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CATS metric Definition

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Abstract

This document defines the computing metrics used in Computing-Aware

Traffic Steering.

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Kehan, et al. Expires 24 April 2025 [Page 1]

Internet-Draft CATS Metric October 2024

Table of Contents

1. Introduction . . . . . . . . . . . . . . . . . . . . . . . . 2

2. Conventions and Definitions . . . . . . . . . . . . . . . . . 3

3. Definition of Metrics . . . . . . . . . . . . . . . . . . . . 4

3.1. Level 0: Raw Metrics . . . . . . . . . . . . . . . . . . 4

3.2. Level 1: Normalized Metrics in Categories . . . . . . . . 5

3.3. Level 2: Fully Normalized Metric. . . . . . . . . . . . . 6

4. Representation of Metrics . . . . . . . . . . . . . . . . . . 6

4.1. Level 0 Metric Representation . . . . . . . . . . . . . . 7

4.1.1. Compute Raw Metrics . . . . . . . . . . . . . . . . . 7

4.1.2. Storage Raw Metrics . . . . . . . . . . . . . . . . . 7

4.1.3. Network Raw Metrics . . . . . . . . . . . . . . . . . 8

4.1.4. Delay Raw Metrics . . . . . . . . . . . . . . . . . . 8

4.1.5. Considerations on the Sources of Metrics and the

Statistics . . . . . . . . . . . . . . . . . . . . . 8

4.2. Level 1 Metric Representation . . . . . . . . . . . . . . 8

4.2.1. Normalized Compute Metrics . . . . . . . . . . . . . 8

4.2.2. Normalized Storage Metrics . . . . . . . . . . . . . 8

4.2.3. Normalized Network Metrics . . . . . . . . . . . . . 9

4.2.4. Normalized Delay . . . . . . . . . . . . . . . . . . 9

4.2.5. Considerations on the Sources of Metrics and the

Statistics . . . . . . . . . . . . . . . . . . . . . 9

4.3. Level 2 Metric Representation . . . . . . . . . . . . . . 9

5. Comparison of three layers of metric . . . . . . . . . . . . 9

6. Security Considerations . . . . . . . . . . . . . . . . . . . 11

7. IANA Considerations . . . . . . . . . . . . . . . . . . . . . 11

8. References . . . . . . . . . . . . . . . . . . . . . . . . . 11

8.1. Normative References . . . . . . . . . . . . . . . . . . 11

8.2. Informative References . . . . . . . . . . . . . . . . . 11

Authors' Addresses . . . . . . . . . . . . . . . . . . . . . . . 12

1. Introduction

Many modern computing services are deployed in a distributed way. In

this deployment mode, multiple service instances are deployed in

multiple sites to provide equivalent function to end users. In order

to provide better service to end users, a framework called CATS

(Computing-Aware Traffic Steering) [I-D.ietf-cats-framework] is

proposed.

CATS is

a traffic engineering approach that takes into account the dynamic

nature of computing resources and network state to optimize service-

specific traffic forwarding towards a given service contact instance.

Various relevant metrics may be used to enforce such computing-aware

traffic steering policies.asdf

Kehan, et al. Expires 24 April 2025 [Page 2]

Internet-Draft CATS Metric October 2024

To effectively steer traffic to the appropriate service instance,

network devices need a model of the service instance's computing

status. A common definition of computing metrics is essential for

effective coordination between network and computing devices.

Without standardized computing metrics, devices on the network may

interpret and respond to traffic conditions and computing load

differently, leading to inefficiencies and potential conflicts. A

standardized metric allows both network devices and computing systems

to evaluate load consistently, enabling precise traffic steering

decisions that optimize resource utilization and improve overall

system performance.

Various considerations for metric definition are proposed in

[I-D.du-cats-computing-modeling-description], which are useful in

defining computing metrics.

Based on the considerations defined in

[I-D.du-cats-computing-modeling-description], this document defines

relevant computing metrics for CATS by categorizing the metrics into

three levels based on their complexity and richness.

2. Conventions and Definitions

The key words "MUST", "MUST NOT", "REQUIRED", "SHALL", "SHALL NOT",

"SHOULD", "SHOULD NOT", "RECOMMENDED", "NOT RECOMMENDED", "MAY", and

"OPTIONAL" in this document are to be interpreted as described in

BCP 14 [RFC2119] [RFC8174] when, and only when, they appear in all

capitals, as shown here.

