International Telecommunication Union

ITU-T

TELECOMMUNICATION
STANDARDIZATION SECTOR
OF ITU

Q.3914

(01/2018)

SERIES Q: SWITCHING AND SIGNALLING, AND ASSOCIATED MEASUREMENTS AND TESTS

Testing specifications – Testing specifications for next generation networks

---

Set of parameters of cloud computing for monitoring

Recommendation ITU-T Q.3914

ITU-T Q-SERIES RECOMMENDATIONS

SWITCHING AND SIGNALLING, AND ASSOCIATED MEASUREMENTS AND TESTS

SIGNALLING IN THE INTERNATIONAL MANUAL SERVICE	Q.1–Q.3
INTERNATIONAL AUTOMATIC AND SEMI-AUTOMATIC WORKING	Q.4–Q.59
FUNCTIONS AND INFORMATION FLOWS FOR SERVICES IN THE ISDN	Q.60–Q.99
CLAUSES APPLICABLE TO ITU-T STANDARD SYSTEMS	Q.100–Q.119
SPECIFICATIONS OF SIGNALLING SYSTEMS No. 4, 5, 6, R1 AND R2	Q.120–Q.499
DIGITAL EXCHANGES	Q.500–Q.599
INTERWORKING OF SIGNALLING SYSTEMS	Q.600–Q.699
SPECIFICATIONS OF SIGNALLING SYSTEM No. 7	Q.700–Q.799
Q3 INTERFACE	Q.800–Q.849
DIGITAL SUBSCRIBER SIGNALLING SYSTEM No. 1	Q.850–Q.999
PUBLIC LAND MOBILE NETWORK	Q.1000–Q.1099
INTERWORKING WITH SATELLITE MOBILE SYSTEMS	Q.1100–Q.1199
INTELLIGENT NETWORK	Q.1200–Q.1699
SIGNALLING REQUIREMENTS AND PROTOCOLS FOR IMT-2000	Q.1700–Q.1799
SPECIFICATIONS OF SIGNALLING RELATED TO BEARER INDEPENDENT CALL CONTROL (BICC)	Q.1900–Q.1999
BROADBAND ISDN	Q.2000–Q.2999
SIGNALLING REQUIREMENTS AND PROTOCOLS FOR THE NGN	Q.3000–Q.3709
SIGNALLING REQUIREMENTS AND PROTOCOLS FOR SDN	Q.3710–Q.3899
TESTING SPECIFICATIONS	Q.3900–Q.4099
Testing specifications for next generation networks	**Q.3900–Q.3999**
Testing specifications for SIP-IMS	Q.4000–Q.4039
Testing specifications for Cloud computing	Q.4040–Q.4059

For further details, please refer to the list of ITU-T Recommendations.

Recommendation ITU-T Q.3914

Set of parameters of cloud computing for monitoring

Summary

In accordance with the functional reference architecture of cloud computing that was defined in Recommendation ITU-T Y.3502, Recommendation ITU-T Q.3914 specifies the functional reference architecture of cloud computing according to Recommendation ITU-T Y.3500. This Recommendation provides a set of parameters that indicate the status and event of a cloud computing system, including resource layer, service layer and access layer.

History

Edition	Recommendation	Approval	Study Group	Unique ID[*]
1.0	ITU-T Q.3914	2018-01-13	11	11.1002/1000/13487

Keywords

Cloud computing, monitoring, parameter.

[*] To access the Recommendation, type the URL http://handle.itu.int/ in the address field of your web browser, followed by the Recommendation's unique ID. For example, http://handle.itu.int/11.1002/1000/11830-en.

FOREWORD

The International Telecommunication Union (ITU) is the United Nations specialized agency in the field of telecommunications, information and communication technologies (ICTs). The ITU Telecommunication Standardization Sector (ITU-T) is a permanent organ of ITU. ITU-T is responsible for studying technical, operating and tariff questions and issuing Recommendations on them with a view to standardizing telecommunications on a worldwide basis.

The World Telecommunication Standardization Assembly (WTSA), which meets every four years, establishes the topics for study by the ITU-T study groups which, in turn, produce Recommendations on these topics.

The approval of ITU-T Recommendations is covered by the procedure laid down in WTSA Resolution 1.

In some areas of information technology which fall within ITU-T's purview, the necessary standards are prepared on a collaborative basis with ISO and IEC.

NOTE

In this Recommendation, the expression "Administration" is used for conciseness to indicate both a telecommunication administration and a recognized operating agency.

Compliance with this Recommendation is voluntary. However, the Recommendation may contain certain mandatory provisions (to ensure, e.g., interoperability or applicability) and compliance with the Recommendation is achieved when all of these mandatory provisions are met. The words "shall" or some other obligatory language such as "must" and the negative equivalents are used to express requirements. The use of such words does not suggest that compliance with the Recommendation is required of any party.

INTELLECTUAL PROPERTY RIGHTS

ITU draws attention to the possibility that the practice or implementation of this Recommendation may involve the use of a claimed Intellectual Property Right. ITU takes no position concerning the evidence, validity or applicability of claimed Intellectual Property Rights, whether asserted by ITU members or others outside of the Recommendation development process.

