Top 10 2020 – Cloud Compute Europe

Cloud Mercato

I. Introduction

At the start of this year 2020, cloud computing is a large and mature industry, always growing and creating new models of computers' resources consumption. Despite a large adoption by enterprise and governments, from a consumer prospective, the cloud market still tends to appear to be hard to decrypt.

To answer to this problematic, Cloud Mercato designed this report gathering the 10 most interesting cloud service providers in Europe. This document aims to brings a neutral and objective evaluation of CSPs' capabilities. It provides a state-of-the-art of cloud industry made by a third-part analysis team.

II. Executive summary

Across providers, there's a multitude of offering and ways to evaluate cloud vendors, in this document we focus on classical cloud computing services. Virtual machines, containers, VPS, whatever the name is, the principle is selling on-demand an amount of CPU and RAM with a network availability directly on the Internet. This kind of service is one of the most basic IaaS offers provided by CSP and generally called "Compute".
Due to its essential nature and being also one main component of VM offering, block storage is part of evaluation in our study.

The subject of this document is efficiency measurement of compute services by the following questions:

- How do they perform?
- How much do they cost?
- Which is the most valuable?

III. Methodology

According to the nature of analyzed components, definition of performance varies. CPU and storage express their efficacity very differently, so tests and analysis are way different from one component to the other. Cloud Mercato regularly launches tests on many cloud products and for this report we picked few of our existing usual methodologies.

1. Provider criteria

Among vendors tested by Cloud Mercato during year 2019, 10 providers have been selected for this ranking. More candidates were available and we picked only the best performers filling the following requirements:

- Presence with several datacenters in Europe
- Offer VMs with at least 2 up to 16vCPU
- Offer CPU/RAM ratio at least 1:2 up to 1:4
- Offer block storage with volume at least 100 up to 500GB powered by SSD
- Offer hourly billing option without engagement

2. Setup

The ranking is based on 4 categories of VMs, from 2 to 16 vCPU. The table below describes the specifications that we attribute to each category. We tried to match with a CPU/RAM ratio of 1:2, but RAM may vary across providers.

SIZE	vCPU	RAM (GB)	STORAGE (GB)
Small	2	4	100
Medium	4	8	150
Large	8	16	200
Extra large	16	32	500

If a provider allows detachable volume, virtual machines are equipped with SSD block storage as an extra volume else root volume is used. All instances had been tested with Ubuntu 18.04. Appendix brings an accurate definition of virtual hardware used for each provider.

For each VM type, at least three instances were provisioned simultaneously. For confirmation or validation, more copies could have been launched.

3. Test software

TEST	SOFTWARE
Compute	Geekbench 5
Storage IOPS	FIO
Storage bandwidth	FIO

a. Compute

CPU performance was collected using Geekbench 5. This well-known suite runs a large number of tests covering a large spectrum of computing domains. Topics tested are:

- Integer
- Floating point
- Cryptography

Around twenty metrics are reported by Geekbench plus a score linked to each of them, for single and multi-thread workloads. In the context of this report we use:

- **Single score**: As CPU power evaluation
- **Multi score**: As multi-task power evaluation

b. Storage

Storage performance are measured by two metrics: IOPS and bandwidth. For both, Flexible I/O tester has been used with two different scenarios. In both we used the following parameters:

- A number of thread equal to the number of vCPU
- A direct connection to the device without file system
- Flags by-passing buffers and cache such as IO_DIRECT
- Read and write access (not mixed)

i. IOPS

This scenario aims to reveal what is the best rate in terms of block handling. So, we applied a small block size of 4K allowing the maximum number of blocks handled simultaneously. A random access to drive is applied, removing predictability of a sequential operation.

ii. Bandwidth

IOPS captures the transaction rate, but it doesn't reflect the maximum throughput available by volume. The nature of the scenario with small blocks and random access already represent a bottleneck for this metrics. To collect the maximum bandwidth, we access sequentially to drive with big blocks of 1M reducing block processing and allocation time.

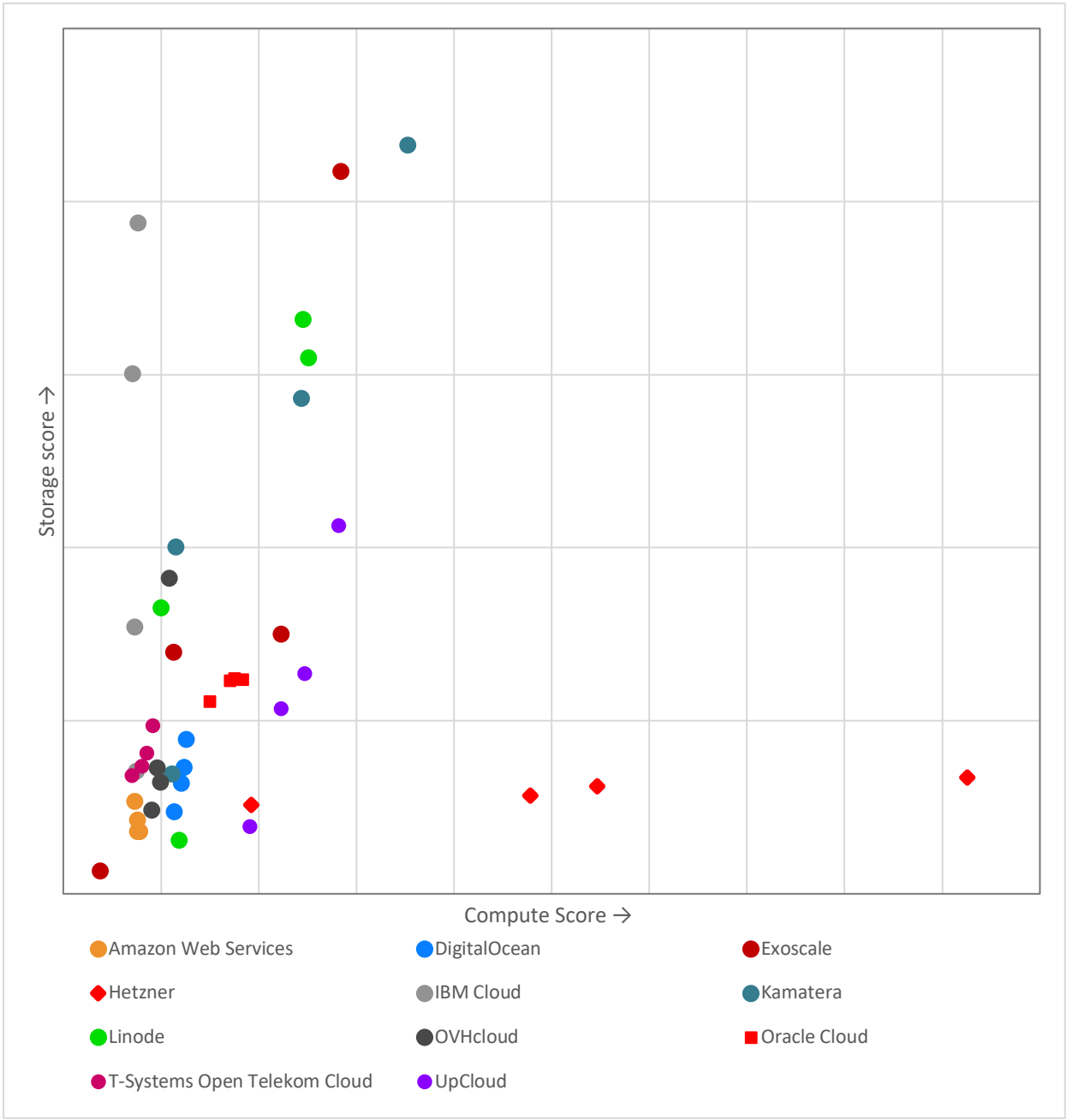
4. Calculations

The performance reported in this document are averages, so to gauge the variability we also bring standard deviation but we don't use it in calculations. For information, in a normal distribution, the range between AVG-STDDEV and AVG+STDDEV represents 68.2% of the population.

To aggregate different kind of values into understandable comprehensive scores, Cloud Mercato used few formulae:

Name	Type	Calculation
Compute score	Compute	Multi thread performance / Monthly price
Storage score	Storage	AVERAGE(IOPS, Bandwidth) / Monthly price
Overall score	Overall	AVERAGE(Compute score, Storage score)

IV. Overview


Storage score →
Compute Score →
Amazon Web Services
DigitalOcean
Exoscale
Hetzner
IBM Cloud
Kamatera
Linode
OVHcloud
Oracle Cloud
T-Systems Open Telekom Cloud
UpCloud

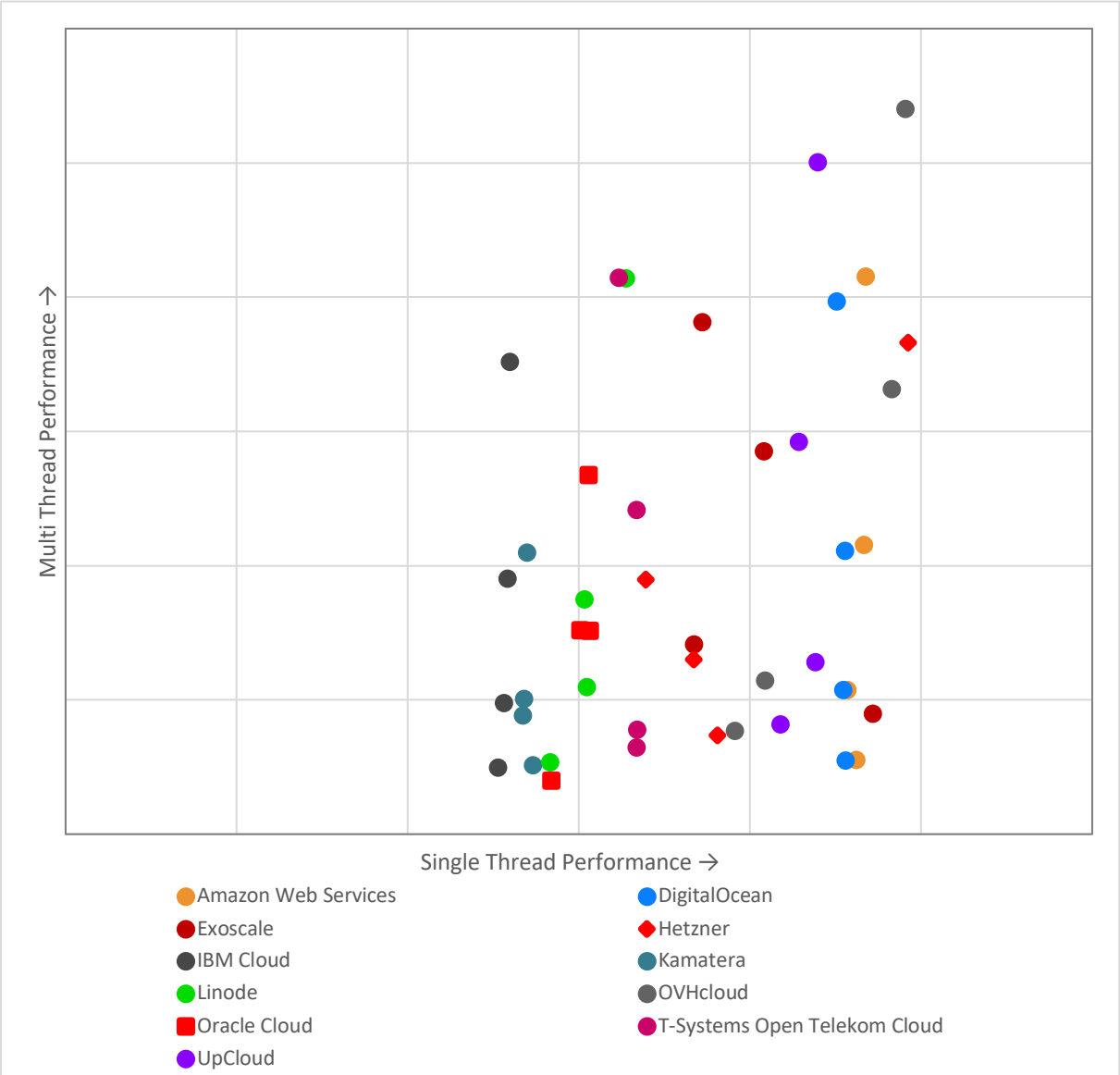
V. Performance

For each category of products analyzed in this document, vendors provide almost the same specification. Catalogs all claim good vCPU, RAM and SSD storage but behind announced virtual hardware, they aren't equal in term of performance. Efficacity is not a value given by catalog or at least in a too subjective manner.

To clarify this question, Cloud Mercato launched a benchmark suite on virtual machines and block storage. This section outlines the average performance discovered during our testing.

