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# Software Metrics for SAAS, PAAS, IAAS-A Review

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***Abstract- This paper deals with software metrics for the distributed computing system over the internet and it is popularly known as cloud computing. This is also known as on-demand service, where there are shared resources, data and information. Cloud computing enables users to use the resources as a utility. Cloud computing is mainly divided into 3 Service models they are 1.Software As A Service(SAAS), 2.Platform As A Service(PAAS), 3.Infrastructure As A Service(IAAS).Cloud computing promises several benefits for enterprises and end users. Studying cloud computing is a complex issue in software engineering. Nevertheless, software metrics play a major role in software engineering. By using metrics we can measure the quality and performance of software and hence plan accordingly to meet the demands and for higher productivity.***
***Keywords— Software metrics, SAAS, PAAS, IAAS, Cloud Computing.***

## I. INTRODUCTION

According to SPECS Open group Systems Group (OSG) - "Cloud computing is a model for enabling ubiquitous, convenient, on-demand network access to a shared pool of configurable computing resources (e.g., networks, servers, storage, applications, and services) that can be rapidly provisioned and released with minimal management effort or provider interaction."
In cloud computing environment, Software designers develop applications on services being offered by cloud providers. In these the resources are shared and given to customers. Providers bill the customer's per-usage basis [1]. Cloud computing needs to be seen as benchmark to achieve resources on demand. The 3 solutions are given by cloud computing environment in keeping the demands of IT clients [2]. First, Software As A Service (SAAS) gives access to a cloud program which can be used at many places as a complete service, e.g. CRM (Customer Relationship Management) and ERP [3]. Platform As A Service (PAAS) is a service which offers Platform for making or managing Applications on it, e.g. Google App Engine [4]. Infrastructure As A Service (IAAS) is a service which provides virtualized resources over internet. It gives us a workplace for releasing, running, and handling VM's and Storage. It gives modern scalability of calculating resources and on demand storage. Service providers like IBM, Microsoft (Azure), Amazon, etc. manage these services
Cloud computing has now become a highly used service due to the high advantages it provides to customers like high speed computing, more storage ,agility, elasticity, scalability, cheap cost of services etc. and there are different types of cloud e.g. private, public, hybrid cloud etc. According to Wikipedia there is 50% growth rate in cloud computing. By using cloud companies can scale down computing needs as demand decreases and scale up when required avoiding unnecessary costs. But due to the fact the cloud is still not very developed and still in its infancy stage growing rapidly, there are many problems which have to be dealt with so that it can become more reliable.
One of such problems is Software Metrics for Cloud computing environment is of utmost importance that we define software metrics for cloud. Metrics provides measurement of the software product and process of software production. Nevertheless, Conventional frameworks for measuring quality such as ISO 9126 would be limited to evaluate the quality of Cloud services and also environment. Basically due to gap or difference between conventional computing and cloud computing paradigm. i.e., by using metrics for conventional quality measurement will not effectively evaluate all the quality aspects that are specific for Cloud Computing. Although, widely accepted quality model to evaluate cloud environment are yet to come [5] .A Software product must be looked at as an object that can be described as, which starts with requirements and will end with a finished software product, which will include the object code and source code. Including forms of documentation exhibited during the various stages of its development [6].

## II. RELATED WORK

Software Metrics for cloud computing has been under study for a long time now and staring with conventional measurement of quality, ISO 9126 is an international standard for evaluation of product quality [7].this model provides 3 aspects for evaluation of software : they are 1. Internal quality 2.external quality, 3.quality in use, and there are sixteen attributes for three type of qualities. This standard focuses on evaluating quality of conventional products. Therefore, it is required that the standard is customized and extended to evaluate the quality of cloud services.

**Scalabilty Metric by Joglekar and Woodside [8]**

Joglekar and Woodside provide a scalability metric that can directly be used to evaluate could services on scaling up and down issues, they use workload as main input context factor for the metric. Output they give is productivity factor which can be used for evaluation

**Elasticity and efficiency metrics by Herbst et al. [9]**

Herbst et al. gave metrics that consider speed and precision of scale in and out. The elasticity and efficiency metric can be used to evaluate time to recover from failure.

**Jureta's work** provided a quality model, "called QVDP (quality, value, dependency, priority) , to measure the quality of service-Oriented System [10]. This model consists of four sub models: quality characteristic, characteristic value, quality dependency, quality Priority. These represent dependencies and priorities between quality dimensions and quality characteristics. However, this work considered services-oriented application as a target of quality model and identifies issues related to them at conceptual level."

