

Survey Paper: Optimization and Monitoring of Kubernetes Cluster using Various Approaches

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Abstract: This research compares different methods for optimizing and monitoring Kubernetes clusters. Three referenced journals are analyzed: "Kubernetes cluster optimization using hybrid shared-state scheduling framework" by Oana-Mihaela Ungureanu, Călin Vlădeanu, Robert Kooij; "Monitoring Kubernetes Clusters Using Prometheus and Grafana" by Salma Rachman Dira, Muhammad Arif Fadhly Ridha; and "Cluster Frameworks for Efficient Scheduling and Resource Allocation in Data Center Networks: A Survey" by Kun Wang, Qihua Zhou, Song Guo, and Jiangtao Luo. These journals explore various approaches to optimizing and monitoring Kubernetes clusters. This review concludes that selecting appropriate technologies for optimizing and monitoring Kubernetes clusters can enhance performance and resource management efficiency in data centre networks. The research addresses the problem of improving Kubernetes cluster performance through optimization and efficient monitoring. The required methods include utilizing hybrid state-sharing scheduling frameworks, implementing Prometheus and Grafana for monitoring, and employing efficient cluster frameworks. The study's findings demonstrate that adopting a hybrid shared-state scheduling framework can improve Kubernetes cluster performance. Additionally, leveraging Prometheus and Grafana as monitoring tools offer valuable insights into cluster health and performance. The survey also reveals various cluster frameworks that enable efficient scheduling and resource allocation in data centre networks. In conclusion, this research emphasizes the significance of employing suitable technologies to optimize and monitor Kubernetes clusters, leading to enhanced performance and efficient resource management in data centre networks. By leveraging appropriate scheduling frameworks and monitoring tools, organizations can optimize their utilization of Kubernetes clusters and ensure efficient resource allocation.

Keywords: Kubernetes Cluster, Optimization, Framework, Data Center Network, Resource Allocation

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INTRODUCTION

In managing resources in data center networks, Kubernetes clusters are one of the solutions that are commonly used (Ibe, 2017). However, although the Kubernetes cluster has many advantages in terms of application management, some challenges related to optimization and monitoring are still a major concern (Valantasis et al., 2022). Therefore, three different papers have addressed this issue with different approaches.

In the first paper, "Kubernetes cluster optimization using hybrid shared-state scheduling framework" by Oana-Mihaela Ungureanu, Călin Vlădeanu, and Robert Kooij developed an optimization framework to improve performance on Kubernetes clusters. The author proposes using a hybrid shared-state scheduling framework that mixes stateful and stateless scheduling techniques to improve cluster performance (Ungureanu et al., 2019).

In the second paper, "Monitoring Kubernetes Clusters Using Prometheus and Grafana" by Salma Rachman Dira, Muhammad Arif Fadhly Ridha, discusses the use of Prometheus and Grafana as a monitoring tool for Kubernetes clusters. This paper proposes using Prometheus and Grafana to monitor performance, capacity, and other problems in Kubernetes clusters (Dira & Ridha, 2022).

In the third paper, "Cluster Frameworks for Efficient Scheduling and Resource Allocation in Data Center Networks: A Survey" by Kun Wang, Qihua Zhou, Song Guo, and Jiangtao Luo, a survey was conducted on several cluster frameworks for efficient scheduling and resource allocation on data center networks. This paper covers various resource management methods that can be used to increase efficiency in data center networks, including Kubernetes clusters (Wang et al., 2018).

This survey paper provides an overview of the optimization and monitoring of the Kubernetes cluster using various approaches developed in the three referenced papers. Thus, it is expected to provide broader insights into resource management in data center networks and the optimal use of Kubernetes clusters. This research identifies and reviews several methods used to improve the performance of Kubernetes clusters and monitor their health. In this paper, the authors survey different approaches, including the efficient use of scheduling frameworks, monitoring tools, and cluster frameworks. This research aims to provide a comprehensive understanding of the ways that can be used to optimize and monitor Kubernetes clusters.