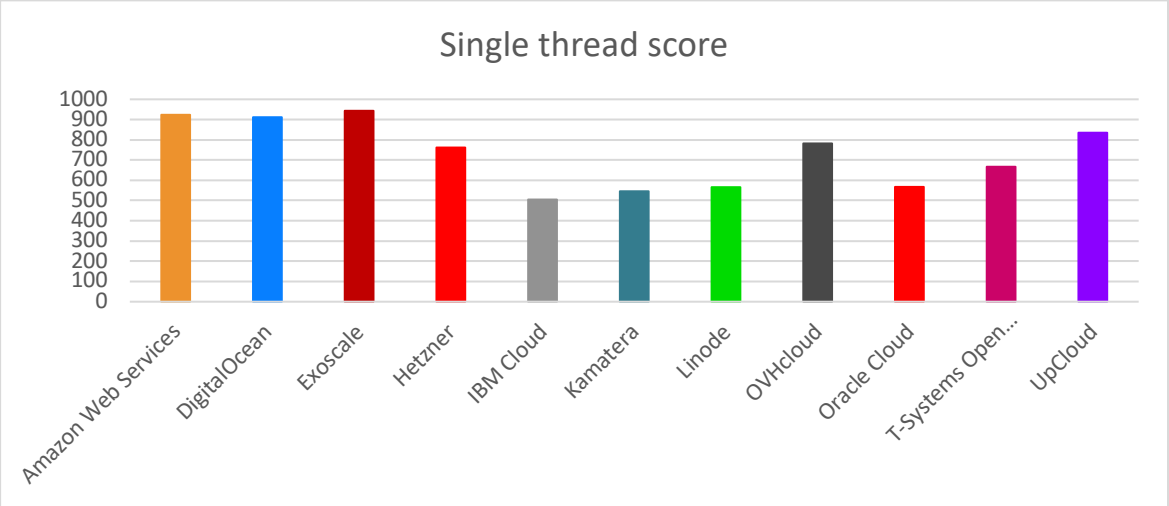
1. Compute

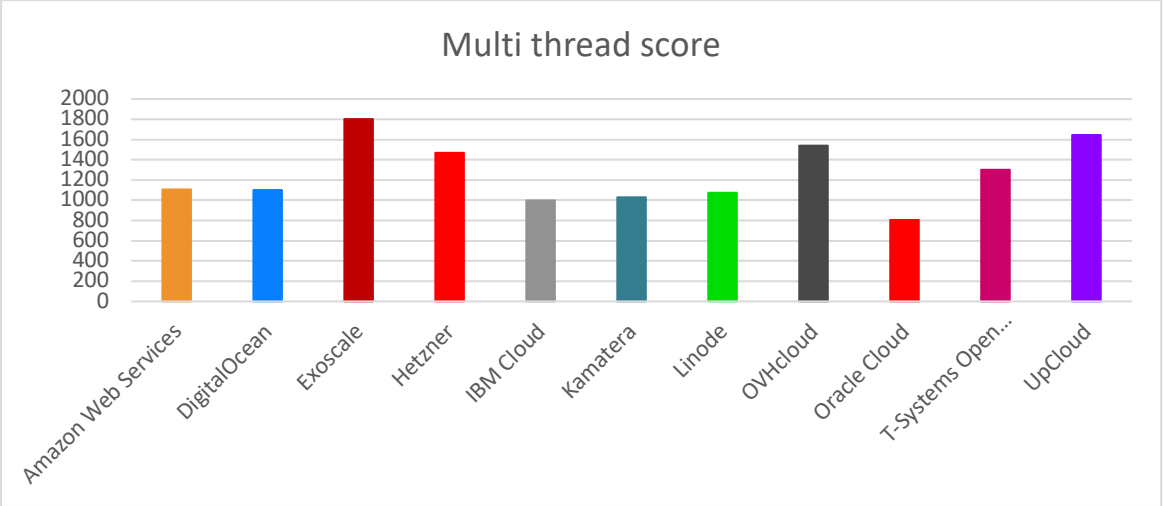
a. Overall



b. By category

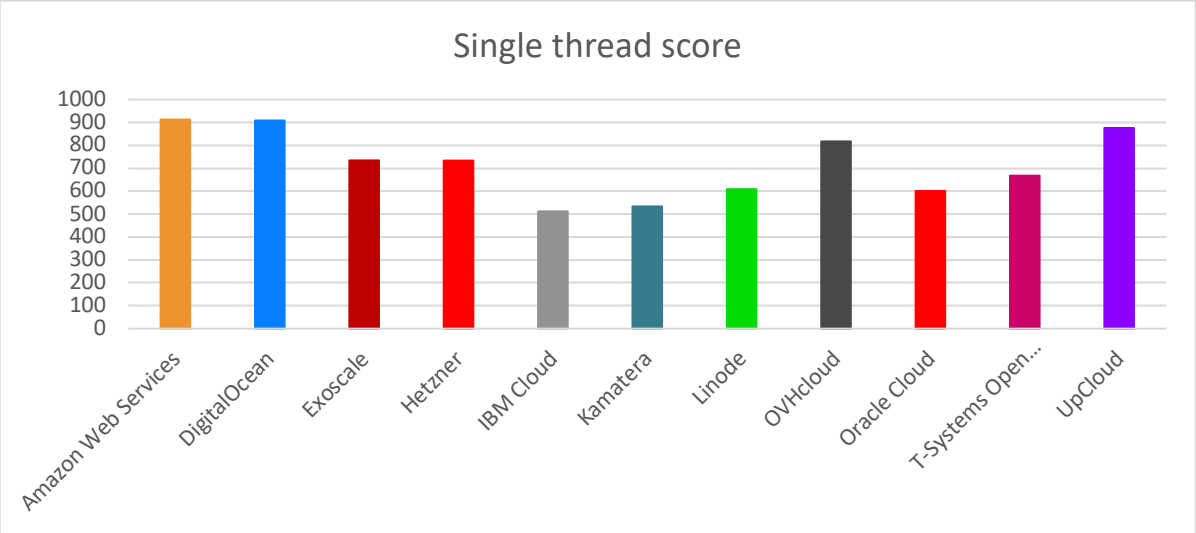
i. Small

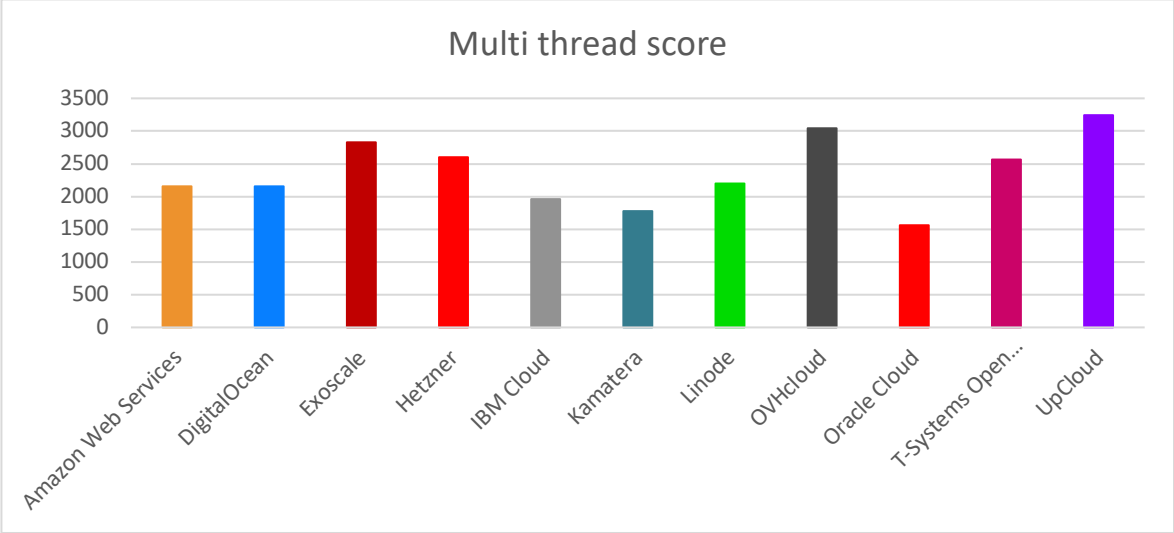




	Single thread		Multi thread	
	Mean	Deviation	Mean	Deviation
Amazon Web Services	923	7,84	1107	8,42
DigitalOcean	911	8,30	1100	5,70
Exoscale	943	14,96	1801	28,02
Hetzner	762	71,60	1468	151,24
IBM Cloud	505	14,53	997	28,54
Kamatera	546	62,23	1029	134,48
Linode	566	56,30	1074	130,82
OVHcloud	782	10,52	1539	19,94
Oracle Cloud	567	20,69	805	29,07
T-Systems Open Telekom Cloud	667	15,15	1301	52,48
UpCloud	835	50,17	1644	105,17

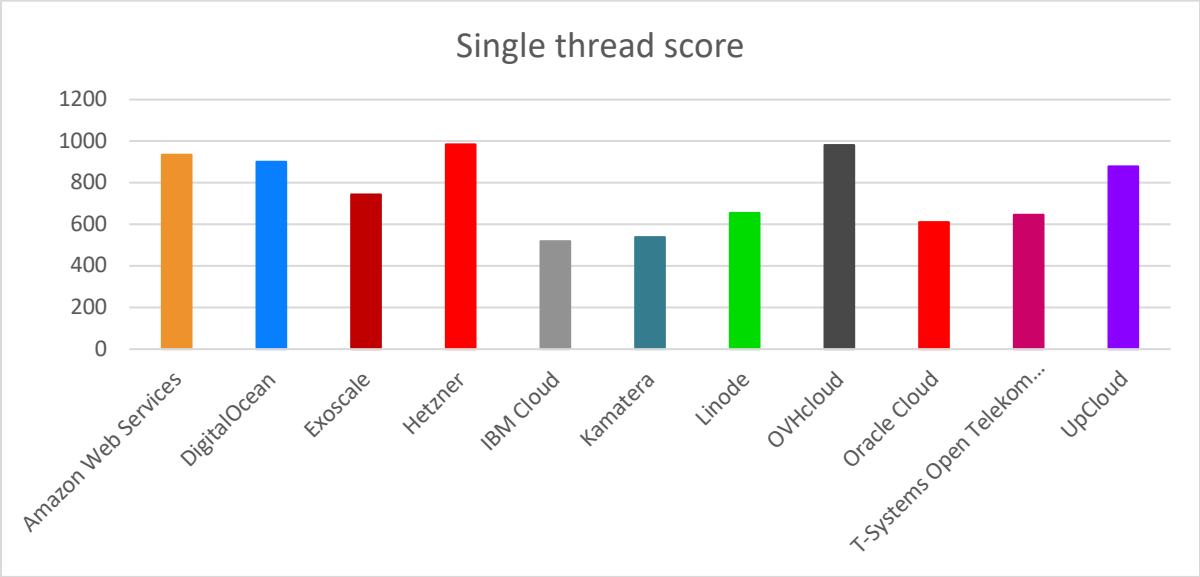
ii. Medium

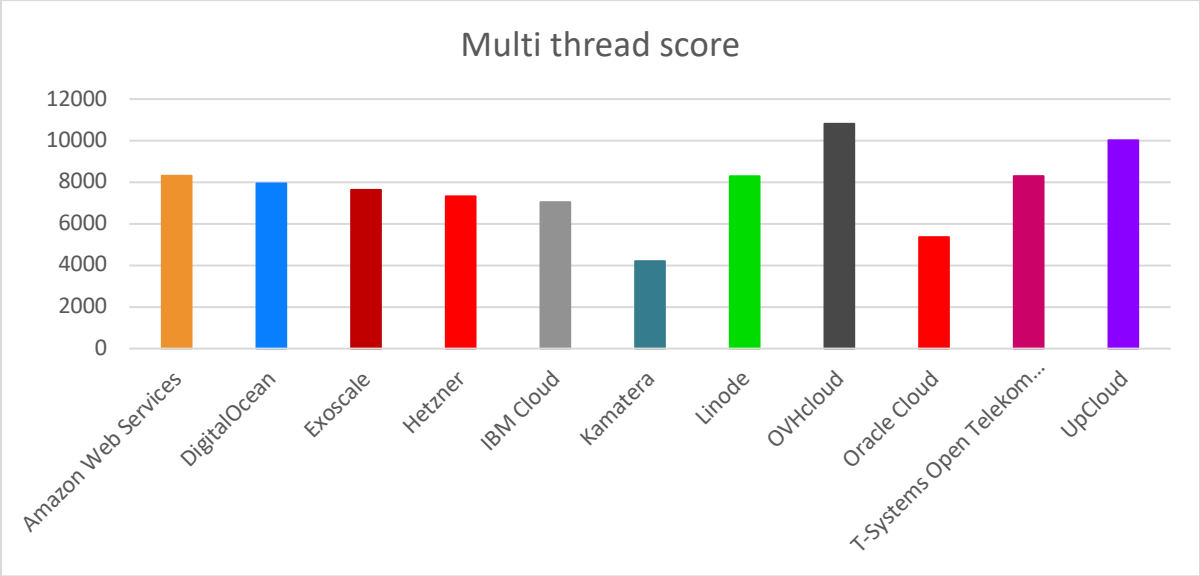




	Single thread		Multi thread	
	Mean	Deviation	Mean	Deviation
Amazon Web Services	913	15,61	2156	25,18
DigitalOcean	909	15,81	2155	24,68
Exoscale	734	13,78	2828	101,64
Hetzner	734	84,21	2601	376,17
IBM Cloud	512	13,68	1960	58,51
Kamatera	534	48,25	1777	238,95
Linode	609	40,56	2199	162,31
OVHcloud	817	87,55	3043	282,32
Oracle Cloud	601	9,27	1561	141,77
T-Systems Open Telekom Cloud	668	9,56	2565	61,83
UpCloud	876	48,28	3243	176,89