As of the date of approval of this Recommendation, ITU had not received notice of intellectual property, protected by patents, which may be required to implement this Recommendation. However, implementers are cautioned that this may not represent the latest information and are therefore strongly urged to consult the TSB patent database at http://www.itu.int/ITU-T/ipr/.

Table of Contents

Recommendation ITU-T Q.3914

Set of parameters of cloud computing for monitoring

1 Scope

This Recommendation specifies the functional reference architecture of cloud computing according to [ITU-T Y.3500], in accordance with the functional reference architecture of cloud computing that was defined in [ITU-T Y.3502].

This Recommendation specifies parameters that should be monitored for the status identification of resource, service and management within a cloud system.

The parameters specified in this Recommendation include:

- monitoring parameters of the resource layer;
- monitoring parameters of the service layer;
- monitoring parameters of the access layer.

2 References

The following ITU-T Recommendations and other references contain provisions which, through reference in this text, constitute provisions of this Recommendation. At the time of publication, the editions indicated were valid. All Recommendations and other references are subject to revision; users of this Recommendation are therefore encouraged to investigate the possibility of applying the most recent edition of the Recommendations and other references listed below. A list of the currently valid ITU-T Recommendations is regularly published. The reference to a document within this Recommendation does not give it, as a stand-alone document, the status of a Recommendation.

[ITU-T Y.3500] Recommendation ITU-T Y.3500 (2014) | ISO/IEC 17788:2014, *Information technology – Cloud computing – Overview and Vocabulary*.

[ITU-T Y.3502] Recommendation ITU-T Y.3502 (2014) | ISO/IEC 17789:2014, *Information technology – Cloud computing – Reference architecture.*

3 Definitions

3.1 Terms defined elsewhere

This Recommendation uses the following terms defined elsewhere:

3.1.1 cloud computing [ITU-T Y.3500]: Paradigm for enabling network access to a scalable and elastic pool of shareable physical or virtual resources with self-service provisioning and administration on-demand.

3.1.2 cloud service [ITU-T Y.3500]: One or more capabilities offered via cloud computing invoked using a defined interface.

3.1.3 cloud service provider [ITU-T Y.3500]: Party which makes cloud services available.

3.1.4 functional component [ITU-T Y.3502]: A functional building block needed to engage in an activity, backed by an implementation.

3.1.5 product catalogue [ITU-T Y.3502]: A listing of all the cloud service products which cloud service providers make available to cloud service customers.

3.2 Terms defined in this Recommendation

This Recommendation defines the following term:

3.2.1 cloud service user: Natural person or entity acting on their behalf, associated with a cloud service customer that uses cloud services.

NOTE – This definition is paraphrased from clause 8.2.1.1 of [ITU-T Y.3502].

4 Abbreviations and acronyms

This Recommendation uses the following abbreviations and acronyms:

CPU	Central Processing Unit
GPU	Graphics Processing Unit
IaaS	Infrastructure as a Service
I/O	Input/Output
IP	Internet Protocol
KPI	Key Performance Indicator
MDT	Mean Down Time
MTBF	Mean Time Between Failures
MTTR	Mean Time To Repair
NF	Network Function
NFS	Network Function Status
OSS	Operational Support System
PaaS	Platform as a Service
QoS	Quality of Service
RAM	Random Access Memory
SC	Service Chain
SDN	Software-Defined Networking
SLA	Service Level Agreement
TCP	Transmission Control Protocol
TBF	Time Between Failures
TTR	Time To Repair
UPS	Uninterruptible Power System
URL	Uniform Resource Locator
VIP	Virtual Internet Protocol
VM	Virtual Machine

5 Conventions

None.

6 Functional reference architecture of cloud computing

The layering framework used in the cloud computing reference architecture has four layers, plus a set of functions that spans across the layers. The four layers are:

- user layer;
- access layer;
- services layer;
- resources layer.

The functions that span layers are called multilayer functions.

The layering framework is shown schematically in Figure 6-1.

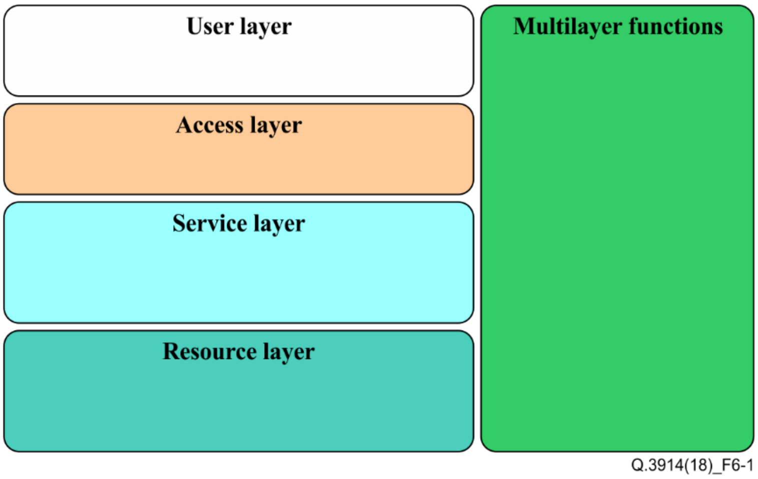


Figure 6-1 – Cloud computing layering framework

The function of each layer in the framework is described in clause 9.2.1 of [ITU-T Y.3502].