This document uses terms defined in [I-D.ietf-cats-framework]. We

list them below for clarification.

\* Computing-Aware Traffic Steering (CATS): An architecture that

takes into account the dynamic nature of computing resources and

network state to steer service traffic to a service instance.

This dynamicity is expressed by means of relevant metrics.

\* Service: An offering that is made available by a provider by

orchestrating a set of resources (networking, compute, storage,

etc.).

\* Service instance: An instance of running resources according to a

given service logic.

Kehan, et al. Expires 24 April 2025 [Page 3]

Internet-Draft CATS Metric October 2024

3. Definition of Metrics

Many metrics are being discussed and/or defined in the routing and

computing areas. Definition and usage of specific metrics are highly

related to the use case. However, when

considering distributing compute metrics to devices,

an appropriate abstraction is required to avoid

introducing extra complexity into the network.

Based on the abstraction level of metrics, this document defines

three levels of metrics to meet different requirements of different

use cases:

\* Level 0(L0): Raw Metrics. In this level, the metrics are not

abstracted, so different metrics use their own unit and format.

\* Level 1(L1): Normalized Metrics by Categories. In this level, the

metrics are classified into multiple categories, such as network,

computing and storage. Each category is normalized into a

value.

\* Level 2(L2): Fully Normalized Metric. In this level, lower level metrics are

normalized into a single value. The category information or raw

metrics information cannot be interpreted from the value directly.

3.1. Level 0 (L0): Raw Metrics

The metrics without any abstraction are Level 0 metrics. Therefore,

Level 0 metrics encompass detailed, raw metrics, including but not

limit to:

\* CPU: Base Frequency, Number of Cores, Boosted Frequency, Memory

Bandwidth, Memory Size, Memory Utilization Ratio, Core Utilization

Ratio, Power Consumption.

\* GPU: Frequency, Number of Render Unit, Memory Bandwidth, Memory

Size, Memory Utilization Ratio, Core Utilization Ratio, Power

Consumption.

\* NPU: Computing Power, Utilization Ratio, Power Consumption.

\* Network: Bandwidth, TXBytes, RXBytes, HostBusUtilization.

\* Storage: Available Space, Read Speed, Write Speed.

\* Delay: Time takes to process a request.

Kehan, et al. Expires 24 April 2025 [Page 4]

Internet-Draft CATS Metric October 2024

In L0, detailed information of a metric can be encoded into the

protocol, and different services can have its own metrics with different

information elements. This kind of metrics are used widely in distributed computing environmens.

Regarding network related raw metrics, IPPM WG defines many types

of metrics in [performance-metrics]. [RFC9439] also defines

metrics of packet performance and Throughput/Bandwidth. Regarding

computing metrics, [I-D.rcr-opsawg-operational-compute-metrics]

defines a set of cloud resource metrics.

3.2. Level 1: Normalized Metrics in Categories

In Level 1, the metrics are classified into different

categories, and appropriate abstraction are applied to each

category. The Level 0 raw metrics can be classified into multiple

categories, such as computing, networking, storage and delay. In

each category, the metrics are normalized into a value that represents

the state of the resource, making it as a Level 1 metric. Potential

categories are shown below:

\* Computing: A normalized value generated from the computing

related L0 metrics, such as CPU/GPU/NPU L0 metrics

\* Networking: A normalized value generated from the network related

L0 metrics.

\* Storage: A normalized value generated from the storage L0

metrics.

\* Delay: A normalized value generated from computing/networking/

storage metrics, reflecting the processing delay of a request.

Editor note: detailed categories can be updated according to the CATS

WG discussion.

The L0 metrics, such as the ones defined in [performance-metrics]

,[RFC9439] and [I-D.rcr-opsawg-operational-compute-metrics] can be

classified into the above categories. Each category can use its own

method(weighted summ, etc.) to generate the normalized value. In

this way, the protocol only needs to concern with the metric class and its

normalized value, avoiding the need to process detailed L0 metrics.

Kehan, et al. Expires 24 April 2025 [Page 5]

Internet-Draft CATS Metric October 2024

3.3. Level 2: Fully Normalized Metric.

The L2 metric is a one-dimensional value derived from a weighted sum of

L1 metrics or from L0 metrics directly. Different services can have their

own normalization method which might use different metrics with

different weights. For the ingress CATS router, it can compare the

metric value to make the traffic steering decision (e.g., larger

value has higher priority). In some cases, some implementations may

support configuring the ingress CATS router to know the metric

normalization method so that it can decode the affection from the L1 or

L0 metrics.