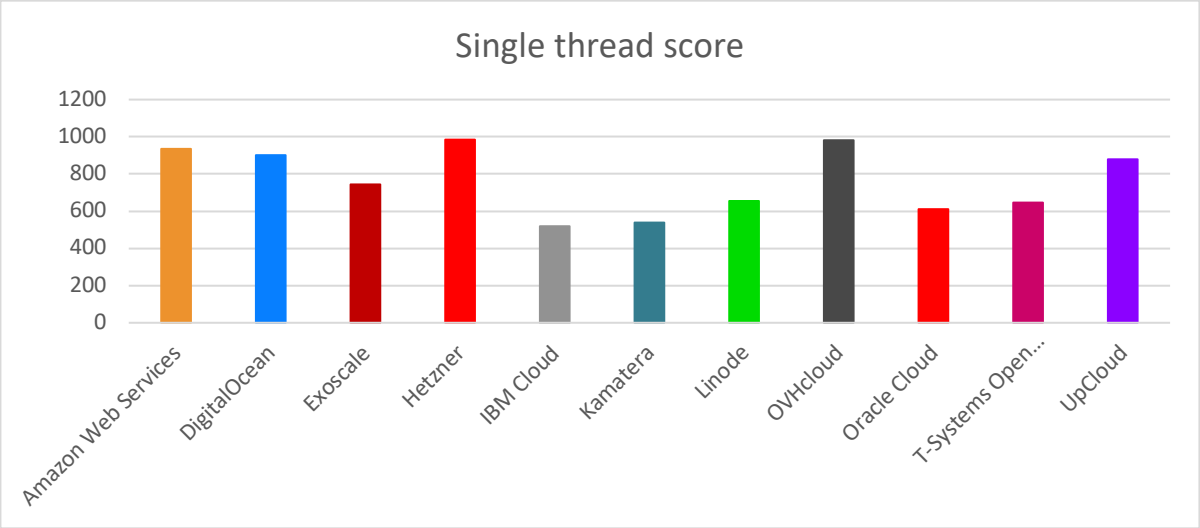
iii. Large

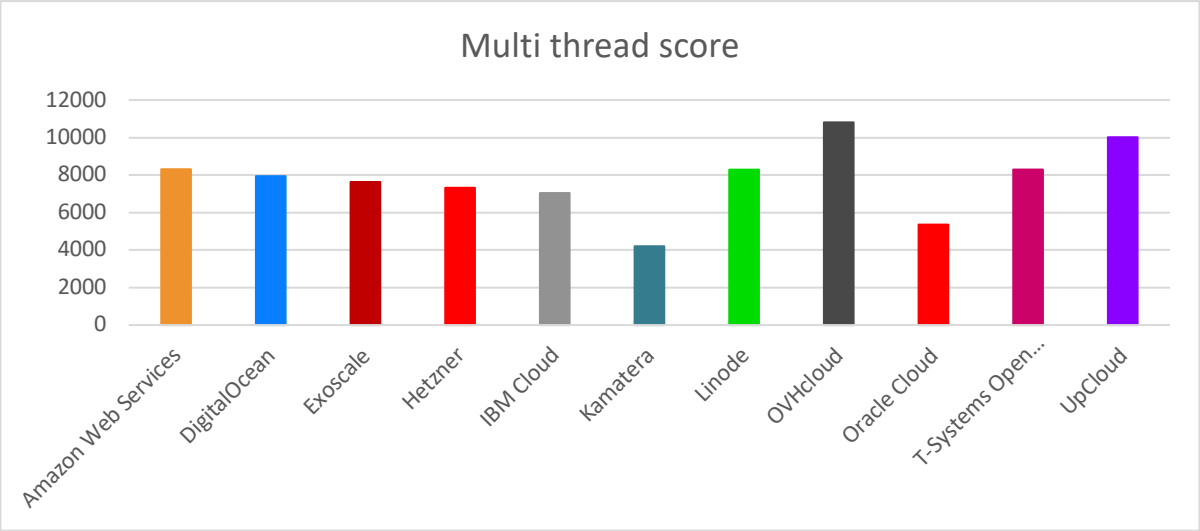




	Single thread		Multi thread	
	Mean	Deviation	Mean	Deviation
Amazon Web Services	933	20,58	4313	110,70
DigitalOcean	911	11,16	4223	19,58
Exoscale	816	72,27	5710	411,47
Hetzner	678	13,79	3792	166,97
IBM Cloud	516	5,15	3815	19,71
Kamatera	536	61,82	2016	659,42
Linode	606	46,62	3500	631,08
OVHcloud	965	24,77	6636	197,11
Oracle Cloud	612	3,27	3037	53,01
T-Systems Open Telekom Cloud	667	13,55	4835	347,44
UpCloud	857	48,56	5849	594,33

iv. Extra Large

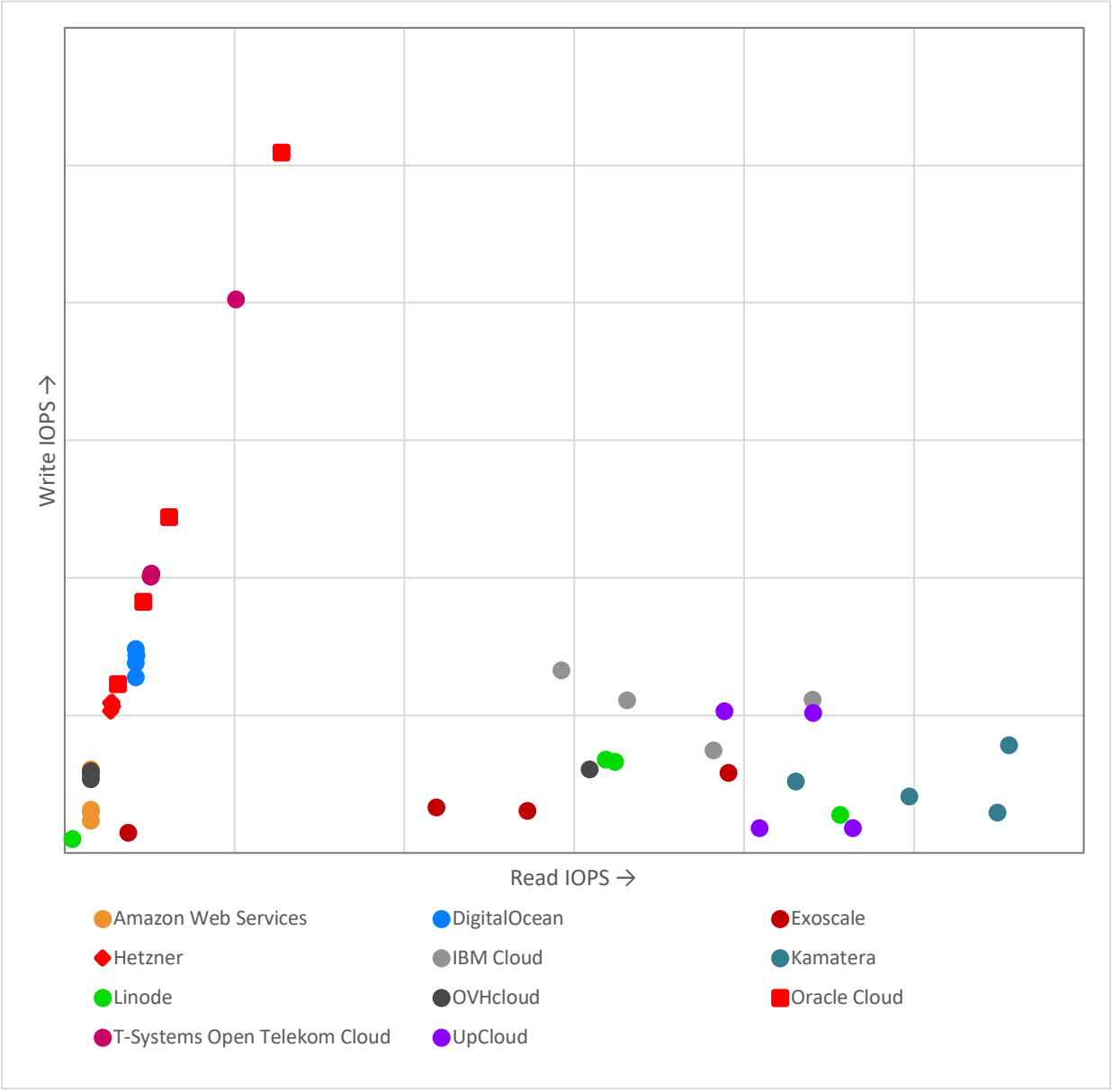




	Single thread		Multi thread	
	Mean	Deviation	Mean	Deviation
Amazon Web Services	935	30,58	8309	271,15
DigitalOcean	901	6,50	7939	86,25
Exoscale	744	26,29	7630	334,16
Hetzner	985	11,98	7320	271,10
IBM Cloud	519	4,37	7040	435,46
Kamatera	539	135,98	4203	1680,75
Linode	655	11,77	8287	682,80
OVHcloud	981	9,62	10809	1154,00
Oracle Cloud	611	3,40	5357	52,71
T-Systems Open Telekom Cloud	646	9,29	8293	349,64
UpCloud	879	30,85	10015	1698,33