Figure 6-2 presents a high-level overview of the cloud computing reference architecture functional components organized by means of the layering framework.

The relevant monitoring functional components are as follows.

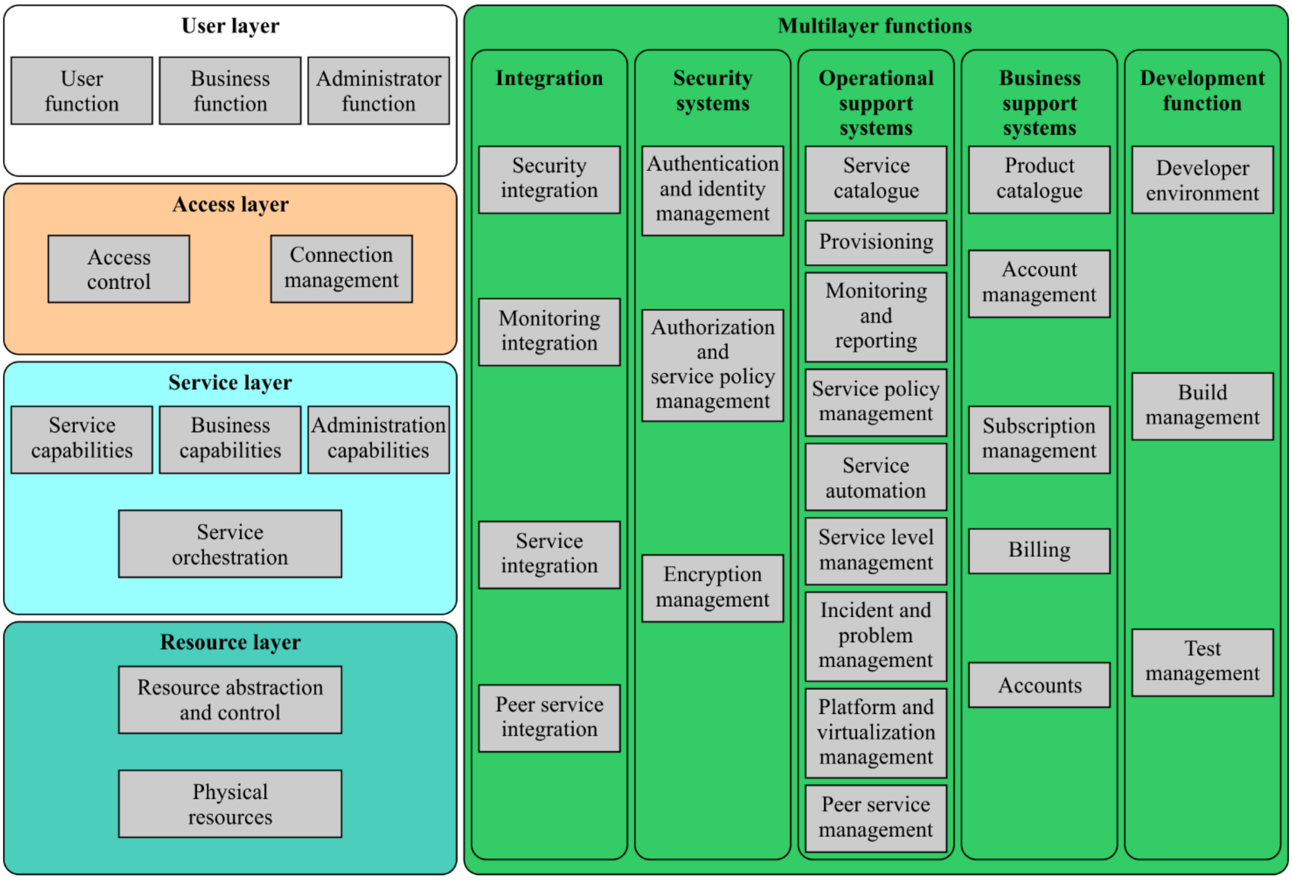
- Resource abstraction and control functional component: the resource abstraction and control functional component which resides in the resources layer enables control functionality, enabling monitoring and management capabilities implemented in the operational support systems functional component.

Monitoring and reporting functional component: the monitoring and reporting functional component that is one of the multilayer operational support systems provides capabilities for the following.

- Monitoring the activities of other functional components throughout the cloud provider's system. This includes the functional components that are involved in the direct use of cloud services by customer cloud service users such as service access and service implementation (e.g., the invocation of cloud service operation by a particular user). This also includes functional components involved in the support of cloud services, such as functional components in the operational support system (OSS) itself, like the service automation functional component (e.g., the provisioning of a service instance for a particular customer).
- Providing reports on the behaviour of the cloud service provider's system, which may take the form of alerts for behaviour that has a time-sensitive aspect (e.g., the occurrence of a fault, the completion of some task) or may take the form of aggregated forms of historical data (e.g., service usage data).
- Storage and retrieval of monitoring and event data as logging records.