**Kim's work** can be categorized into a "model for web services quality management, quality factors for the process of developing and using web services [11]. This work suggests six quality factors and their several sub factors. In addition, it provides metrics to measure quality factors. Therefore, it is required that this model is customized and extended to evaluate the quality of cloud services."

Most of these works are not for cloud services totally or they are for convention software products. Due to this, it is hard to evaluate the services of cloud. Here our work provides insight on metrics to be used to evaluate cloud services.

## III. FEATURES OF CLOUD ENVIRONMENT

To define the metrics for evaluation for cloud computing services , we need to identify the features which make cloud computing unique from conventional computing environment , from our evaluation on reference's to cloud computing services [12][13][14] we identify key features as

A. *Elasticity:* Cloud environment is very elastic in the sense that capabilities can be elastically changed as per demand or automatically, i.e. to scale in or out with demand. To customers, Service or Resources provided are unlimited and can be appropriated at any time.

B. *Scalability:* In SE, Scalability is desirable property of the product. This indicates its dynamic nature to be able to scale to the demand. As the cloud, computing can be considered black box in nature, service consumers are not in control of resources, which they are using, such as memory, network, or CPU utilization. That is, A provider should be responsible for rescaling the resources according to consumers [14].

C. *Reusability:* It is the ability of software resources or services to be used over and over for many applications. The fundamental vision of CC(cloud computing) is reusing the Resources and other services [12]. The cloud services is a target of reuse and it is distributed over internet to the customers, i.e. one-to-many relationship.

D. *Data Managed by Provider:* In cloud computing services, data is managed by service providers. Service providers license the application to the customers and they are responsible for service installation, data and support. Which increases the productivity, as we are not concerned how data is managed.

E. *Service customizability:* It can be defined as the ability of the customers to change or modify, based on the individual requirements and benefits. This is a feature, which will allows the service providers to meet the deferential needs of each customer.

F. *Availability:* Cloud services are accessed via the internet so it need to be available every time and availability is a characteristic which providers need to focus on since if service is down for some minutes at least consumer may lose his trust. For ex., if Gmail goes down productivity of the company using it goes down since communication will be restricted.

G. *Quality of Service:* The level of service the cloud provider gives is the quality of service (QOS), this may include performance, quality of product, availability, Network and data Security etc.

H. *Pay per Use:* It is an on demand service and the expenses are calculated as on the basis of how much customer uses the service rather than a capital cost which may not be fruitful investment.

## IV. KEY METRICS

Software Metrics are the standards measure of a degree to which a system or process possess some property. As we know the metrics we choose depends on the service features to be evaluated. According to the "Spec Open Systems Group, cloud computing

working group" [18]. Key metrics are [9] [14] [18] [19] [20] [21] Elasticity (also includes Provisional Interval, Elastic Speedup, Scale up/down, and Agility), Variability, Response time, and Throughput, other metrics also include Reliability, Density, Durability, Price, Efficiency and Scalability.

Elasticity can be measured by,

*A. Mean Time to Quality Repair (MTTQR)*

MTTQR can be defined as how quickly or fast a service is adaptive to the changes in the workload. It is a measurement for elasticity; it depends on increase and decrease of workload. MTTQR is the mean time, which the system or environment needs to restart or repair its SLOs, when the workload suddenly increases/decreases. MTTQR can be measured in units of time. Since it is a mean time, MTTQR will be specific for a specified time period.

*B. Number of SLO violations (NSLOV)*

It is the NSLOV in defined time interval. This metric will measures the elasticity of the system. The workload delta is specified as a factor as well. NSLOV shows us how often a system will violate its SLOs when workload changes at a given rate, measured as a real number.

Other metrics include provisional Interval, delete time, boot time, suspend time, and agility, provisional interval, total acquisition time [20] [18].

*C. Response time*

Same as Conventional Response time, it is the response time between request made by time to response received

*D. Throughput*

It is same as Conventional Response time, it is referred to as units of work processed by the system or cloud per unit time, exact definition varies as per workload.

*E. Durability*

Durability can be defined as the probability of data loss. It checks whether the proposed solution meets the customer current needs and possible future needs. Durability metrics gives the stability of transaction responses times over the duration of test.

*F. Reliability*

Reliability is the ability of the system to remain functional and perform functions under any workloads and any specified time period.Reliability of a system is often measured by **Probability of failures** or **Mean Time Between Failures (MTBF)**

$$\textbf{MTBF} = \frac{Total\ time\ Measures}{total\ no\ of\ failures}$$

And other techniques include service constancy, accuracy of service, fault tolerance, maturity, recoverability.