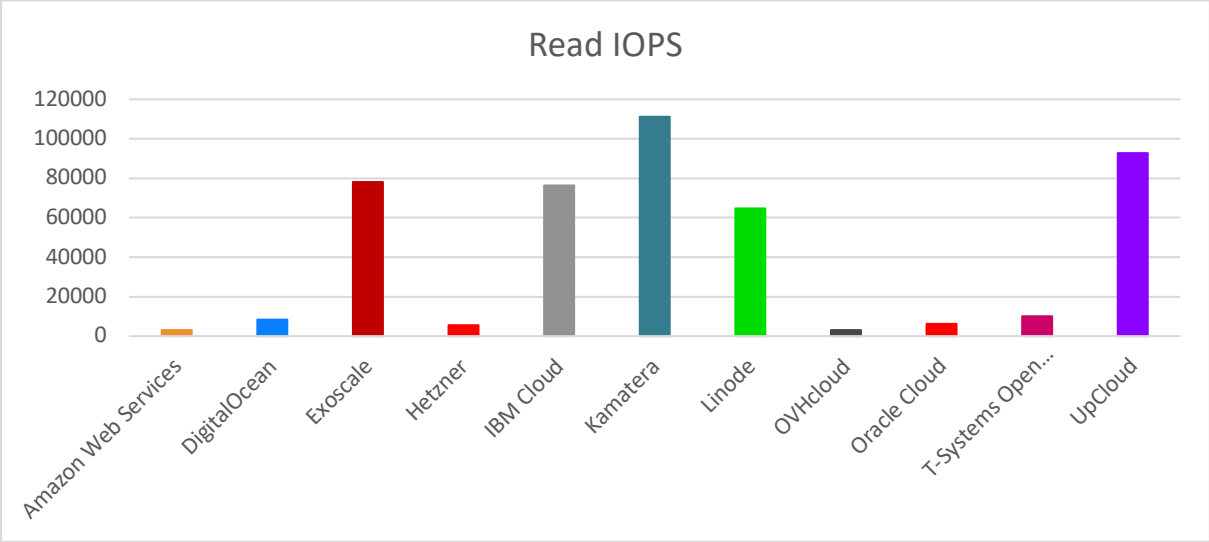
2. Storage IOPS

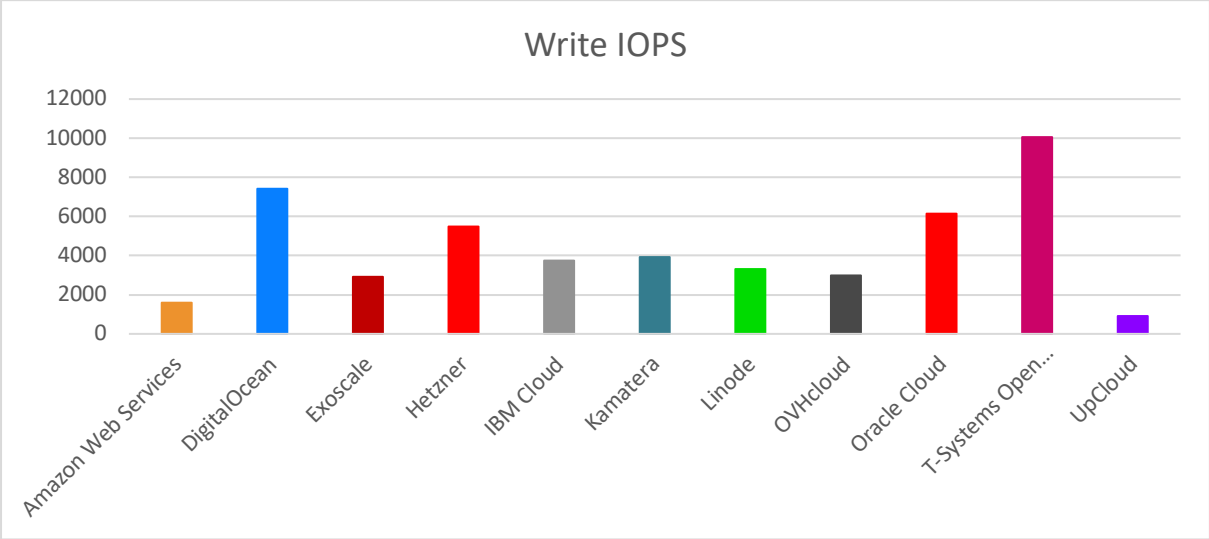
a. Overall



b. By category

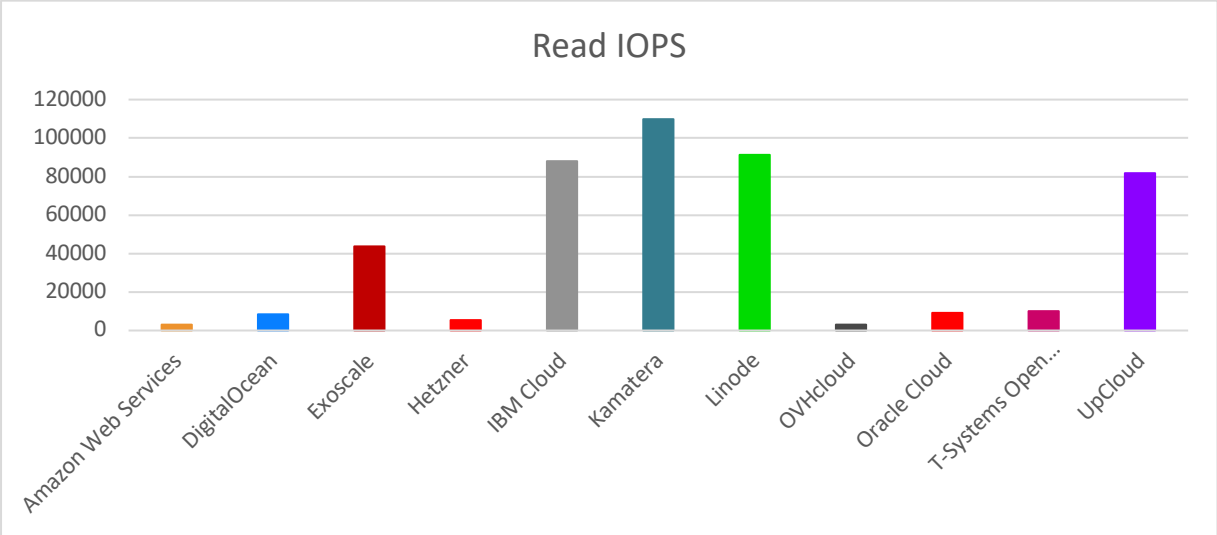
i. Small

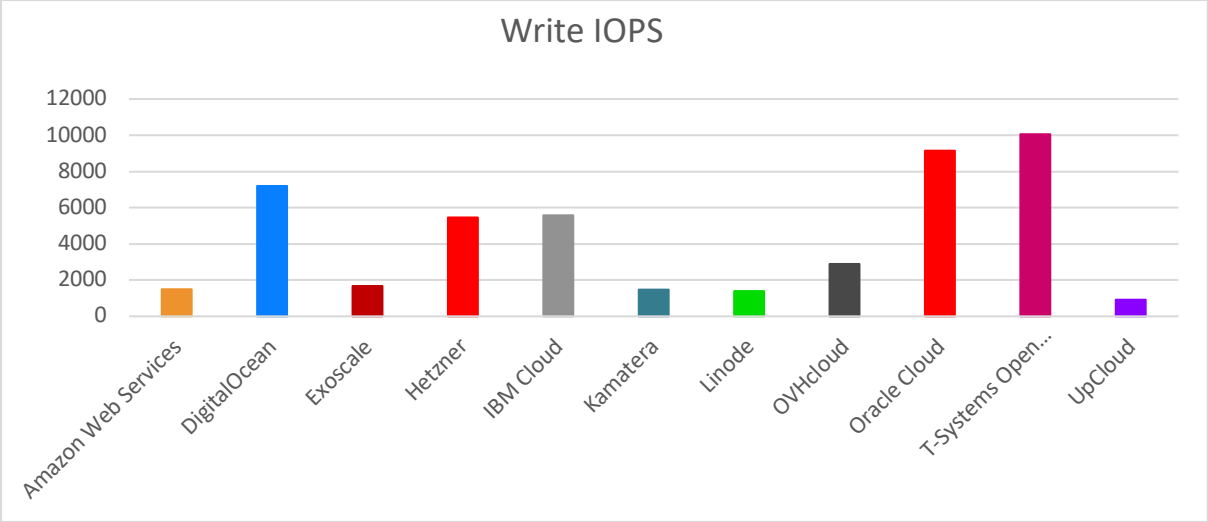




	Read		Write	
	Mean	Deviation	Mean	Deviation
Amazon Web Services	3048	0,71	1593	1351,86
DigitalOcean	8337	885,78	7417	980,71
Exoscale	78085	7147,11	2916	768,12
Hetzner	5527	859,78	5485	794,86
IBM Cloud	76330	7691,95	3745	3046,35
Kamatera	111169	20867,21	3925	2920,50
Linode	64717	20332,51	3312	1640,24
OVHcloud	3055	0,71	2986	90,19
Oracle Cloud	6193	40,99	6144	3,89
T-Systems Open Telekom Cloud	10056	31,59	10056	34,57
UpCloud	92738	25453,72	911	67,66

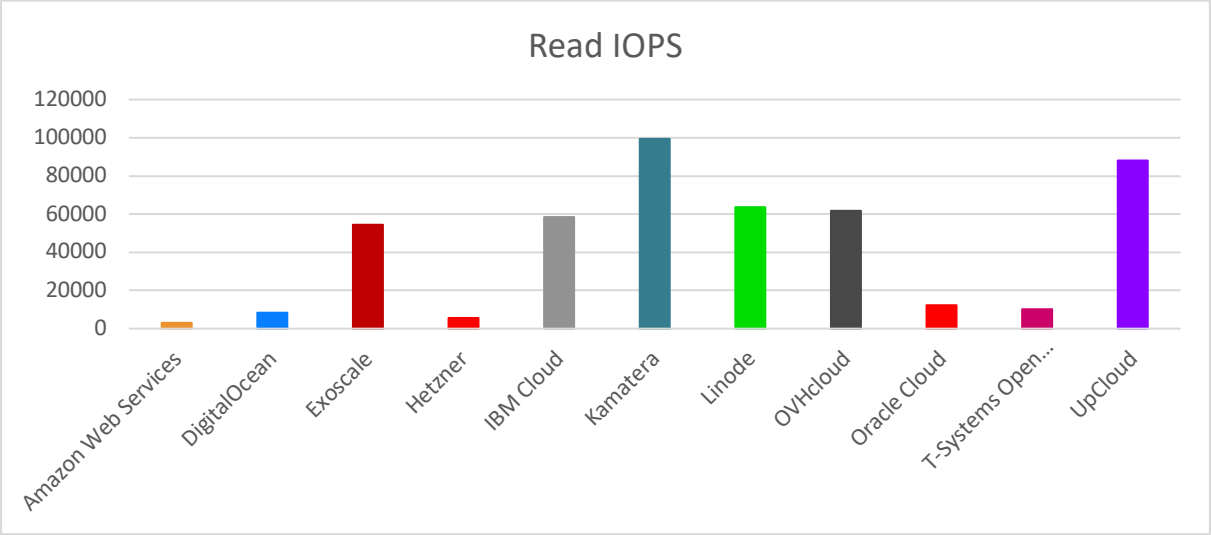
ii. Medium

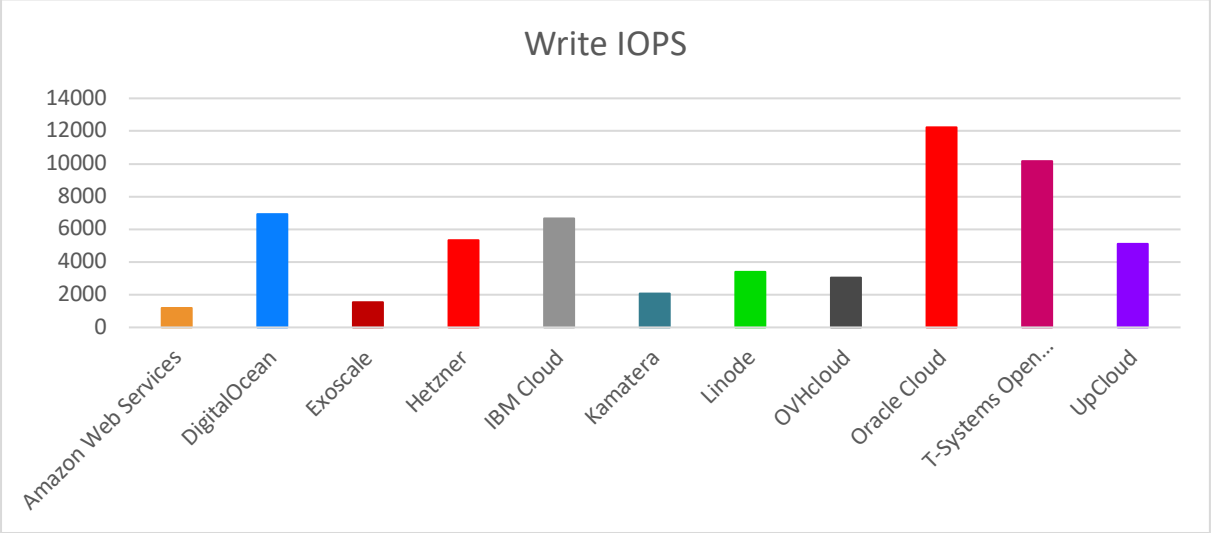




	Read		Write	
	Mean	Deviation	Mean	Deviation
Amazon Web Services	3048	0,71	1496	1229,68
DigitalOcean	8416	949,13	7199	1372,16
Exoscale	43706	4495,20	1674	401,43
Hetzner	5400	723,51	5459	938,71
IBM Cloud	87995	35584,62	5579	2327,64
Kamatera	109819	21406,93	1475	640,64
Linode	91281	9832,33	1394	565,18
OVHcloud	3055	0,71	2892	327,64
Oracle Cloud	9166	53,90	9147	8,60
T-Systems Open Telekom Cloud	10054	18,21	10056	28,27
UpCloud	81756	25624,58	918	36,18