Service level management functional component: the service level management functional component, which also resides in the operational support systems, obtains monitoring information from the monitoring and reporting functional component in order to measure and record key performance indicators (KPIs) for the cloud service. Capacity is allocated or de-allocated based on the basis of these KPIs.

The details of the functional components are described in clause 9.2 of [ITU-T Y.3502].



Q.3914(18)_F6-2

Figure 6-2 – Functional components of the cloud computing reference architecture

7 Monitoring parameters

Monitoring cloud resources and services is a key tool that helps cloud computing providers and consumers in designing, building and improving a cloud system, eliminating performance bottlenecks and identifying security flaws. Applications (e.g., streaming, web, indexing, compute and storage services) are distributed across cloud layers including platform as a service (PaaS) and infrastructure as a service (IaaS). In consequence, all parameters performed across all layers of the cloud stack need to be metered and monitored. These include not only cloud resource and network access, but also deployed services and applications.

7.1 Resource layer parameters

The resources layer is where the physical and virtual resources, as well as generic software, reside. This layer includes equipment typically used in a data centre such as servers, networking switches and routers, storage devices, in addition to the corresponding non-cloud specific software that runs on the servers and other equipment such as host operating systems, hypervisors, device drivers and generic systems management software.

7.1.1 Physical computing resources

Physical computing resources include any hardware within a computer system for running an operating system and software. An IaaS administrator can add physical computing resources to or remove physical computing resources from a virtual machine (VM).

In order to ensure that the deployed software and hardware resources run at the required level to satisfy the service level agreement (SLA), a continuous physical resource monitoring process is desirable.

Processors, memory and disks are basic computing and storage resources. Monitoring these resources can detect system failures or corruption before they become completely non-recoverable. So, monitoring functions and status of these resources to ensure system availability benefits users.

See Table 7-1.

Table 7-1 – Parameters collected to monitor physical computing resources

Metric name	Description	Unit
Central processing unit (CPU) frequency	CPU frequency	MHz
CPU util	Average CPU utilization	%
CPU idle time	Time of CPU is in idle status	ns
CPU load	CPUs have been loaded	process
CPU input/output (I/O) wait time	CPU I/O wait time	ns
CPU idle percent	Percent of CPU is in idle status	%
CPU user percent	Percent of CPU is in using status	%
CPU I/O wait percent	Percent of CPU I/O is in waiting status	%
memory	Volume of random access memory (RAM)	MB
memory util	Average RAM utilization	%
memory used	Used physical memory size	kB
disk size	Total size of disk	GB or TB
disk size used	Total size of disk used	GB or TB
disk random/sequential read requests	Volume of read requests	request
disk random/sequential read request rate	Average rate of read requests	request/s
disk random/sequential read delay	Average delay of read request	ms
disk random/sequential read error	Volume of read error	kB
disk random/sequential write requests	Volume of write requests	request
disk random/sequential write request rate	Average rate of write requests	request/s
disk random/sequential write delay	Average delay of write request	ms
disk random/sequential write error	Volume of write error	kB
disk random/sequential read bytes	Volume of reads	MB
disk random/sequential read byte rate	Average rate of reads	MB/s
disk random/sequential write bytes	Volume of writes	MB
disk random/sequential write byte rate	Average rate of writes	MB/s
Graphics processing unit (GPU) util	Average GPU utilization	%
GPU idle time	Time of GPU is in idle status	ns
GPU load	GPUs have been loaded	process
GPU I/O wait time	GPU I/O wait time	ns
GPU idle percent	Percent of GPU is in idle status	%
GPU user percent	Percent of GPU is in using status	%
GPU I/O wait percent	Percent of GPU I/O is in waiting status	%

Table 7-1 – Parameters collected to monitor physical computing resources

Metric name	Description	Unit
NOTE – All metrics should be measured over different durations, e.g., 1 min, 5 min, 15 min or 30 min.		

7.1.2 Virtual computing resources

Virtual computing resources include any virtual component within a virtual computer system for running an operating system, software and applications. Similarly to physical computing resources, running data and status of resources from VMs in which the applications are currently running require collection. These data provide a picture of how much of the VM is being utilized and helps in analysis and determination of the scaling requirement of applications.

See Table 7-2.