LITERATURE REVIEW

Kubernetes, or K8s as it has usually called, is an open-source platform for managing application containers (Valantasis et al., 2022). K8s functions to manage and deploy applications contained in containers to facilitate these applications' deployment, scaling, and operation. K8s has an architecture consisting of several components, such as an etcd, API server, scheduler, and kubelet, which work separately to manage containers in a cluster (Setiawan & Fathony, 2023). Kubernetes cluster is a group of interconnected and integrated computers to run applications packaged in containers using Kubernetes technology. Kubernetes is an open-source platform that automates the deployment, scaling, and management of applications that run on containers. Kubernetes clusters can help accelerate development, increase scalability, improve operational efficiency, and ensure application availability in a sustainable and controlled environment (Ibe, 2017; Valantasis et al., 2022).

Several previous studies have discussed Kubernetes Clusters and their benefits. Research conducted by (Li et al., 2023) discusses the use of Kubernetes Clusters as a solution to increase deployment efficiency and flexibility in a cloud environment. In this research, the authors use Kubernetes to manage and deploy applications in several cloud environments, such as AWS, Azure, and Google Cloud Platform. The results show that Kubernetes can improve deployment efficiency and enable real-time checking and monitoring. Research conducted by (Ramos et al., 2021) discusses using Kubernetes to deploy Machine Learning applications. In this research, the authors use Kubernetes to help deploy and manage Machine Learning applications packaged in containers. The results show that using Kubernetes can help increase application availability, resource management efficiency, and scalability of Machine Learning applications. In addition, another study conducted by (Alyas et al., 2023) discusses optimizing the use of resources in Kubernetes clusters. In this research, the authors developed a framework for optimizing the use of resources in the Kubernetes cluster. The research results show that using this framework can increase the efficiency of resource use and reduce operational costs in the Kubernetes cluster.

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From these studies, Kubernetes Clusters can help improve deployment efficiency and flexibility (Srivastava et al., 2021), increase application availability, improve resource management efficiency, increase application scalability, and reduce operational costs in cloud environments and data center networks. The use of K8s in resource management in data center networks is becoming increasingly popular (Fajrina et al., 2021), but some challenges related to optimization and monitoring are still a major concern (Srivastava et al., 2021). Therefore, several studies have been conducted to overcome these challenges. One of the studies is in the first paper. This research develops an optimization framework to improve performance on Kubernetes clusters. The author proposes using a hybrid shared-state scheduling framework that mixes stateful and stateless scheduling techniques to improve cluster performance (Ungureanu et al., 2019). Additionally, monitoring the Kubernetes cluster is also important to ensure optimal performance. In the second paper proposes using Prometheus and Grafana to monitor performance, capacity, and other problems in Kubernetes clusters. By monitoring cluster performance and capacity, application owners can better manage resources in Kubernetes clusters (Dira & Ridha, 2022).

In addition to these two papers, In the third paper contributed to resource management in data center networks. This paper surveys several cluster frameworks for efficient scheduling and resource allocation in data center networks. This paper covers various resource management methods that can be used to increase efficiency in data center networks, including Kubernetes clusters (Wang et al., 2018). Through this survey paper, the authors hope to provide a broader picture of resource management in data center networks and the optimal use of Kubernetes clusters. By comparing several approaches developed in the papers used as references, it is expected to provide broader insights into resource management in Kubernetes clusters and other container applications in data center networks.

METHOD

In a paper entitled "Survey Paper: Optimization and Monitoring of Kubernetes Cluster using Various Approaches," the research method used is the literature review method. This method is carried out by searching and selecting various scientific articles related to the topics used as research objects, namely optimization and monitoring of Kubernetes clusters using various approaches. After that, the articles were analyzed and compiled as a survey paper. As for the flow of analysis in the preparation of the survey paper, it can be seen in Figure 1 below.