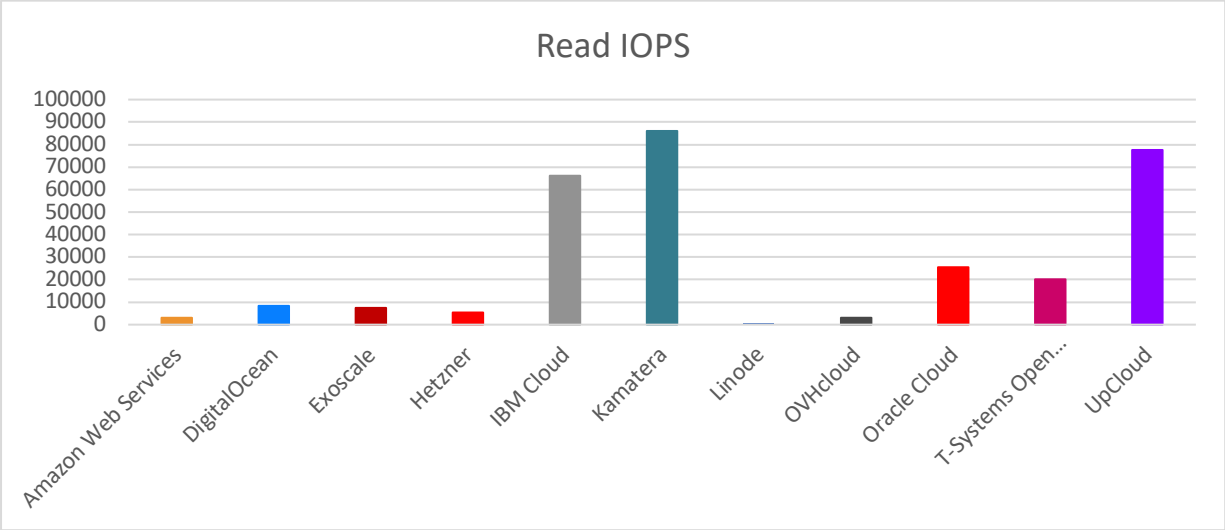
iii. Large

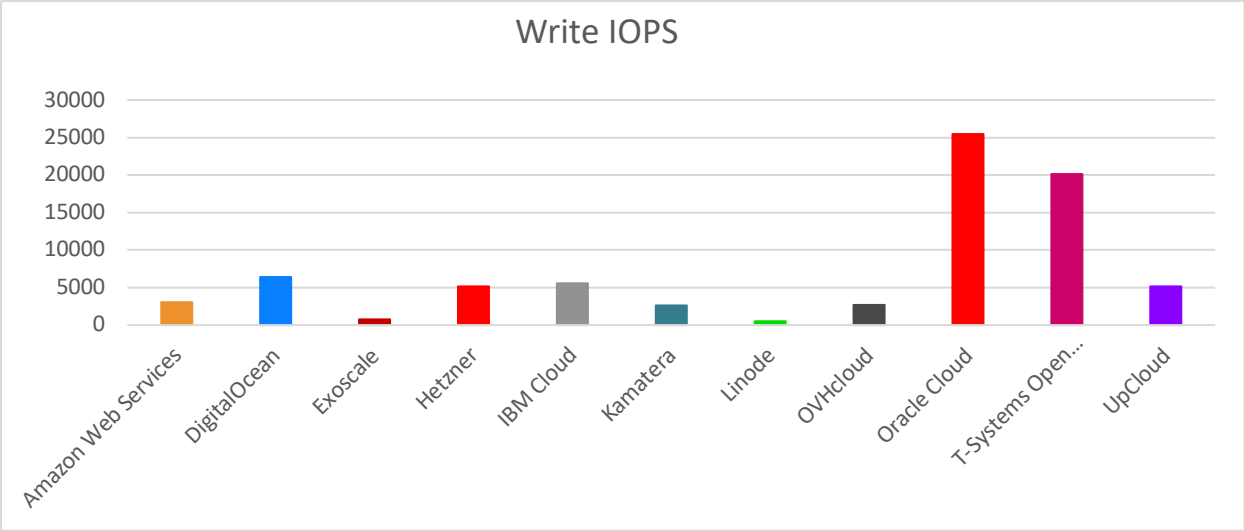




	Read		Write	
	Mean	Deviation	Mean	Deviation
Amazon Web Services	3048	0,71	1186	932,93
DigitalOcean	8344	894,65	6922	1559,57
Exoscale	54429	7895,09	1538	833,69
Hetzner	5590	888,85	5329	1130,66
IBM Cloud	58454	37625,61	6659	2872,83
Kamatera	99432	16158,74	2068	1281,16
Linode	63633	11722,60	3395	899,65
OVHcloud	61736	22906,86	3042	152,39
Oracle Cloud	12255	76,21	12228	10,28
T-Systems Open Telekom Cloud	10169	24,23	10161	17,71
UpCloud	88081	28591,25	5105	171,11

iv. Extra Large

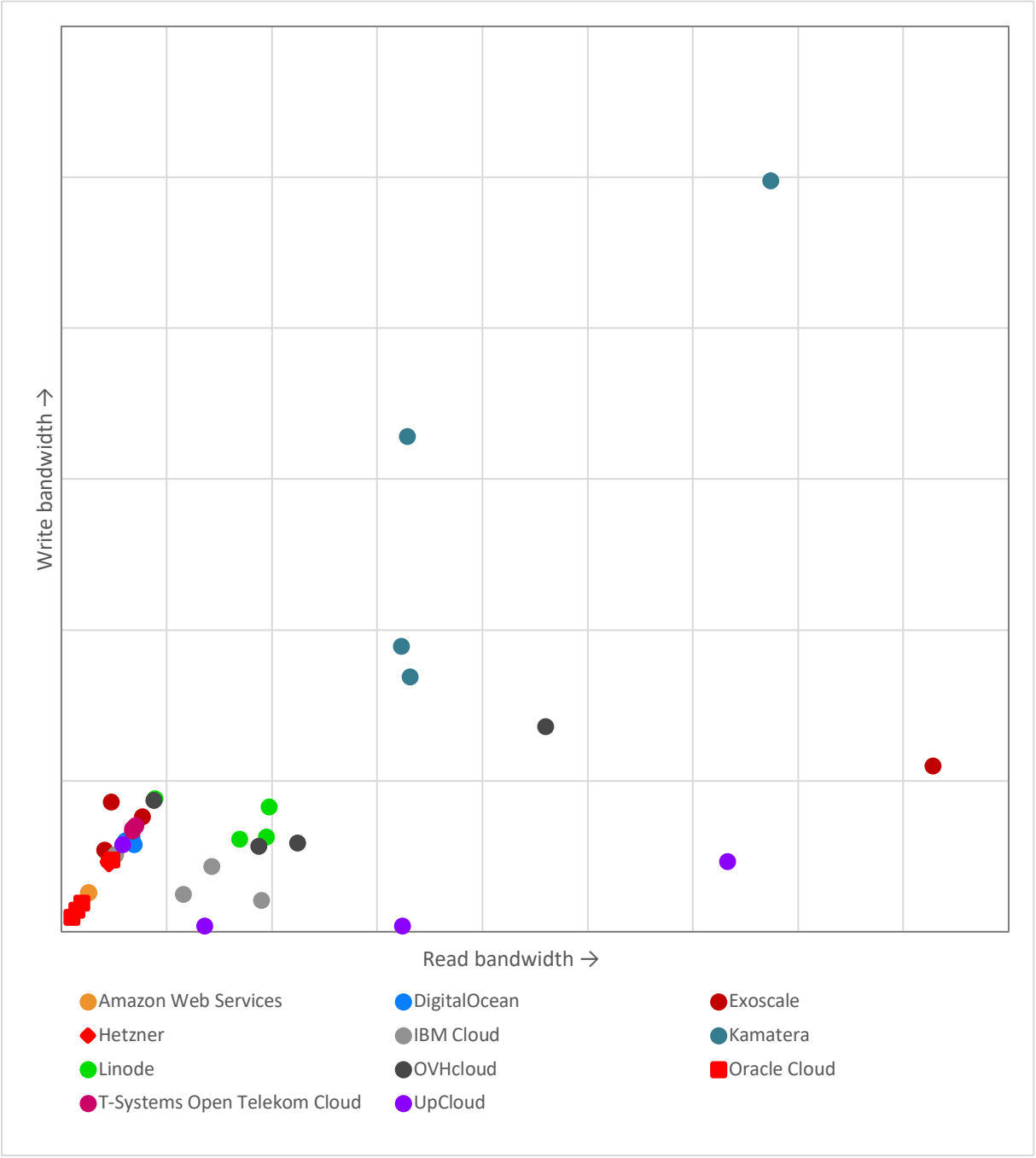




	Read		Write	
	Mean	Deviation	Mean	Deviation
Amazon Web Services	3048	0,71	3047	0,71
DigitalOcean	8341	1000,86	6405	2130,00
Exoscale	7439	1142,96	755	132,68
Hetzner	5386	704,84	5155	1370,54
IBM Cloud	66163	49791,17	5572	3253,84
Kamatera	86058	37473,57	2615	1427,07
Linode	865	448,97	508	8,49
OVHcloud	3054	1,52	2685	629,25
Oracle Cloud	25503	201,13	25466	69,01
T-Systems Open Telekom Cloud	20139	39,00	20130	20,61
UpCloud	77611	21302,15	5156	149,04