This method simplifies the complexity of transmission and management

of multiple metrics by consolidating them into a single, unified

measure.

Figure 1 shows the logic of metrics in Level 0, level 1 and

level 2.

+--------------+

Level 2 +------| Normalized M |-------+

| +--------------+ |

| | |

| | Normalizing |

+---------+ +--------+ +--------+

Level 1 | Cate M1 | | Cate M2| | Cate M3| ...

+---------+ +--------+ +--------+

| | | | |

| | |Normalizing | |

+------+ +------+ +------+ +------+ +------+

Level 0 |Raw M1| |Raw M2|...|Raw M3|...|Raw M4| |Raw M5| ...

+------+ +------+ +------+ +------+ +------+

Figure 1: Logic of CATS Metrics in levels

4. Representation of Metrics

A hierarchical view of metrics has been shown in the previous section.

In this section, a detailed representation of metrics is

described.

[RFC9439] gives a good way to show the representation of some network

metrics that are used for network capabilities exposure to the

application. This document further describes the representation of

CATS metrics.

Kehan, et al. Expires 24 April 2025 [Page 6]

Internet-Draft CATS Metric October 2024

For each metric at a given level, we define a set of common fields, including metric type, unit,

and precision. Metric type is a name for network devices and

protocols to recognize what the metric is. unit and precision are

necessary for metric descripition. How many bits a metric occupies

in protocols is also required.

Beyond these basic representations, the source of the metrics MUST

also be declared. As defined in [RFC9439], there are three cost-

sources, nominal, sla, and estimation. This document further divides

the estimation type into three sub-types, direct measurement,

aggregation, and normalization, since different levels of metrics

require different sources to acquire CATS metrics. Directly measured

metrics have physical meanings and units without any processing.

Aggregation metrics can be either physically meaningful or not, and

they maintain their meanings compared to the directly measured

metrics. Normalized metrics can have physical meanings or not, but

they do not have units, and they are just numbers that used for

routing decision making.

To be more fine grained, This document refers to the definition of

[RFC9439] on the metrics statistics.

4.1. Level 0 Metric Representation

Raw metrics have exact physical meanings and units. They are

directly measured from the underlying computing resources providers.

An extennsive set of definitions at this level have been defined in the

industry and standard organizations [DMTF], and this document only

show some examples for different categories of metrics for reference.

4.1.1. Compute Raw Metrics

\* The metric type of compute resources are named as “compute\_type:

CPU” or “compute\_type: GPU”. Their frequency unit is GHZ, the

compute capabilities unit is FLOPS. Format should support integer

and FP8. It will occupy 4 octets.

\* Example[TBA].

4.1.2. Storage Raw Metrics

The metric type of storage resources like SSD are named as

“storage\_type: SSD”. The storage space unit is megaBytes(MBs).

Format is integer. It will occupy 2 octets. The unit of read or

write speed is denoted as MB per second.

\* Example[TBA].

Kehan, et al. Expires 24 April 2025 [Page 7]

Internet-Draft CATS Metric October 2024

4.1.3. Network Raw Metrics

The metric type of network resources like bandwidth are named as

“network\_type: Bandwidth”. The unit is gigabits per second(Gb/s).

Format is integer. It will occupy 2 octets. The unit of TXBytes and

RXBytes is denoted as MB per second.

\* Example[TBA].

4.1.4. Delay Raw Metrics

Delay is a kind of synthesized metric which is influenced by

computing, storage access, and network transmission. It is named as

“delay\_raw”. Format should support integer and FP8. Its unit is

microsecond. It will occupy 4 octets.

4.1.5. Considerations on the Sources of Metrics and the Statistics

The sources of L0 metrics can be nominal, directly measured, or

aggregated. Nominal L0 metrics are provided initially by resource

providers. Dynamic L0 metrics are measured and updated during

service stage. L0 metrics also support aggregation, in case that

there are multiple service instances.

The statistics of L0 metrics will follow the definition of section

3.2 of [RFC9439].

4.2. Level 1 Metric Representation

Normalized metrics in categories have physical meanings but they do

not have units. They are numbers after some ways of abstraction, but

they can represent their type, in case that in some use cases, some

specific types of metrics require more attention.

4.2.1. Normalized Compute Metrics

The metric type of normalized compute metrics is “compute\_norm”, and

its format is integer. It has no unit. It will occupy a octet.