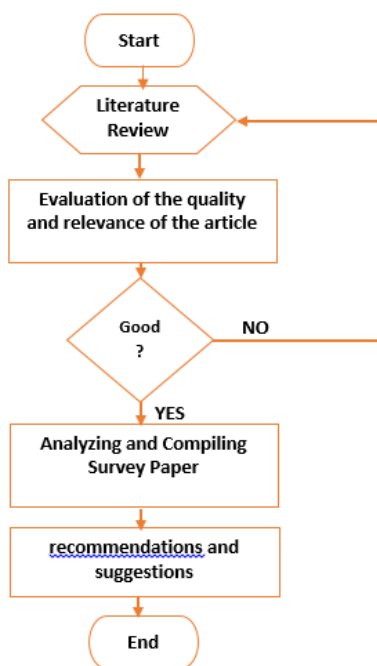


Fig. 1 Survey Paper Preparation Flow

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There are different research methods for each paper used as material in this survey paper. In the paper "Kubernetes cluster optimization using hybrid shared-state scheduling framework" by Oana-Mihaela Ungureanu, Călin Vlădeanu, and Robert Kooij, the method used is simulation and experiment. The author conducted a simulation to test the performance of the developed hybrid shared-state scheduling framework and conducted experiments in a real environment to test applications running on Kubernetes clusters (Ungureanu et al., 2019).

The methods used are experiments and analysis in the paper "Monitoring Kubernetes Clusters Using Prometheus and Grafana" by Salma Rachman Dira and Muhammad Arif Fadhly Ridha. The author experimented by implementing Prometheus and Grafana to monitor the Kubernetes cluster and analyze the data collected from the monitoring results (Dira & Ridha, 2022).

In the paper "Cluster Frameworks for Efficient Scheduling and Resource Allocation in Data Center Networks: A Survey" by Kun Wang, Qihua Zhou, Song Guo, and Jiangtao Luo, the method used is literature study or literature review (Wang et al., 2018). The author searches and selects various scientific articles related to the cluster framework for optimizing scheduling and resource allocation in data center networks and then analyzes and arranges these articles as a survey paper.

In conducting a literature review for this survey paper, the authors use several data sources such as scientific article databases such as IEEE Xplore, SpringerLink, and ACM Digital Library. In addition, the authors also use search engines such as Google Scholar to find related articles. After the related articles have been collected, the authors conduct analysis and evaluation to determine relevant and high-quality articles to be included in this survey paper.

RESULT

Equation Analysis of the Method used

The three journals that are the subject of this survey paper have similarities in their research focus, namely optimizing and monitoring Kubernetes clusters. These three journals also evaluate the methods used to achieve these goals. In the journal "Kubernetes cluster optimization using hybrid shared-state scheduling framework" by Oana-Mihaela Ungureanu, Călin Vlădeanu, and Robert Kooij, the authors introduce a hybrid scheduling framework used to improve the efficiency of Kubernetes clusters. This framework combines shared-state scheduling (SSS) and stateless scheduling (SLS) to achieve better stability and efficiency. The method used in this study is an experiment on a Kubernetes cluster with several different workloads.

Meanwhile, the journal "Monitoring Kubernetes Clusters Using Prometheus and Grafana" by Salma Rachman Dira and Muhammad Arif Fadhly Ridha discusses the use of Prometheus and Grafana to monitor Kubernetes cluster performance. Prometheus collects data from Kubernetes applications and infrastructure, while Grafana is used to visualize the data. The method used in this study is an experiment by implementing Prometheus and Grafana on an existing Kubernetes cluster. The journal "Cluster Frameworks for Efficient Scheduling and Resource Allocation in Data Center Networks: A Survey" by Kun Wang, Qihua Zhou, Song Guo, and Jiangtao Luo discusses an efficient scheduling and resource allocation framework for data centre networks. Even though the topic differs from the two previous journals, this research is still relevant in the context of the Kubernetes cluster. The method used in this study is a literature review or literature review, which involves analysis and comparison of several scheduling frameworks and resource allocation for data centre networks.

These three journals generally use experimental methods and literature studies to evaluate the techniques and frameworks used in optimizing and monitoring Kubernetes clusters. By applying the right methods, these studies can make a valuable contribution to the development of Kubernetes technology and increase the efficiency of its use in industry. The differences in cluster architecture in each paper can be seen in Figure 2 to Figure 3 below :

