By analysing historical data, organisations

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can identify performance patterns, predict capacity requirements, and detect anomalies or unusual changes in network behaviour (O., 2023).

Increased efficiency occurs when organisations can anticipate and respond to network needs proactively, avoid bottlenecks, and ensure optimal performance. Big data analytics enable more responsive and adaptive network management to changes, and assist in more accurate data-driven decision-making (P. Wang, H. Lv, X. Zheng, W. Ma, & W. Wang).

Compliance is related to ensuring that network infrastructure meets applicable standards and regulations. With big data analytics, organisations can monitor and document network performance in real-time, ensuring that network operations remain compliant with security policies and standards. It also helps in more efficient auditing and reporting, ensuring that all aspects of network management comply with set regulations (J. Lee, B. Kim, & J. M. Chung).

Development of a More Sustainable Network Strategy

By understanding complex network patterns and trends, organisations can develop more sustainable and adaptive network strategies. This helps organisations to remain competitive in a rapidly changing environment. The development of a more sustainable network strategy through optimising computer network management using big data analysis, particularly time series analysis methods, is an important approach in today's digital era. By continuously collecting and analysing historical data, organisations can identify network performance patterns, forecast future capacity requirements, and detect possible anomalies (S. Liu, Y. Xia, & D. Wang).

Time series analysis methods allow for more accurate forecasting based on trends and seasonal patterns in the data, thus enabling more timely decision-making in network infrastructure management. By leveraging the insights gained from big data analysis, organisations can optimise resource usage, improve operational efficiency, and reduce the risk of service disruptions. This strategy not only supports operational needs, but also helps in adaptation to changing technology and evolving business needs (M. Suradji).

```
                               SARIMAX Results
==============================================================================
Dep. Variable:                  r_asn   No. Observations:                  365
Model:                 ARIMA(1, 1, 1)   Log Likelihood               -1753.091
Date:                Tue, 16 Jul 2024   AIC                           3512.182
Time:                        11:23:23   BIC                           3523.874
Sample:                             0   HQIC                          3516.829
                                - 365
Covariance Type:                  opg
==============================================================================
                 coef    std err          z      P>|z|      [0.025      0.975]
------------------------------------------------------------------------------
ar.L1          0.0819      0.055      1.500      0.134      -0.025       0.189
ma.L1         -0.9999      1.658     -0.603      0.546      -4.249       2.249
sigma2       879.0206   1457.940      0.603      0.547   -1978.490    3736.531
===================================================================================
Ljung-Box (L1) (Q):                   0.01   Jarque-Bera (JB):                22.12
Prob(Q):                              0.92   Prob(JB):                         0.00
Heteroskedasticity (H):               0.93   Skew:                             0.08
Prob(H) (two-sided):                  0.67   Kurtosis:                         1.80
===================================================================================
```

Figure 5**.** The result of the above data

DISCUSSION

The application of big data analysis with time series analysis method in computer network management has been identified as a highly effective approach to improve network efficiency and performance. The following are some of the main points of discussion regarding the research results:

Improved Efficiency of Network Management

By analysing large and complex network data, organisations can identify performance patterns, trends and anomalies that may not be visible with traditional methods. This enables network managers to take the necessary actions to improve network management efficiency and optimise overall performance. These efficiency improvements include optimising the use of network resources, continuous performance monitoring, and automating routine tasks to reduce manual workload and the risk of human error (M. Jin et al).

Improved Compliance and Security

Continuous monitoring and analysis of network data enables organisations to ensure compliance with relevant security standards and regulations. Big data analysis helps in documenting network performance in real-time, ensuring that network operations remain compliant with security policies and standards, and facilitating audits and whistleblowers (B. Wang, Q. Zhang, C. Zhao, A. Pepe, & Y. Niu).

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Sustainable Network Strategy Development

By understanding complex network patterns and trends, organisations can develop more sustainable and adaptive network strategies. Time series analysis methods allow for more accurate forecasting based on trends and seasonal patterns in the data, thus enabling more timely decision-making in network infrastructure management. This strategy supports operational needs and assists in adapting to changing technology and evolving business needs (R. E. Santoso, A. Giri Prawiyogi, U. Rahardja, F. P. Oganda, & N. Khofifah).

Network Management Optimisation

Insights gained from time series analysis and big data can be used to optimise network management, including traffic scheduling, resource allocation, and anomaly detection. Network management strategies and policies developed based on the findings of this research can improve overall network performance and security (A. Fauzi, A. Mahmud, E. Sulaeman).

Evaluation and Validation

The developed model should be evaluated for its performance using split test data or cross-validation. The results of the proposed model should be compared with existing network management methods or approaches to assess their effectiveness and relative advantages (Y. Chen).

CONCLUSION

Big data analysis has a significant positive impact on the management of computer networks (Y. Yang & Y. Yang). By identifying traffic patterns, detecting anomalies, optimising performance, predicting capacity requirements, and improving data security and can forecast data through data history using time series analysts and make more timely and effective decisions. Although challenges such as data complexity and security still exist, the development of innovative solutions continues. By continuing to explore big data analysis, we can better understand modern computer networks and better address emerging challenges in the future. In the ever-evolving digital age, managing computer networks is becoming increasingly important for organisations to maintain the performance and security of IT infrastructure. As the complexity and volume of data increases, innovative and efficient approaches are needed to manage network infrastructure sustainably. Before the advent of big data, decisions were often based on non-optimal data samples. However, with big data analysis, especially time series analysis methods, organisations can model and predict future network behaviour more accurately (K. Tanuwidjaja & A. Widjaja).

Historical data analysis enables the identification of performance patterns, prediction of capacity requirements, and detection of anomalies in the network. In this context, wireless connections such as cellular and Wi-Fi are becoming increasingly popular due to their mobility. Intelligent and adaptive management of computer networks is now an urgent need. Network administrators face complex challenges, such as monitoring increased traffic, addressing performance issues, and securing the infrastructure from evolving threats (G. Firmansyah, H. Akbar, & B. Tjahjono).

Big data analysis is becoming a key element in modern network management strategies. By leveraging data from the network infrastructure, organisations can gain deep insights into network operations, future trends, and how to improve efficiency and performance. The application of the principles of time series analysis and big data analysis is expected to optimise network infrastructure to support operational and strategic needs in this digital era (Y. Zhang, W. Song, M. Karimi, C. H. Chi, & A. Kudreyko).

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