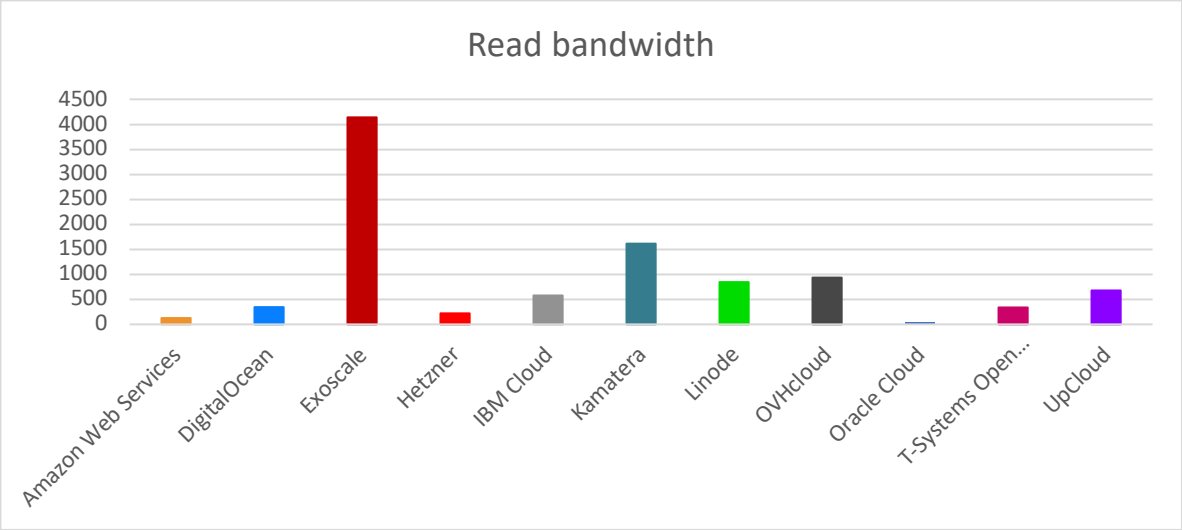
3. Storage Bandwidth

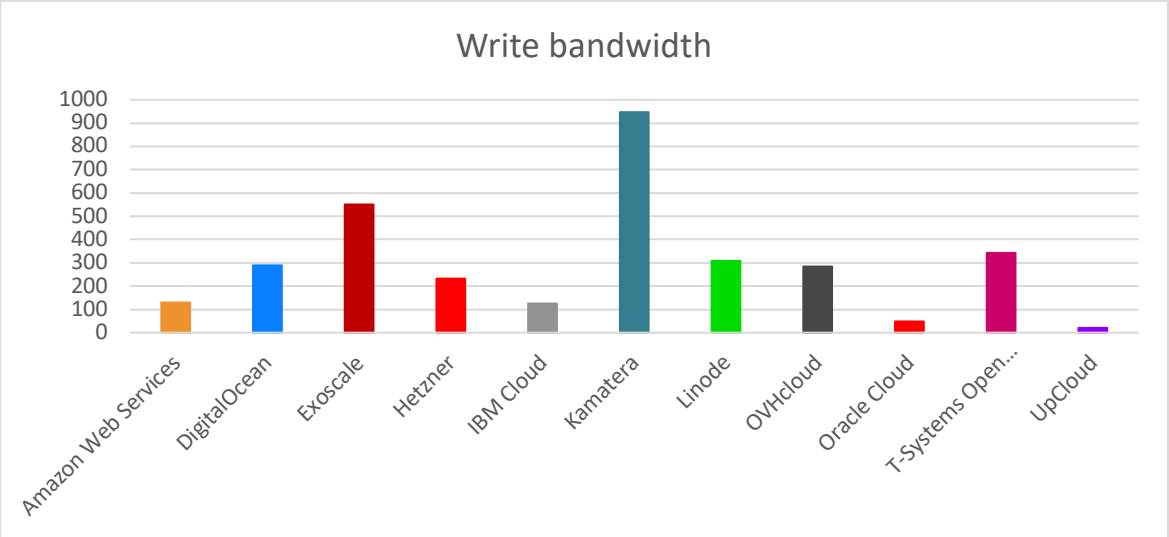
a. Overall



b. By category

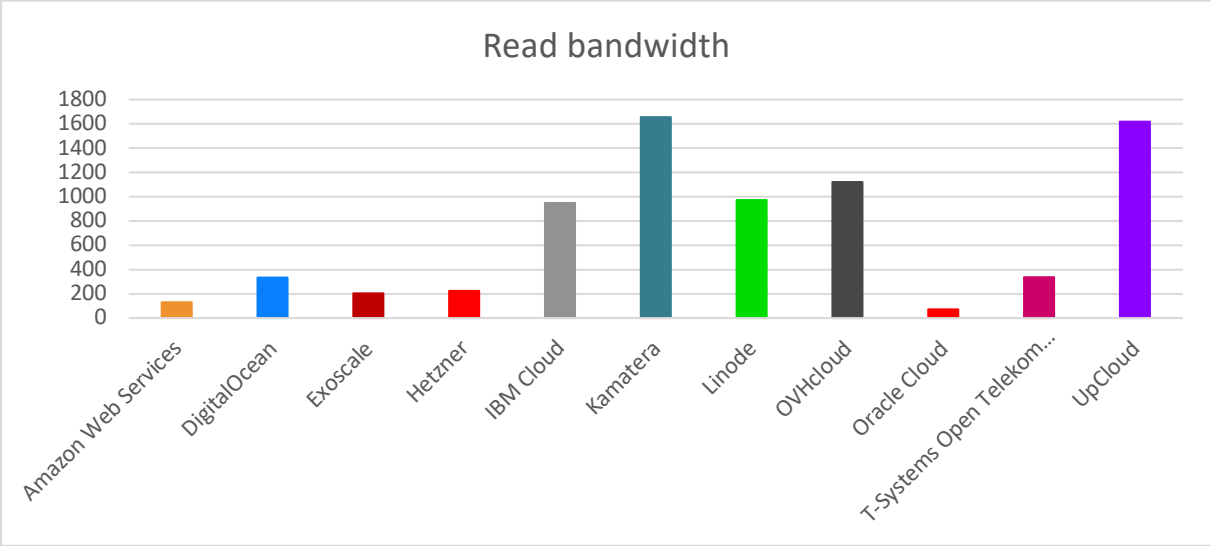
i. Small

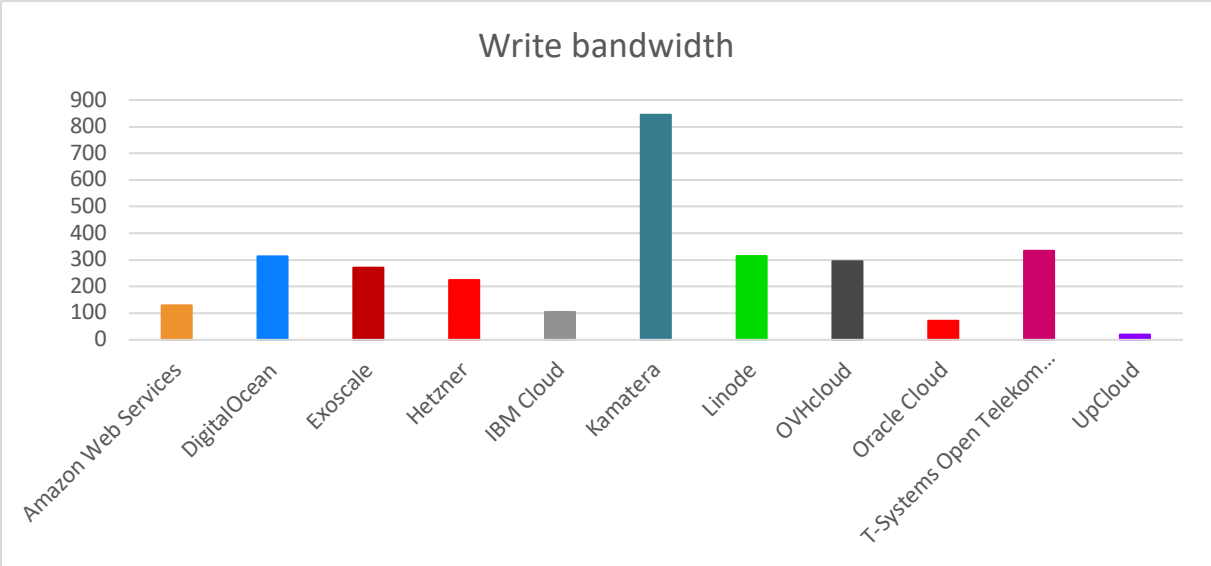




	Read Mean	Deviation	Write Mean	Deviation
Amazon Web Services	126,2	4,99	129,5	0,71
DigitalOcean	344,8	56,33	288,9	36,45
Exoscale	4139,1	221,17	550,2	76,90
Hetzner	220,1	30,21	232	39,42
IBM Cloud	577,3	185,24	125,2	49,71
Kamatera	1614	2246,12	946,7	1057,93
Linode	844,7	167,71	307,9	80,13
OVHcloud	935,1	102,76	283,9	70,39
Oracle Cloud	48	0,00	48	0,00
T-Systems Open Telekom Cloud	337,6	12,67	342,4	9,41
UpCloud	677,8	119,88	20,5	3,61

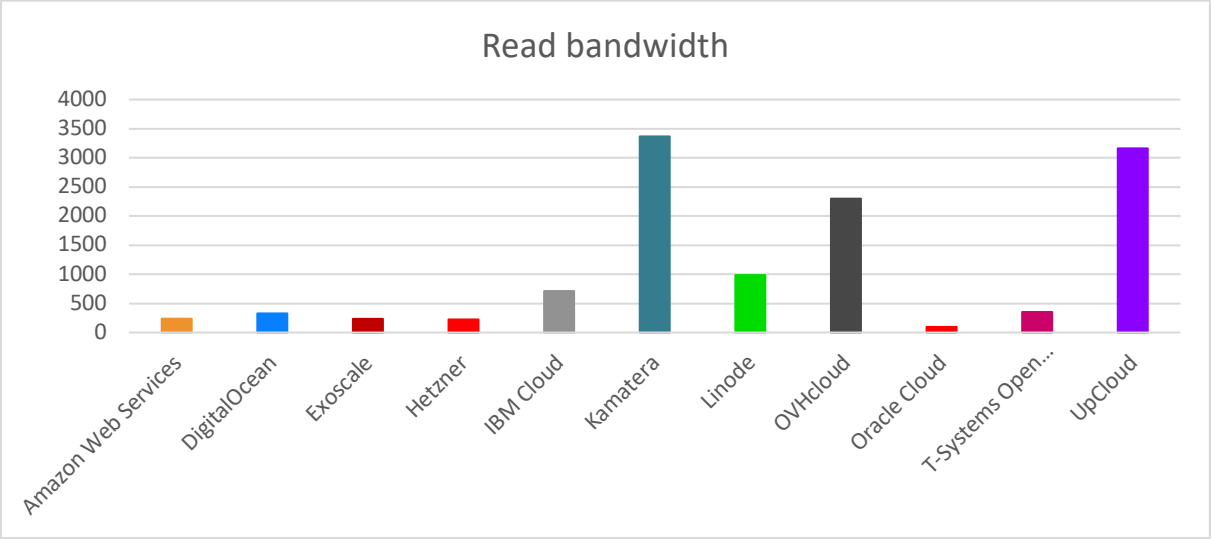
ii. Medium

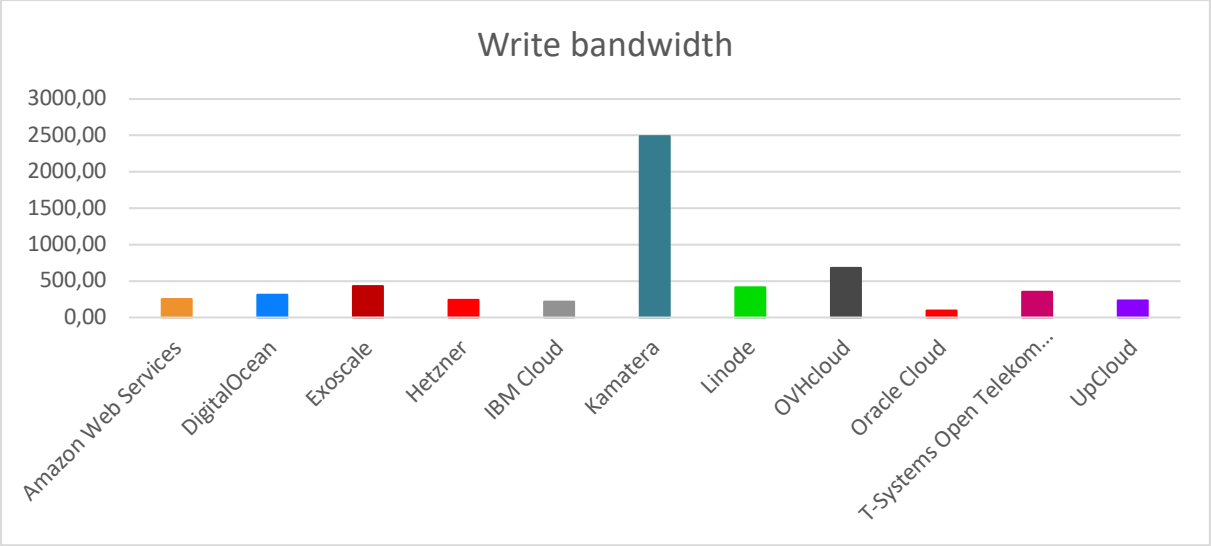




	Read		Write	
	Mean	Deviation	Mean	Deviation
Amazon Web Services	130	0,00	129,5	0,72
DigitalOcean	333,6	41,68	313,3	17,69
Exoscale	203,5	12,57	270,8	11,61
Hetzner	223,6	37,53	224,2	38,41
IBM Cloud	947,8	202,72	104,5	13,44
Kamatera	1655,3	178,32	844,7	285,45
Linode	972,1	36,91	314,5	38,52
OVHcloud	1120,8	82,19	294,9	61,02
Oracle Cloud	71,5	0,71	71,5	0,71
T-Systems Open Telekom Cloud	336,4	11,08	334,1	12,45
UpCloud	1618,2	71,27	19,6	3,19

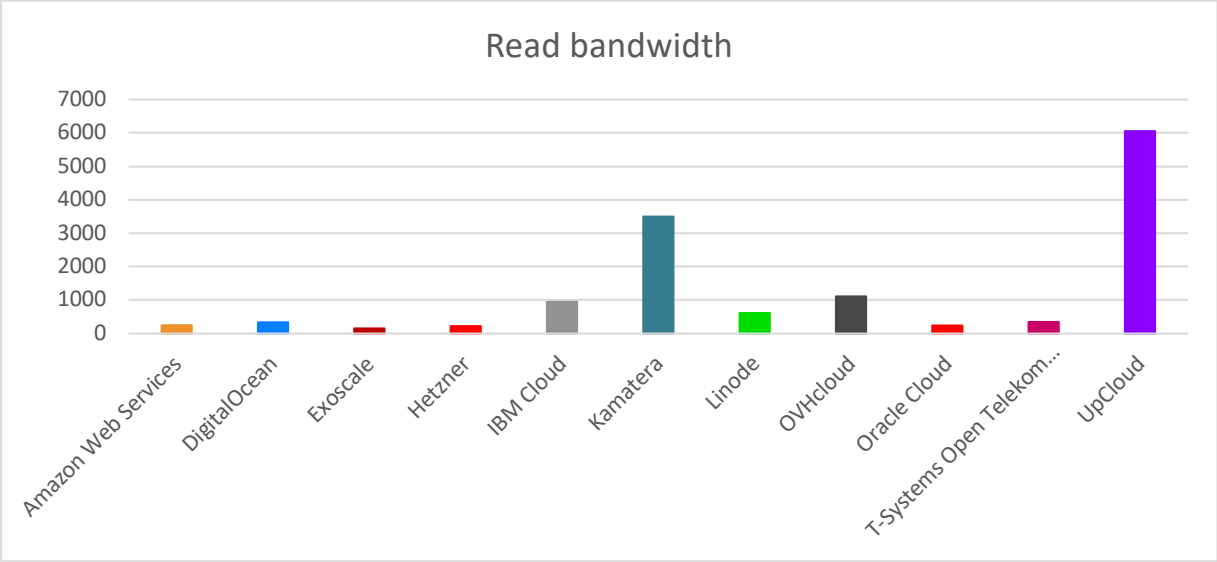
iii. Large

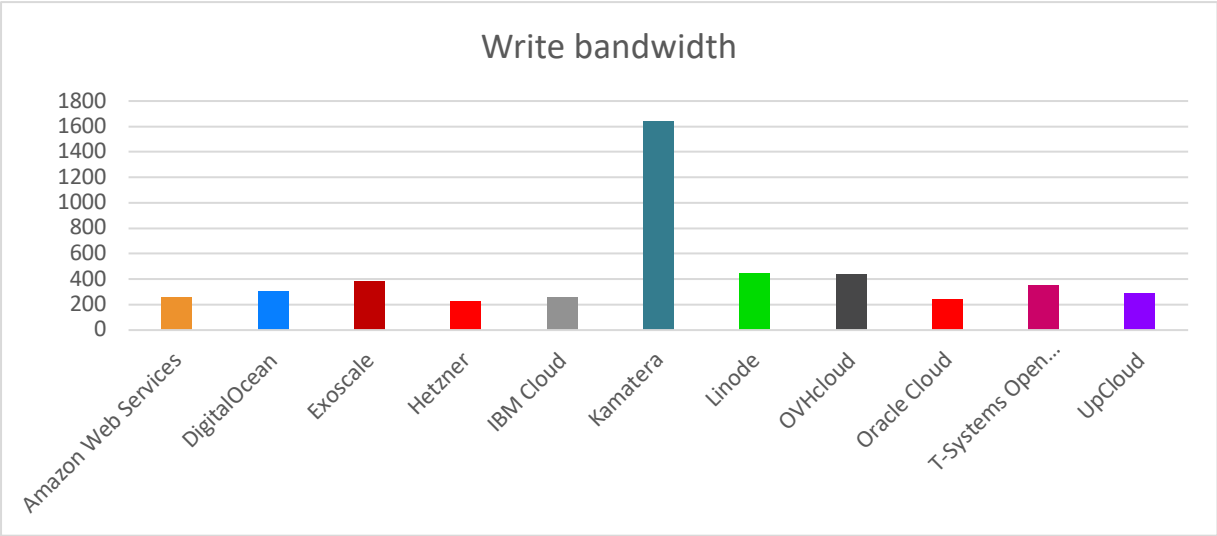




	Read Mean	Deviation	Write Mean	Deviation
Amazon Web Services	236,7	13,48	253,5	0,71
DigitalOcean	327,8	37,48	312,6	34,72
Exoscale	234,2	21,04	431	142,47
Hetzner	224	37,41	242,1	39,56
IBM Cloud	712	298,69	217,9	111,96
Kamatera	3367,6	1689,38	2489	988,89
Linode	985,7	13,57	414,6	41,08
OVHcloud	2298,7	1253,17	681,1	112,97
Oracle Cloud	95,5	0,70	95,5	0,71
T-Systems Open Telekom Cloud	352	1,58	353	1,58
UpCloud	3162,4	256,67	234	45,94

iv. Extra Large





	Read		Write	
	Mean	Deviation	Mean	Deviation
Amazon Web Services	248,8	3,79	254	0,00
DigitalOcean	336,4	63,52	301,5	24,36
Exoscale	152,8	12,85	382,1	92,39
Hetzner	221,8	38,47	226,4	39,23
IBM Cloud	946,6	286,58	256,3	132,06
Kamatera	3499,9	446,74	1642,1	254,38
Linode	613,2	204,92	441,7	58,09
OVHcloud	1111,6	44,98	437,2	92,89
Oracle Cloud	240,00	0,00	239	1,07
T-Systems Open Telekom Cloud	346,7	5,93	349,2	5,23
UpCloud	6056,5	663,75	290,5	27,33