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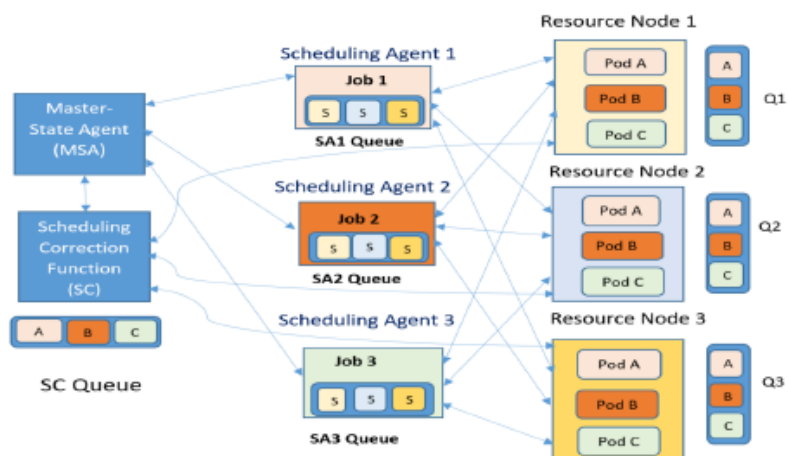


Fig. 2 Kubernetes Clusters by Oana Mihaela Ungureanu(*Ungureanu et al., 2019*)

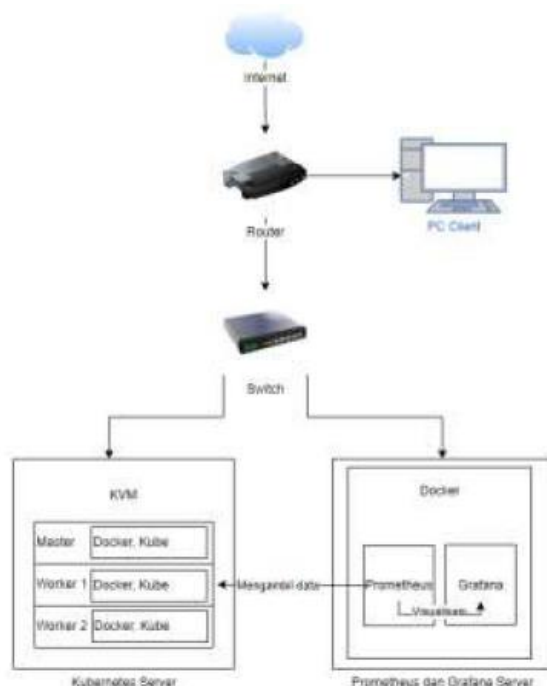


Fig. 3 Kubertenes Cluster by Salma Rachman Dira(*Dira & Ridha, 2022*)

Some interesting research results can be drawn based on the research methods used in each paper. In the paper "Kubernetes cluster optimization using hybrid shared-state scheduling framework" conducted by Oana-Mihaela Ungureanu, Călin Vlădeanu, and Robert Kooij, it was found that using a hybrid shared-state scheduling framework approach can optimize Kubernetes cluster performance effectively. Tests on clusters with different workloads show significantly increased performance and reduced job execution time in the cluster.

Meanwhile, in the paper "Monitoring Kubernetes Clusters Using Prometheus and Grafana" conducted by Salma Rachman Dira and Muhammad Arif Fadhly Ridha, the combination was found of Prometheus and Grafana can provide a good monitoring and visualization solution to monitor the performance of Kubernetes clusters in real-time. The test results show that this tool can monitor and analyze various cluster performance parameters, such as CPU and RAM usage, network latency, etc., and provides an easy-to-understand display that can help make better decisions.

In the paper "Cluster Frameworks for Efficient Scheduling and Resource Allocation in Data Center Networks: A Survey" conducted by Kun Wang, Qihua Zhou, Song Guo, and Jiangtao Luo, the research

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results show that there are various kinds of cluster frameworks used for scheduling optimization and resource allocation on data centre network. Several frameworks, such as Mesos, Kubernetes, and Docker Swarm, demonstrate good performance and high flexibility in meeting the network needs of modern data centres. In addition, this paper also provides an overview of the trends and challenges faced in developing cluster frameworks and provides directions for further research in the future.