*G. Availability*

Availability can be defined as the assurance of service being offered without any problem of connectivity over the internet and it being operational and accessible whenever required. Time when system is accessible is Uptime and not accessible is downtime, but they can be misleading hence we use MTBF together with Mean Time to Repair (MTTR)

$$\textbf{Availability} = \frac{MTBF}{MTBF+MTTR}$$

*H. Price*

As the cloud services are on demand or pay per use services. Price of the services also plays a crucial role to evaluate the services. It directly rules the economical metrics. It is what divides if customes wants to move to cloud from conventional computing.

Metrics include **Total cost, FLOP cost, Component Resource cost,** $\frac{Price}{Performance}$ **ratio, cost over a fixed time [20].**

*I. Density*

Density measures how many instances of the workload can be run on SUT before the performance of the system downgrades below

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a specified QOS [18].

*J. Efficiency*

Efficiency can be defined as the evaluation of how good the pooled resources are used by the service to achieve the goal. It can be measured by resource utilization and time behavior metrics [14].

$$\text{Resource utilization} = \frac{amount\ of\ allocated\ resources}{amount\ of\ pre-defined\ resources}$$

$$\text{Time behavior} = \frac{Execution\ time}{Total\ servie\ invocation\ time}$$

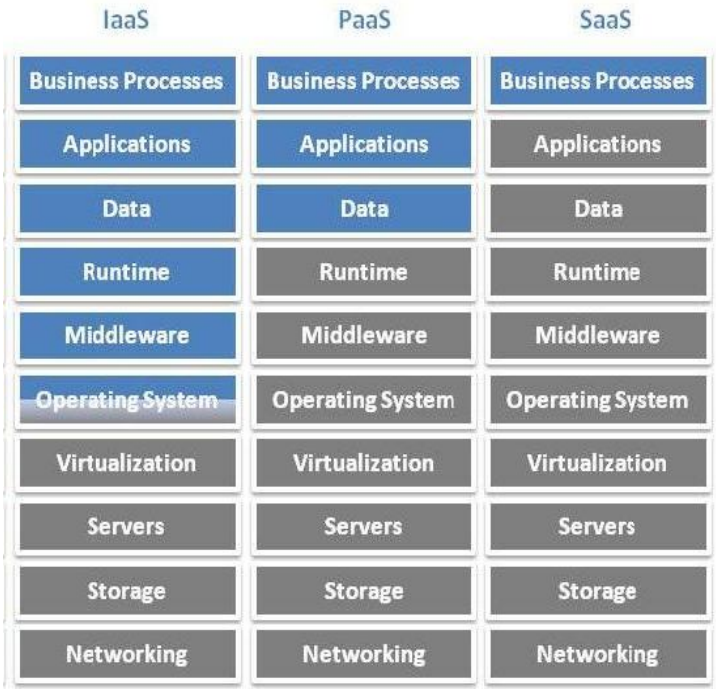
Taking the average of two metrics gives us the Efficiency of the cloud service higher the efficiency better the product.

*K. Scalability*

Scalability can be measured by the metric in which we take the average of the assigned resources among the requested resources.

$$\text{Scalability} = \sum \left(\frac{ampunt\ of\ allocated\ resources\ (ith)}{toatal\ amout\ of\ requested\ resources}\right)$$

These are the key metrics which needed to be considered while evaluating the cloud services and some of these may not be considered for all the cloud services (SAAS, PAAS, IAAS). And other metrics include for attributes of communication, computation, memory, time, data security, authentication, reusability, adaptability, modifiability, sustainability etc.




## V. CLASSIFICATION AND COMPARISON OF METRICS

Although Most of the metrics and attributes are same for all the Service Models of cloud computing environment the way we use them are different for different service model

For ex., density is common for all 3 service models but it is interpreted in different way for each model, Provisioning Interval which is metric to measure Elasticity is defined as the time we need to bring up or drop a resource. Time b/w request initiation and to bringing up a resource or relinquish it [18].

| | |
|---|---|
| SAAS | The measured time needed to bring new application instances online to meet increasing demand (moving from 10000 to 20000 concurrent users). |
| PAAS | The measured time needed to bring up a new instance of an application server (example: Microsoft Azure) |
| IAAS | The measured time needed to bring up a new instance, or add more resources (like cpu or storage) to existing instance. |