Table 7-2 – Parameters collected to monitor virtual computing resources

Metric name	Description	Unit
vCPUs	Number of virtual CPUs allocated to the virtual machine (VM)	CPU
vCPU idle time	Time of virtual CPUs is in idle status	ns
vCPU idle percent	Percent of vCPU is in idle status	%
vCPU user percent	Percent of vCPU is in using status	%
vCPU load	Virtual CPUs have been loaded	process
vCPU I/O wait time	Time of virtual CPUs I/O is in waiting status	ns
vCPU I/O wait percent	Percent of virtual CPU is in using status	%
vMemory	Volume of virtual RAM allocated to the VM	MB
vMemory utilization	Average virtual RAM utilization	%
vMemory used	Used virtual memory size	MB
vDisk size	Total size of virtual disk allocated to the VM	GB
vDisk size used	Total size of virtual disk used	MB
vDisk random/sequential read requests	Number of read requests of virtual disk	request
vDisk random/sequential read request rate	Average rate of read requests of virtual disk	request/s
vDisk random/sequential write requests	Number of write requests of virtual disk	request
vDisk random/sequential write request rate	Average rate of write requests of virtual disk	request/s
vDisk random/sequential read bytes	Volume of reads of virtual disk	kB
vDisk random/sequential read byte rate	Average rate of reads of virtual disk	kB/s
vDisk random/sequential read delay	Average delay of read request	ms
vDisk random/sequential read error	Volume of read error	kB
vDisk random/sequential write bytes	Volume of writes of virtual disk	kB

Table 7-2 – Parameters collected to monitor virtual computing resources

Metric name	Description	Unit
VDisk random/sequential write byte rate	Average rate of writes of virtual disk	kB/s
vDisk random/sequential write delay	Average delay of write request	ms
vDisk random/sequential write error	Volume of write error	kB
vGPU util	Average vGPU utilization	%
vGPU idle time	Time of vGPU is in idle status	ns
vGPU load	vGPUs have been loaded	process
vGPU I/O wait time	vGPU I/O wait time	ns
vGPU idle percent	Percent of vGPU is in idle status	%
vGPU user percent	Percent of vGPU is in using status	%
vGPU I/O wait percent	Percent of vGPU I/O is in waiting status	%
NOTE – All metrics should be measured over different duration, e.g., 1 min, 5 min, 15 min or 30 min.		

7.1.3 Virtual machine operation and control

VM operation and control are referred to the management of physical or virtual computing resources that allow users to create, edit, start and stop VMs.

The impetus behind cloud computing is the ever-increasing demand to manage growth and increase computing flexibility by dynamic resource operation and control based on demand. An example of resource control operation could be to horizontally scale a database server by migrating it from a small CPU resource configuration to an extra-large CPU resource to improve throughput. This basic requirement of cloud computing is supported by the resource operation and control system. An inefficient resource operation and control system has a direct negative effect on performance. It can also indirectly affect system functionality. Some system functions provided might become ineffective due to poor performance.

See Table 7-3.

Table 7-3 – Parameters collected to monitor VM operation and control

Metric name	Description	Unit
CPU of VM start	Time of CPU start	s
CPU of VM stop	Time of CPU stop	s
CPU of VM restart	Time of CPU restart	s
CPU of VM select	Time of CPU select	s
CPU of VM scale down	Time of CPU scale down	s
CPU of VM scale up	Time of CPU scale up	s
VM start	Time of VM start	s
VM acquisition	Time of VM acquisition	s
VM release	Time of VM release	s
memory of VM scale down	Time of memory scale down	s
memory of VM scale up	Time of memory scale up	s
disk of VM scale down	Time of disk scale down	s

Table 7-3 – Parameters collected to monitor VM operation and control

Metric name	Description	Unit
disk of VM scale up	Time of disk scale up	s
upload file	Time of upload file	s
download file	Time of download file	s
allocation Internet protocol (IP)	Time of allocation IP	s
allocation ports	Time of allocation ports	s
allocation URL	Time of allocation uniform resource locator (URL)	s
VM live migration	Time that is needed to move a VM from two predefined resources	s
migration Interruption Time	Maximum time in which a customer has no access to migration to the resource	s
VM cloning	Time of VM cloning	s
VM backup	Time of VM backup	s
VM imaging	Time of VM imaging	s
recovery time	Time from the failure of a storage, to the successful restore from an existing backup	s
NOTE – VM backup time interval varies according to backup type, e.g., full backup or incremental backup.		

7.1.4 Network

High-performance computing requires large amounts of network bandwidth. Particularly for cloud computing, the network has a strong meaning, as all provided resources and services are available through a network. It has been found that poor network performance is caused by virtualization I/O overhead. A network monitoring system helps in realization of traffic, utilization and errors and then, based on accurate monitoring information, quality of service (QoS) policy validation, network outage resolution, performance problem troubleshooting, and in making important capacity planning decisions.

See Table 7-4.