\* Example[TBA].

4.2.2. Normalized Storage Metrics

The metric type of normalized compute metrics is “storage\_norm”, and

its format is integer. It has no unit. It will occupy a octet.

\* Example[TBA].

Kehan, et al. Expires 24 April 2025 [Page 8]

Internet-Draft CATS Metric October 2024

4.2.3. Normalized Network Metrics

The metric type of normalized compute metrics is “network\_norm”, and

its format is integer. It has no unit. It will occupy a octet.

\* Example[TBA].

4.2.4. Normalized Delay

The metric type of normalized compute metrics is “delay\_norm”, and

its format is integer. It has no unit. It will occupy a octet.

\* Example[TBA].

4.2.5. Considerations on the Sources of Metrics and the Statistics

The sources of L1 metrics is normalized and support aggregation.

Based on L0 metrics, service providers design their own algorithms to

normalize metrics. For example, assigning different cost values to

each raw metric and do summation. L1 metric do not need further

statistical values.

4.3. Level 2 Metric Representation

The fully normalized metric is a single value which does not have any

physical meaning or unit. Each provider may have its own method to

derive the value, but all providers MUST follow the definition in

this section to represent the fully normalized value.

Metric type is “Norm\_fi”. The format of the value is non-negative

integer. It has no unit. It will occupy an octet.

The fully normalized value also supports aggregation when there are

multiple service instances providing these fully normalized values.

When providing fully normalized values, service instances do not need

to do further statistics.

5. Comparison of three layers of metric

From L0 to L1 to L2, the computing metric is consolidated. Different

levels of abstraction can meet the requirements from different

services. Table 1 shows the comparison among metric levels.

Kehan, et al. Expires 24 April 2025 [Page 9]

Internet-Draft CATS Metric October 2024

+=======+=============+===============+===========+==========+

| Level | Encoding | Extensibility | Stability | Accuracy |

| | Complexity | | | |

+=======+=============+===============+===========+==========+

| Level | Complicated | Low | Low | High |

| 0 | | | | |

+-------+-------------+---------------+-----------+----------+

| Level | Medium | Medium | Medium | Medium |

| 1 | | | | |

+-------+-------------+---------------+-----------+----------+

| Level | Simple | High | High | Medium |

| 2 | | | | |

+-------+-------------+---------------+-----------+----------+

Table 1: Comparison among Metrics Levels

Since Level 0 metrics are raw metrics, therefore, different services

may have their own metrics, resulting in hundreds or thousands of

metrics in total, this brings huge complexity in protocol encoding

and standardization. Therefore, this kind of metrics are always used

in customized IT systems case by case. In Level 1 metrics, metrics

are categorized into several categories and each category is

normalized into a value, therefore they can be encoded into the

protocol and standardized. Regarding the Level 2 metrics, all the

metrics are normalized into one single metric, it is easier to be

encoded in a standardized protocol. Therefore, from the encoding

complexity aspect, Level 2 and Level 1 metrics are preferred.

Similarly, when considering extensibility, new services can define

their own new L0 metrics, which requires protocol to be extended as

needed. Too many metric types can create significant overhead to the

protocol, resulting in a bad extensibility of the protocol. Level 1

metrics introduce only several categories, which is acceptable for

protocol extension. Level 2 metric only need one single metric, so

it incurs the lowest overhead on the protocol. Therefore, from the

extensibility aspect, Level 2 and Level 1 metrics are suggested.

Regarding Stability, new Level 0 raw metrics may require new

extensions in the protocol, which brings unstable format for protocol,

therefore, this document does not recommend to standardize Level 0

metrics in protocol. Level 1 metrics request only few categories,

and Level 2 Metric only introduce one metric to the protocol, so they

are preferred from the stability aspect.

Kehan, et al. Expires 24 April 2025 [Page 10]

Internet-Draft CATS Metric October 2024

In conclusion, for computing-aware traffic steering, it is

recommended to use the L2 metric due to its simplicity. If advanced

scheduling is needed, L1 metric can be used. L2 metrics are the most

comprehensive and dynamic, therefore transferring them to network

devices is discouraged due to their high overhead.

Editor notes: this draft can be updated according to the discussion

of metric definition in CATS WG.

6. Security Considerations

TBD

7. IANA Considerations

TBD

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Kehan, et al. Expires 24 April 2025 [Page 11]

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Kehan, et al. Expires 24 April 2025 [Page 12]