*A. Metrics for SAAS (Software as a service)*

Let us see some main metrics for SaaS Service model, As we can see from fig.1 in SaaS service model everything is managed by the vendor and user has no way to change the way the service is, so the metrics to evaluate the SaaS service model will include **Elasticity**, **Availability, Reliability, Scalability, Reusability, Pay-per-use, Multi-tenancy, Response time, Sustainability.**

1) *Multi-tenancy:* Multi-Tenancy can be determined as how good the software can be of service to the customer when there are more than one client seeking service.
2) *Security:* Security include data security and also network security. Security is a main concern is SaaS since all the user data will be with vendor.
3) *Service customizability:* Service consumers based on the individual requirements and benefits can define it as the ability for system to be able to change or modify the services. This feature will allows the service providers to meet the needs of each customer.
4) *Rapport:* Service quality of technology support and customer care made available by cloud service providers

*B. Metrics for PAAS (Platform as a service)*

As we can observe from Fig 1, we have application and data managed by user and others by vendor. Hence here key metrics would be the key metrics along with the **Adaptability, portability.**

1) *Adaptability:* It determines to what different cases the software with no or little changes can adapt. The changes may be demanded by the customer. This attribute also determines how easy is the software to upgrade or update.
2) *Interoperability:* It is ability to use other services which may be by the same vendor or other vendors. This is one of the most important attribute and is of a qualitative type. This attributes shows how well the software will can be used along with others.
3) *Portability:* Portability here can be defined as the situation where the service can be available for different situations such as different programming language or different OS's which user want to develop in.

*C. Metrics for IAAS (Infrastructure as a service)*

In IAAS we can see from Fig 1. That services offered in this model to the customer include OS, middleware, runtime along with data and application which were available with even PaaS. Key metrics to evaluate IAAS include **Scalability, Adaptability** and **Manageability.**

1) *Manageability:* Manageability can be defined as the degree of automation and control available to manage the solution. It includes Infra (compute, storage, and network), VM's etc.
2) *Interoperability:* It is ability to use other services which may be by the same vendor or other vendors. This is one of the most important attribute and is of a qualitative type. This attributes shows how well the software will can be used along with others.
3) *Sustainability:* These play a major role especially if the service is meant for a long term usage. This also is basic feature for which common to all the service models (SaaS, PaaS and IaaS). This factor directly reflects endurance of the software. Power Usage Efficiency and Data Centre Infrastructure Efficiency (DCIE), Data Centre Performance per Energy And carbon foot print play a major role in determining the sustainability of the product.

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*4) Adaptability:* Adaptability in IAAS slightly differs from that of PAAS inn sense that here adaptability refers to adjust changes to only levels managed in Iaas i.e. VM's increasing capacity of VM etc.

## VI. COMPARATIVE ANALYSIS OF METRICS FOR IAAS, PAAS, SAAS

This tabulation of the Metrics gives us the comparative analysis of which attributes we need to consider to evaluate the service model. Although there may be attributes common to all the model but they are evaluated as per the service model since these differ from model to model.

TABLE 1 Comparative Analysis of Metrics for IAAS, PAAS, SAAS

| Metrics | IAAS | PAAS | SAAS |
|---|---|---|---|
| Elasticity | ✓ | ✓ | ✓ |
| Scalability | ✓ | ✓ | ✓ |
| Reusability | ✓ | ✓ | ✓ |
| Availability | ✓ | ✓ | ✓ |
| Reliability | ✓ | ✓ | ✓ |
| Service customizability | - | - | ✓ |
| Multi-Tenancy | ✓ | ✓ | ✓ |
| QOS(quality of Service) | ✓ | ✓ | ✓ |
| Sustainability | ✓ | ✓ | ✓ |
| Interoperability | ✓ | ✓ | - |
| Stability | ✓ | ✓ | ✓ |
| Adaptability | ✓ | ✓ | - |
| Portability | ✓ | ✓ | - |
| Response time | ✓ | ✓ | ✓ |
| Pay Per Use | ✓ | ✓ | ✓ |
| Throughput | ✓ | ✓ | ✓ |
| Density | ✓ | ✓ | ✓ |
| Security | ✓ | ✓ | ✓ |
| Efficiency | ✓ | ✓ | ✓ |
| Cost | ✓ | ✓ | ✓ |
| Durability | ✓ | ✓ | ✓ |
| Manageability | ✓ | - | - |
| Data Management(backup and recoverability) | ✓ | ✓ | ✓ |

## VII. CONCLUSION

The three different types of architectures, SaaS, PaaS and IaaS have different methodologies for measuring quality or for designing quality metrics. The attributes may remain same but the way they are considered changes accordingly to the different architecture. Also, the cloud software cannot be evaluated in the same way as that of the usual software, which function on a desktop or a workstation environment. The above stated quality metrics should be used for a proper benchmarking of a software on a cloud environment as the cloud brings a lot of change in the functioning of a software thereby changing the way to measure their quality. The software, alone has different attributes which are used for measuring the quality apart from those the above stated attributes must also be used as the environment on which the software is deployed has an impact on the functioning of the software and also on the services provided by the software.