Table 7-4 – Parameters collected to monitor a network

Metric name	Description	Unit
incoming bytes	Number of bytes received by network interface	KB
incoming byte rate	Average rate of bytes received by network interface per second	KB/s
maximum incoming byte rate	Maximum incoming byte rate during a specific period (5 minute/15 minutes/60 minutes)	KB/s
outgoing bytes	Number of bytes sent by network interface	KB
outgoing byte rate	Average rate of bytes sent by network per second	KB/s
maximum outgoing byte rate	Maximum outgoing byte rate (5 minute/15 minutes/ 60 minutes)	KB/s
incoming packets	Number of incoming packets	packet

Table 7-4 – Parameters collected to monitor a network

Metric name	Description	Unit
incoming packet rate	Average rate of incoming packets per second	packet/s
average packets size incoming	Average packets size incoming (1 minute/5 minutes/ 15 minutes)	byte
outgoing packets	Number of outgoing packets	packet
outgoing packet rate	Average rate of outgoing packets per second	packet /s
average packets size outgoing	Average packets size outgoing (1 minute/5 minutes/ 15 minutes)	byte
outgoing errors	Sending error of network interface	packet
bandwidth of incoming	Total capacity of the connection of the incoming	Mb
utilization of incoming interface	Percentage of incoming byte rate with respect to bandwidth of incoming.	%
bandwidth of outgoing	Total capacity of the connection of the outgoing	Mb/s
utilization of outgoing interface	Percentage of outgoing byte rate with respect to bandwidth of outgoing link.	%
average latency	Average of delay of data transition	ms
Minimum latency	Minimum time interval between submitting a packet and arrival at its destination	ms
Maximum latency	Maximum time interval between submitting a packet and arrival at its destination	ms
packet loss	Percentage of packets lost with respect to packets sent.	%
jitter	The difference in end-to-end one-way delay	ms

7.1.5 Software-defined networking

Software-defined networking (SDN) is a concept that enables network operators and data centres to flexibly manage their networking equipment using software. SDN introduces new levels of flexibility and automation without manual interaction for networking.

7.1.5.1 Software-defined networking-based network

Network setup in SDN is now separated from a network engineer's regular activities; network issue troubleshooting and diagnosis have become more complex. The availability, performance, utilization and capacity of SDN monitoring can enable a cloud computing provider more confidently to adopt SDN in cloud computing.

See Table 7-5

Table 7-5 – Parameters collected to monitor a software-defined networking controller

Metric name	Description	Unit
latency of topology discovery	Latency of topology discovery	ms
latency of connection from switch to controller	Latency of connection from switch to controller	ms
number of active switches	Number of active switches	switch
incoming packets of the same source addresses	Numbers of incoming packets with the same incoming source addresses	packet
incoming packets of the same destination addresses	Numbers of incoming packets with the same incoming destination addresses	packet
outgoing packets of the same source addresses	Numbers of outgoing packets with the same outgoing source addresses	packet
outgoing packets of destination addresses	Numbers of outgoing packets with the same outgoing destination addresses	packet
incoming packets of the same source port	Numbers of incoming packets with the same incoming source port numbers	packet
incoming packets of the same destination port	Numbers of incoming packets with the same incoming destination port number	packet
outgoing packets of the same source port	Numbers of outgoing packets with the same outgoing source port numbers	packet
outgoing packets of the same destination port	Numbers of outgoing packets with the same outgoing destination port numbers	packet

7.1.5.2 Service chain

Cloud computing provides not only computing and storage resources to consumers as a resource pool, but also as a network resource pool. According to appointed service logic, network traffic passes though several service points (generally reference is made to firewall, load balance or any other network functions (NFs)). A service chain (SC) links these service points together. A cloud computing provider should consider the ’performance and status of an SC when it provides service to consumers.

See Table 7-6.

Table 7-6 – Parameters collected to monitor a service chain

Metric name	Description	Unit
NFS	Network function status	normal/fail
NF start	Time of network function start	s
NF stop	Time of network function stop	s
NF migration	Time that is needed to move a NF from two predefined resources	s
SC start	Time of a service chain established	s
SC stop	Time of a service chain destroy	s

7.1.6 Energy consumption

Voltage or power use out of the permissible range can damage electrical components or cause system failure. If the fan stops working, the server overheats, is damaged and goes out of service. So, it is important to monitor the voltage or wattage, fan and temperature to ensure that they are within safe operating limits.

In order to handle massive amounts of data generated by consumers and businesses, cloud computing typically needs a lot of power. A sharp increase in energy consumption can indicate server load unbalance that leads to performance degradation. Real-time monitoring is helpful for avoiding these consequences. Different states of the physical or VMs require different power levels. These states can normally be divided into six types: named as shutdown, work, idle, dormant, sleep and standby.

See Table 7-7.

Table 7-7 – Parameters collected to monitor energy consumption in each state

Metric name	Description	Unit
power of CPU	Current power of CPU consumption	w
power of GPU	Current power of GPU consumption	w
power of Memory	Current power of Memory consumption	w
power of storage	Current power of storage consumption	w
power of network	Current power of disk consumption	w
power of power Systems	Current power of power system consumption	w
temperature of CPU	Current temperature of CPU	ºC

7.1.7 Environment

The server room environment requires strict control processes for temperature, humidity and power supply. A fully automated monitoring system can help prevent overheating of servers and condensation on equipment. Keeping temperatures within range and carefully monitoring humidity to prevent corrosion or static electricity reduce energy consumption and keep servers running smoothly. Voltage use out of the permissible range can damage electrical components or cause system failure. If the fan stops working, the server overheats, is damaged and goes out of service. So, it is important to monitor the voltage or wattage, fan and temperature to ensure that they are within safe operating limits.