VI. Pricing

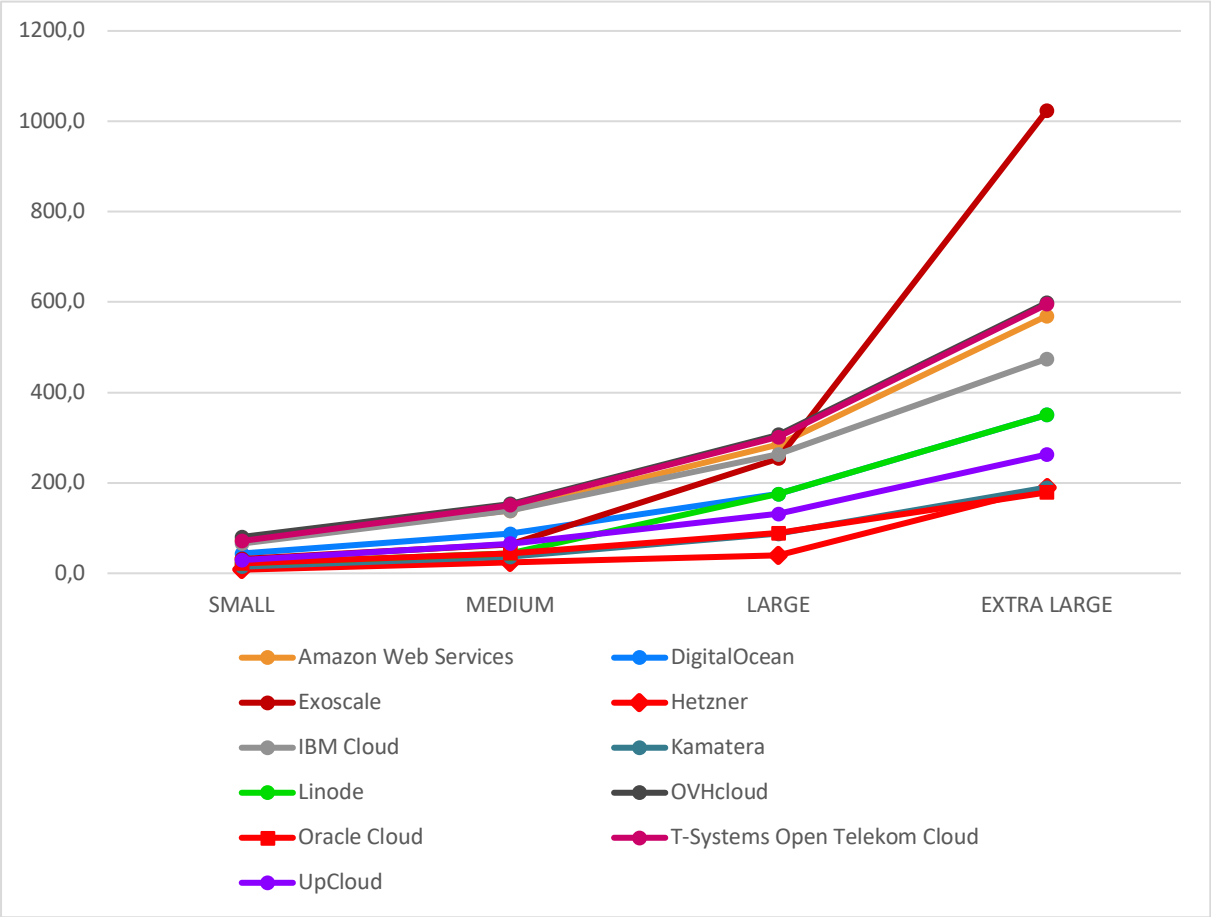
In comparison of similar products, price is one of the main metrics differentiating the value of an offer. Like performance, pricing is unequal across providers, we can observe a large gap between the smaller price and the most expensive virtual machine. Same thing for volume, where block storage varies from the most competitive to the less affordable pricing.

This section summarizes the cost of VMs and block storage for all products studied in the document.

To improve readability and give a better understanding of presented data, we convert hourly pricing into a monthly one by multiplying by 730. Vendors may apply custom discount after a long-term usage or for a monthly billing, this is not reflected in this document.