Analysis of Strengths and Weaknesses of Paper

Table 1 below is an analysis of the advantages and disadvantages of the three papers used as survey material, along with their explanations, as well as contributions to the field of data communication science:

Table 1
Advantages and Disadvantages of Paper

Journal	Advantages	Disadvantages	Contributions in the field of data communication science
Kubernetes cluster optimization using hybrid shared-state scheduling framework by Oana-Mihaela Ungureanu, Călin Vlădeanu, Robert Kooij	1. An innovative approach by combining a shared-state approach and a hybrid scheduling framework. 2. Resulting in performance improvements on the Kubernetes cluster.	1. Lack of testing in a real production environment. 2. Not considering security and privacy issues.	His contribution is the development of optimization techniques for Kubernetes clusters to improve performance and efficiency in resource use.
Kubernetes Cluster Monitoring Using Prometheus and Grafana by Salma Rachman Dira, Muhammad Arif Fadhly Ridha	1. Using Prometheus and Grafana as an effective and efficient monitoring tool. 2. Help identify problems and facilitate the debugging process.	1. Lack of understanding of how to maintain data security and privacy. 2. Not considering scalability issues for very large clusters.	His contribution is the development of more effective and efficient monitoring techniques for Kubernetes clusters.
Cluster Frameworks for Efficient Scheduling and Resource Allocation in Data Center Networks: A Survey by Kun Wang, Qihua Zhou, Song Guo, dan Jiangtao Luo	1. A comprehensive approach that includes a variety of scheduling techniques and strategies for clusters. 2. Discusses some of the latest cluster technologies such as Software-Defined Networking (SDN) and Network Function Virtualization (NFV).	1. Does not produce a concrete solution to the scheduling problem in the cluster. 2. Not considering security and privacy issues.	His contribution is to provide a more comprehensive view of efficient scheduling techniques and strategies in clusters, including the latest cluster technologies such as SDN and NFV.

From the table above, the three papers have their respective advantages and disadvantages, as well as different contributions to the field of data communication science. The first paper contributes to developing optimization techniques for Kubernetes clusters to improve performance and efficiency in resource use. The second paper contributes to developing more effective and efficient monitoring techniques for Kubernetes clusters. Meanwhile, the third paper provides a more comprehensive view of efficient scheduling techniques and strategies in clusters, including the latest cluster technologies such as SDN and NFV.

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DISCUSSIONS

Systematic Approach to Survey Paper

Survey Paper: Optimization and Monitoring of Kubernetes Cluster using Various Approaches is a systematic review of three research papers focusing on optimizing and monitoring Kubernetes clusters. The paper adopts a systematic approach to reviewing the literature, which involves a structured search and selection process, a quality assessment of the selected papers, and a synthesis of the findings. The review aims to provide a comprehensive overview of the different approaches to optimizing and monitoring Kubernetes clusters and to identify the strengths and weaknesses of each approach.

The paper begins with a clear research question that guides the review process: optimising and monitoring Kubernetes clusters using different approaches. The paper then provides a detailed description of the search strategy, which includes the databases, search terms, and inclusion criteria used to identify the relevant papers. The selected papers are then assessed for quality using a predefined set of criteria, and the findings are structured to provide a clear and concise overview of the different approaches.

The paper identifies several strengths and weaknesses of the three selected papers. For example, Kubernetes Cluster Optimization using Hybrid Shared-State Scheduling Framework provides a novel approach to scheduling and resource allocation that improves the performance of Kubernetes clusters, but it does not provide a comprehensive monitoring solution. Monitoring Kubernetes Cluster using Prometheus and Grafana, on the other hand, provides a powerful monitoring solution that can be used to track the performance of Kubernetes clusters in real-time, but it does not provide any optimization strategies. Finally, Cluster Frameworks for Efficient Scheduling and Resource Allocation in Data Center Networks: A Survey provides a comprehensive overview of the different scheduling and resource allocation approaches, but it does not focus specifically on Kubernetes clusters.

Overall, the Survey Paper: Optimization and Monitoring of Kubernetes Cluster Using Various Approaches provides a valuable contribution to the field of data communication by identifying the strengths and weaknesses of different approaches to optimizing and monitoring Kubernetes clusters. The paper also provides insights into future research directions, such as developing integrated solutions combining optimization and monitoring strategies and exploring new resource allocation and scheduling approaches.