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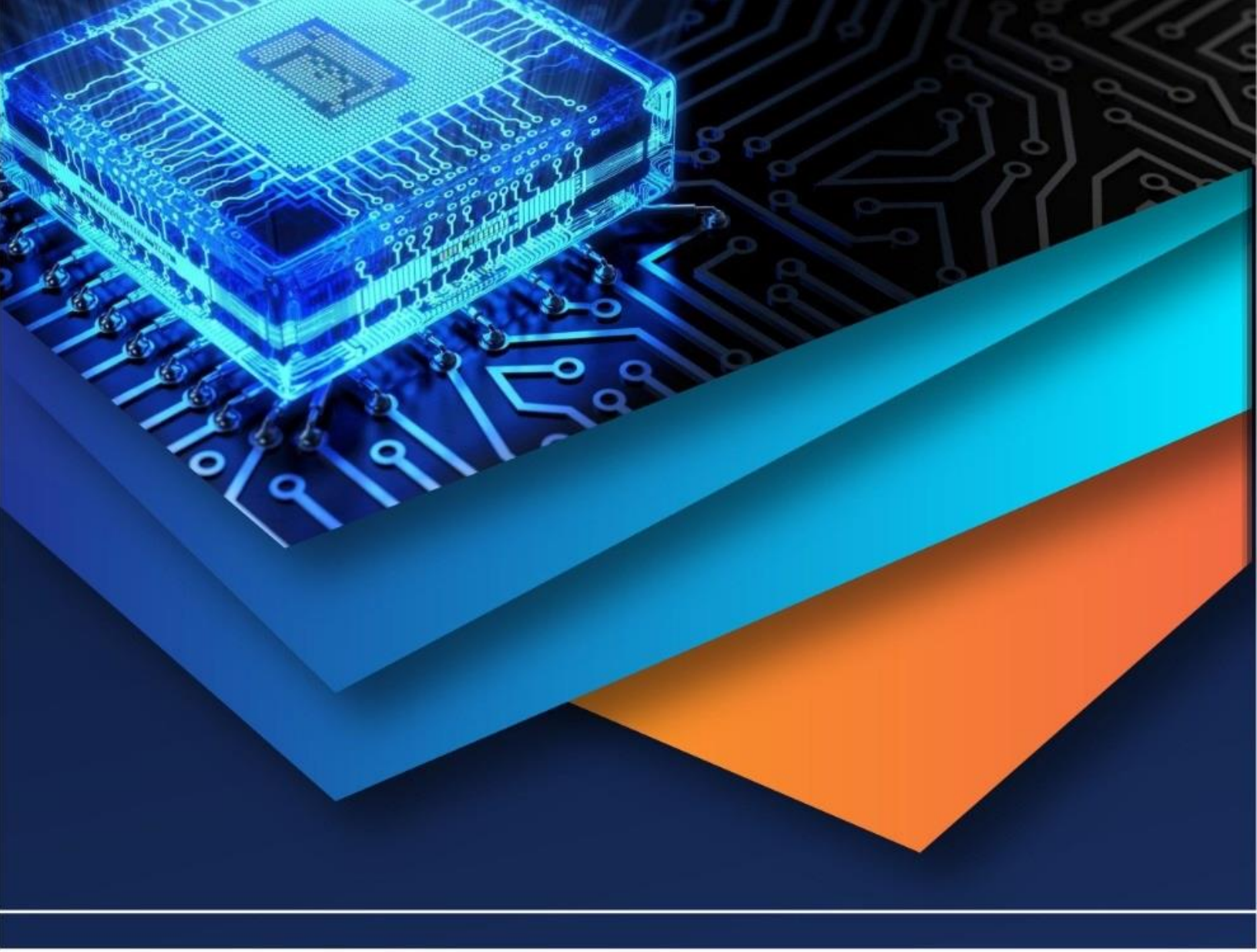

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