See Table 7-8.

Table 7-8 – Parameters collected for the monitoring environment

Metric name	Description	Unit
temperature	Current temperature of server room	ºC
voltage	Current voltage of electricity supply	V
electric current	Electric current of electricity supply	A
UPS voltage	Output voltage of an uninterruptible power system (UPS) battery	V
UPS output electric current	Output electric current of UPS battery	A
UPS charging electric current	Electric current of charging	A
humidity	Relative humidity of server room	%
fan rotations	Fan rotations per minute	rotations/min
power of fan	Current power of fan consumption	W

7.2 Service layer parameters

7.2.1 General

One of the most important areas for provider and consumer is service performance and availability when it comes to cloud computing. Cloud service provider and consumer need to get an entire view of the health of service. A lot of decision making and SLA determination are driven by service performance and availability. The monitoring system should report the service performance and availability parameters to identify whether the QoS specified in the SLA is fulfilled.

Different cloud services can be offered with different terminologies, specifications and features. Cloud services can achieve different levels of performance under various workloads generated by diverse applications. For example, unlike computation and communication-intensive applications, performance of data-intensive applications typically will be strongly affected by I/O performance and storage access in a cloud infrastructure. The monitoring parameters of typical services are included in this clause. Others are for further study.

See Table 7-9.

Table 7-9 – Performance metrics for monitoring general cloud services

Category	Metric name	Description
Availability	MTBF	Mean time between failures
	MTTR	Mean time to repair
Performance	Response time	Response time for composite or atomic service
	Throughput	Number of transactions or requests processed per specified unit of time
Capacity	Bandwidth	Bandwidth of the connection that supports a service
	Storage capacity	Capacity of a temporary or persistent storage medium, such as RAM, disk or tape

7.2.2 Service availability

Service availability is the property of being accessible and usable upon demand by an authorized entity. Continuity is the key feature used to measure service availability, which ensures the service is available for a certain amount of time without any interruption. Furthermore, if there is an incident, continuity enables the service to be restarted and access to data and functionality of the service regained within a particular period. All elements, including computing, storage, network and power supplement, can affect service continuity. For example, for a public-cloud end user, availability of the cloud not only refers to the services provided by the cloud service provider, but also to the possibility of accessing those services remotely.

See Table 7-10.

Table 7-10 – Parameters collected for monitoring service availability

Metric name	Description	Unit
mean time between failures (MTBF)	Time between inherent failures of element or service during operation	h
maximum TBF	Maximum time between failures	h
minimum TBF	Minimum time between failures	h
mean time to repair (MTTR)	The average time repair a failed element or service	h

Table 7-10 – Parameters collected for monitoring service availability

Metric name	Description	Unit
maximum TTR	Maximum time to repair	h
minimum TTR	Minimum time to repair	h
mean down time (MDT)	The average time that an element or service is non-operational. This includes all downtime associated with repair	h
maximum down time	Maximum time of down	h
minimum down time	Minimum time of down	h

7.2.3 Service performance

7.2.3.1 Transaction process

Transaction process metrics can give a clear picture of the performance of an application in a cloud, such as response time to complete service requests and transaction rate at which service requests are executed. Latency for service requests, which calculates the time taken for the application to respond to user requests, is the key metric.

See Table 7-11.

Table 7-11 – Parameters collected for monitoring the transaction process

Metric name	Description	Unit
transactions	Number of transactions during a period (1 min, 5 min, 15 min)	transaction
transaction rate	Transaction rate at which service requests are executed per second	transaction/s
errors	Number of error transactions	transaction
concurrent transactions	Average number of new transactions processed simultaneously	transaction
time per transactions	Average time necessary to process a single transactions item	ms
disk throughput rate	Throughput rate (input and output) for a specific service	kB/s
memory throughput rate	Throughput rate (input and output) for a specific service	kB/s
delay	Delay of message passing between processes	ms
time of task	Duration of specific predefined tasks	ms

7.2.3.2 Load balance

Load balancing of cloud computing is the process of distributing workloads across multiple computing resources, which provides an efficient solution to various issues residing in cloud computing environment usage.

See Table 7-12.

Table 7-12 – Parameters collected for monitoring the efficiency and effectiveness of load balancing

Metric name	Description	Unit
load balance pool	Number of load balance pools	pool
load balance VIPs	Number of virtual internet protocol (VIP) addresses	member
load balance member	Number of load balance member	member
load balance health monitor	Number of Load balance health monitor	monitor
load balance connections	Volume of Load balance connections	connection
load balance active connections	Volume of Load balance active connections	connection
load balance incoming bytes	Volume of Load balance incoming bytes	MB
load balance outgoing bytes	Volume of Load balance outgoing bytes	MB

7.2.3.3 Database

A cloud database is a database that typically runs on a cloud computing platform. Poor database performance can dramatically degrade QoS. Cloud providers who offer database as a service, without physically launching a VM instance for the database, should have a clear picture of how a database is running and what is needed by consumers.