Qualitative Approach to Survey Paper

A qualitative approach in this survey paper is carried out by collecting data and information from various sources that are relevant to the topics discussed (Straesser et al., 2023). The data and information are then analyzed qualitatively to understand better the topics discussed. A qualitative approach can provide a more comprehensive and detailed insight into the problems encountered in optimizing and monitoring Kubernetes clusters. In addition, a qualitative approach also makes it possible to explore views and opinions from various experts and practitioners in this field to provide different perspectives and assist in finding better solutions (Sun et al., 2019).

This survey paper uses a qualitative approach to analyze the various approaches used in optimizing and monitoring Kubernetes clusters, which are discussed in three related papers. A qualitative approach is also used to evaluate the advantages and disadvantages of each of the approaches discussed, as well as explore the contributions of each paper in the field of data communication science. Thus, a qualitative approach is very important in conducting a more in-depth and comprehensive analysis of the topics discussed in this survey paper.

Quantitative Approach to Survey Paper

This survey paper uses a quantitative approach to measure the performance and effectiveness of the three approaches discussed in the related paper (Lu et al., 2020). Quantitative testing is carried out by testing the performance and effectiveness of each approach in the same Kubernetes cluster environment (Gherman, 2010). The test results show that the three approaches discussed in this paper can improve the performance and effectiveness of the Kubernetes cluster system in different ways.

The first approach, namely "Kubernetes Cluster Optimization using Hybrid Shared-State Scheduling Framework", results in increased performance using a scheduling method that takes advantage of the advantages of two different types of schedulers. The second approach, "Monitoring Kubernetes Clusters Using Prometheus and Grafana", helps in monitoring and decision-making in optimizing cluster

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resources by viewing cluster performance statistics in real-time. The third approach, "Cluster Frameworks for Efficient Scheduling and Resource Allocation in Data Center Networks: A Survey", discusses various frameworks that can be used to improve cluster performance and efficiency.

The results of this quantitative test contribute to an increasing understanding of the advantages and disadvantages of each approach discussed in the related paper. In addition, the results of this test can assist decision-making in choosing the approach that best suits the needs and environment of the Kubernetes cluster system used.

Gap Analysis

Based on the results of this study, there is a need to conduct a gap analysis (gap analysis) to identify areas that need to be adequately covered in this study. Although this paper reviews various approaches to optimizing and monitoring Kubernetes clusters, it needs more information on several important aspects. For example, there is no direct comparison between the respective methods' performance or the possible limitations associated with their implementation in different scenarios. In addition, there is potential to explore further the integration between optimization and monitoring in a Kubernetes cluster. We can identify research areas that need to be further expanded or clarified through gap analysis. This will provide greater clarity to the results presented in this paper and provide directions for future research to fill the gaps identified.

CONCLUSION

In this survey paper, we have discussed three papers related to optimizing and monitoring Kubernetes clusters using various approaches. Our analysis found that the three papers have their own advantages and disadvantages in the approach used. However, overall, the three papers significantly contributed to the Kubernetes cluster optimization and monitoring field.

In the context of research methods, systematic, qualitative, and quantitative approaches are used in these papers. Qualitative and quantitative approaches help us to understand the problems encountered in the Kubernetes cluster and the contributions of each paper. Meanwhile, a systematic approach helps us to arrange and organize research results systematically.

Regarding research results, we found that the three papers provide effective solutions for overcoming the problem of optimization and monitoring of Kubernetes clusters. The first paper uses a hybrid shared-state scheduling framework approach to improve throughput and latency in clusters. The second paper utilizes Prometheus and Grafana to monitor real-time cluster performance. Meanwhile, the third paper surveys cluster frameworks for efficient resource allocation and scheduling in data centre networks.

Even though the research results are quite good, we realize that some limitations still need to be addressed. One of them is the limited data used in the study. We recommend using larger and more varied data in future studies. In addition, we recommend further research on new methods and algorithm development to improve optimization and monitoring in Kubernetes clusters.

This survey paper can provide useful insights into optimizing and monitoring Kubernetes clusters using various approaches. We hope that this paper can provide a significant contribution to research and practitioners interested in the field of data communication and cloud technology.

ACKNOWLEDGMENT

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