A relational database is organized based on the relational model of the data. A non-relational database provides a mechanism for storage and retrieval of data that is modelled by means other than the tabular relations used in relational databases. Non-relational databases are increasingly used in big data and real-time web applications. The operation mechanisms of the two types of databases are entirely different. So relational and non-relational databases should be monitored separately.

See Table 7-13.

Table 7-13 – Parameters collected for monitoring database efficiency

Metric name	Description	Unit
space	Total space of DB	kB
space used	Total space used of DB	kB
queries	Total number of DB queries (select, insert, update, delete, replace)	query
replace request	Volume of replace requests	request
replace request rate	Average rate of replace requests per second	request/s
response time of replace request	Average time of responding replace request	ms
insert/set request	Volume of insert/set requests	request
insert/set request rate	Average rate insert/set request of per second	request/s
response time of insert/set request	Average time of responding insert/set request	ms
update request	Volume of update requests	request
update request rate	Average rate of update requests per second	request/s
response time of update request	Average time of responding update request	ms
delete request	Volume of delete requests	request
delete request rate	Average rate of delete requests per second	request/s
response time of delete request	Average time of responding delete request	ms

Table 7-13 – Parameters collected for monitoring database efficiency

Metric name	Description	Unit
select/get request	Volume of select requests	request
select/get request rate	Average rate of select requests per second	request/s
response time of select/get request	Average time of responding select/get request	ms
connect	Connection number of concurrent clients	request
connect rate	Average rate of connections per second	request/s
slow/expired query	Volume of slow/expired queries	query
slow/expired query rate	Average rate of slow/expired queries per second	request/s

7.2.3.4 Web service performance

The main function of the web server is to provide an online information browsing service. There are three types of performance parameter for web service: throughput, concurrent transactions and response time.

See Table 7-14.

Table 7-14 – Parameters collected for monitoring web service performance

Metric name	Description	Unit
throughput	Number of service request that a web service can complete in a given period of time	request/s
users	Number of new connection users servicing per second	user/s
transactions per second	Average number of transactions processed per second	transaction/s
connection rate	Number of new transmission control protocol (TCP) connections setting up per second	link/s
response time	The time duration from receiving the request to the web service to sending the response from the web service	ms
round trip time	Time from sending SYN to receiving SYN ACK	ms
TCP setting up time	Average time of TCP link setting up	
simultaneous connections	Number of TCP connections setting up between client and server	link/s
cumulative transactions	Total number of transactions processing processed	transaction

7.3 Access layer parameters

Principally, access control involves the authentication of a user through the presentation and validation of credentials, followed by the authorization of this authenticated user to use specific services. Associated with this is identity management. Access behaviour and management events should be monitored for the access layer.

See Table 7-15.

Table 7-15 – Parameters collected for monitoring the access layer

Metric name	Description	Unit
account entries	Number of successful account logon events	event
unsuccessful account entries	Number of unsuccessful account logon events	event
account exits	Number of account logout events	event
create account	Number of successful account creation events	event
modify account	Number of successful account modification events	event
delete account	Number of successful account deletion events	event
unsuccessful account management	Number of unsuccessful account management events	event
policy change	Number of successful policy change events	event
unsuccessful policy change	Number of unsuccessful policy change events	event
data deletions	Number of successful data deletion events	event
unsuccessful data deletions	Number of unsuccessful data deletion events	event
data access	Number of successful data access events	event
unsuccessful data access	Number of unsuccessful data access events	event
data changes	Number of successful data changes events	event
unsuccessful data changes	Number of unsuccessful data change events	event
unauthorized access,	Number of unauthorized service access events	event
unauthorized modification	Number of unauthorized service modification events	event
unauthorized deletion	Number of unauthorized service deletion events	event

SERIES OF ITU-T RECOMMENDATIONS

Series A	Organization of the work of ITU-T
Series D	Tariff and accounting principles and international telecommunication/ICT economic and policy issues
Series E	Overall network operation, telephone service, service operation and human factors
Series F	Non-telephone telecommunication services
Series G	Transmission systems and media, digital systems and networks
Series H	Audiovisual and multimedia systems
Series I	Integrated services digital network
Series J	Cable networks and transmission of television, sound programme and other multimedia signals
Series K	Protection against interference
Series L	Environment and ICTs, climate change, e-waste, energy efficiency; construction, installation and protection of cables and other elements of outside plant
Series M	Telecommunication management, including TMN and network maintenance
Series N	Maintenance: international sound programme and television transmission circuits
Series O	Specifications of measuring equipment
Series P	Telephone transmission quality, telephone installations, local line networks
Series Q	**Switching and signalling, and associated measurements and tests**
Series R	Telegraph transmission
Series S	Telegraph services terminal equipment
Series T	Terminals for telematic services
Series U	Telegraph switching
Series V	Data communication over the telephone network
Series X	Data networks, open system communications and security
Series Y	Global information infrastructure, Internet protocol aspects, next-generation networks, Internet of Things and smart cities
Series Z	Languages and general software aspects for telecommunication systems

Printed in Switzerland
Geneva, 2018