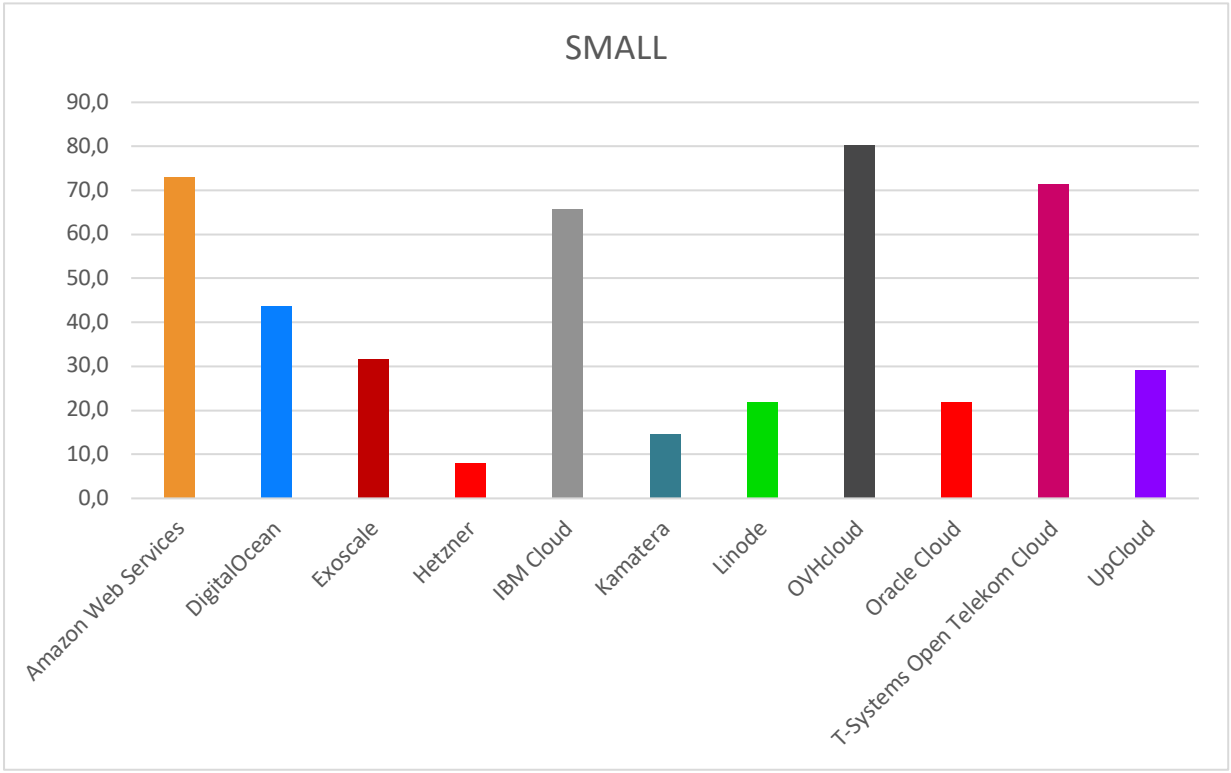
1. Virtual machines

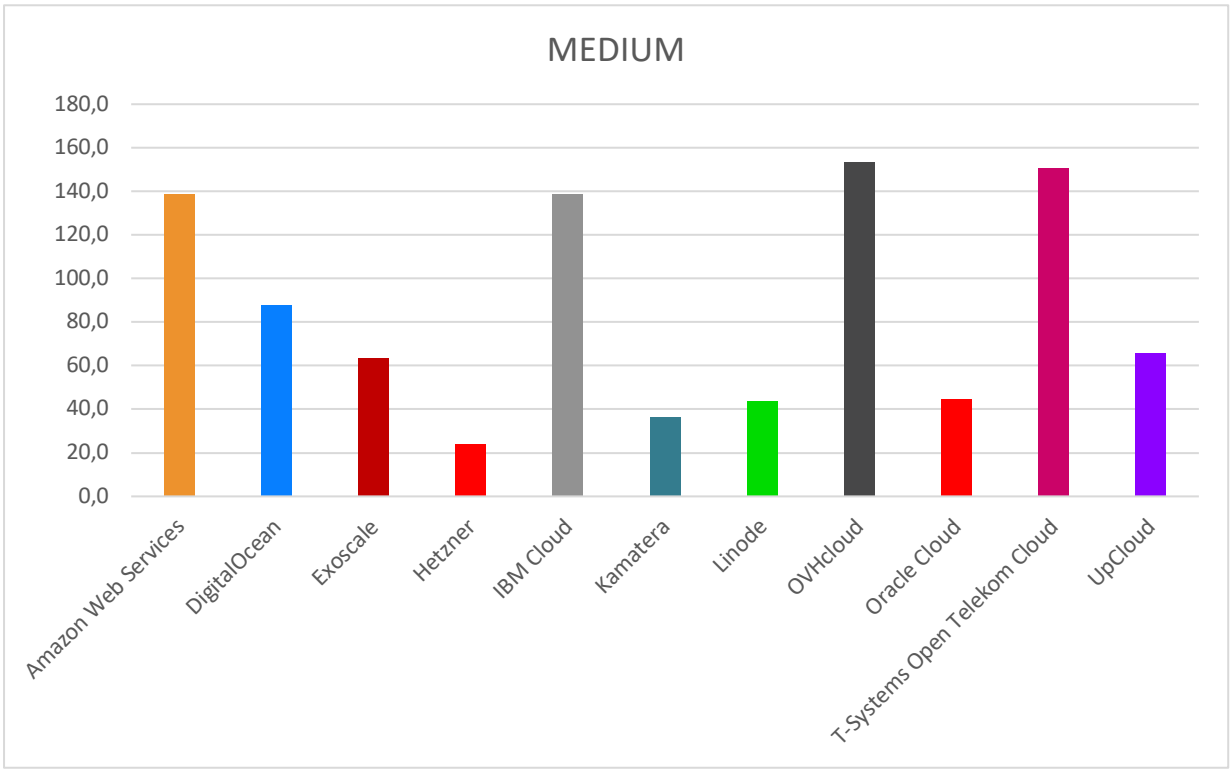
a. Overall

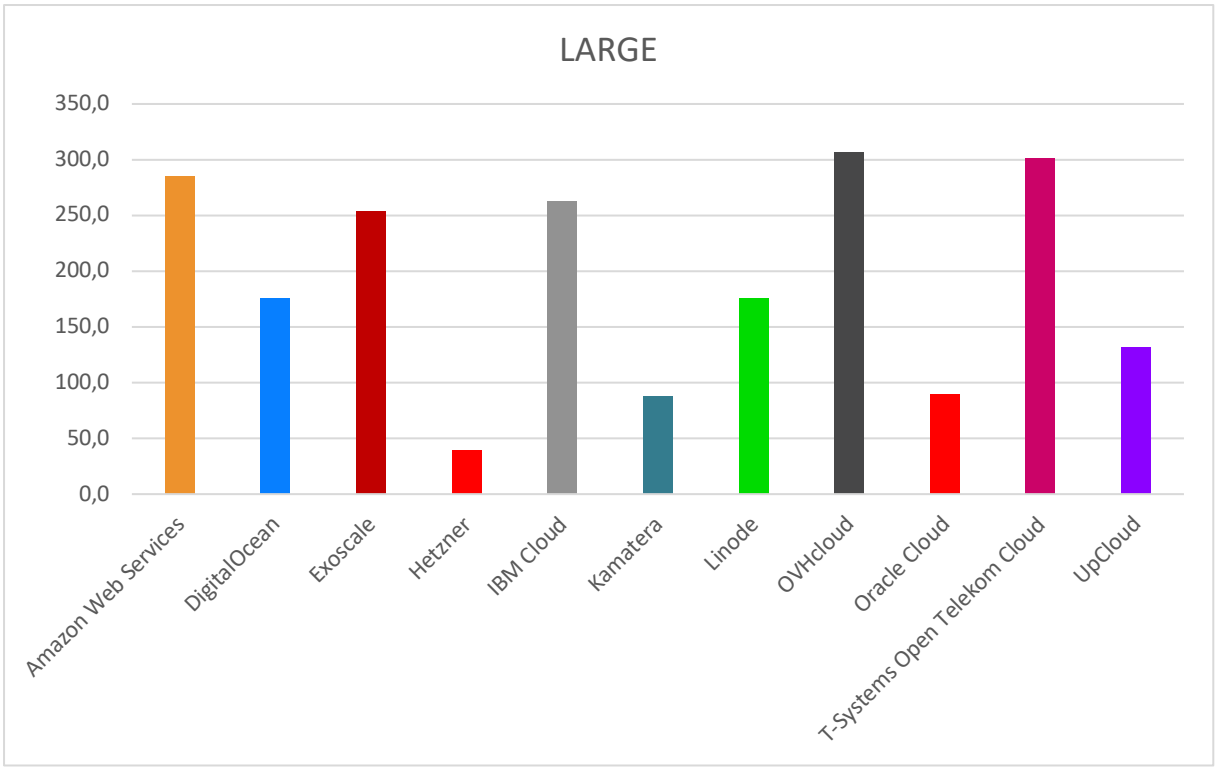


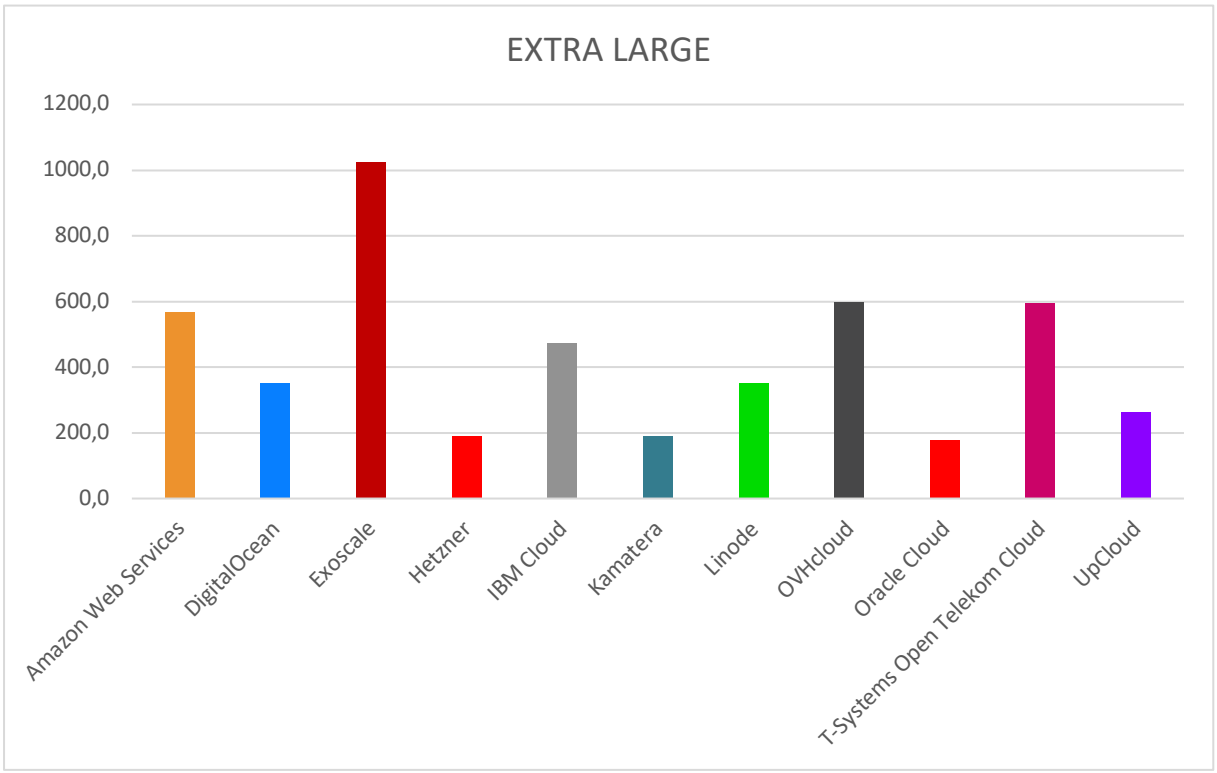
	SMALL	MEDIUM	LARGE	EXTRA LARGE
Amazon Web Services	73,0	138,7	284,7	569,4
DigitalOcean	43,8	87,6	175,2	350,4
Exoscale	31,7	63,5	253,9	1023,4
Hetzner	7,9	23,8	39,7	190,4
IBM Cloud	65,7	138,7	262,8	474,5
Kamatera	14,6	36,5	87,6	189,8
Linode	21,9	43,8	175,2	350,4
OVHcloud	80,3	153,3	306,6	598,6
Oracle Cloud	21,9	44,5	89,1	178,9
T-Systems Open Telekom Cloud	71,4	150,7	301,5	595,0
UpCloud	29,2	65,7	131,4	262,8

b. By category

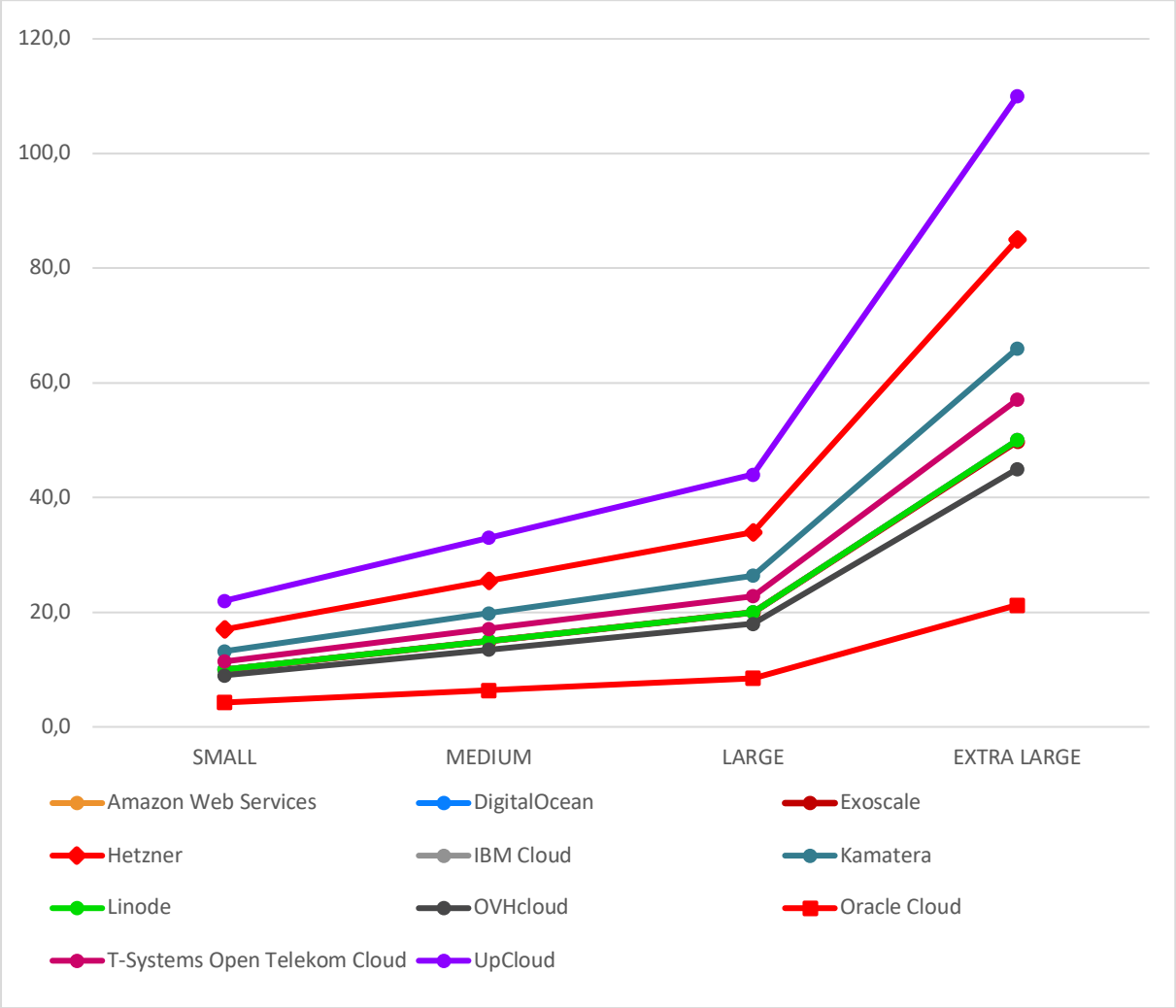





LARGE
350,0
300,0
250,0
200,0
150,0
100,0
50,0
0,0
Amazon Web Services
DigitalOcean
Exoscale
Hetzner
IBM Cloud
Kamatera
Linode
OVHcloud
Oracle Cloud
T-Systems Open Telekom Cloud
UpCloud


EXTRA LARGE
1200,0
1000,0
800,0
600,0
400,0
200,0
0,0
Amazon Web Services
DigitalOcean
Exoscale
Hetzner
IBM Cloud
Kamatera
Linode
OVHcloud
Oracle Cloud
T-Systems Open Telekom Cloud
UpCloud

2. Storage



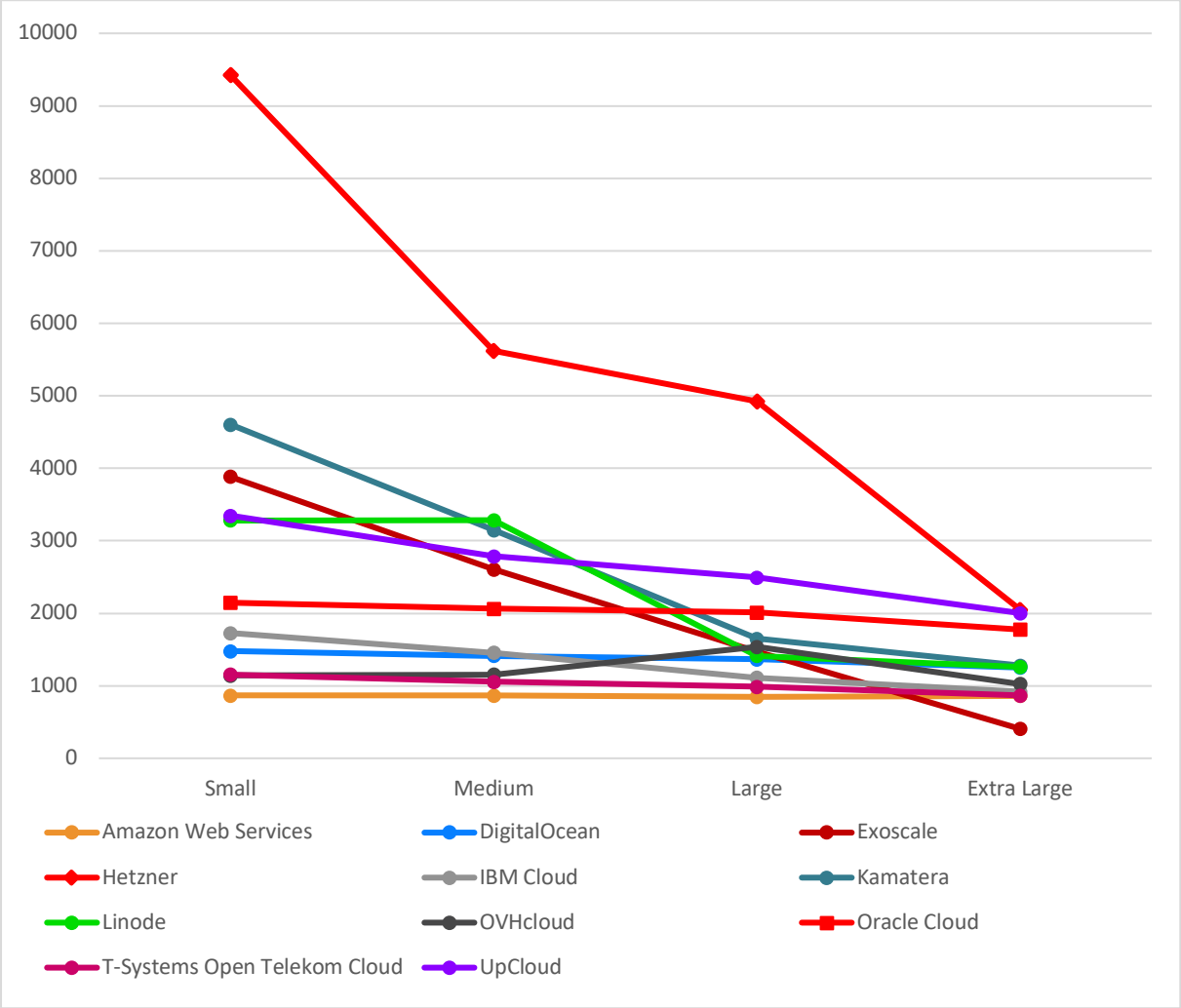
	SMALL	MEDIUM	LARGE	EXTRA LARGE
Amazon Web Services	10,0	15,0	20,0	50,0
DigitalOcean	10,0	15,0	20,0	50,0
Exoscale	10,0	14,9	19,9	49,8
Hetzner	17,0	25,5	34,0	85,0
IBM Cloud	10,0	15,0	20,0	50,0
Kamatera	13,2	19,8	26,4	66,0
Linode	10,0	15,0	20,0	50,0
OVHcloud	9,0	13,5	18,0	45,0
Oracle Cloud	4,3	6,4	8,5	21,3
T-Systems Open Telekom Cloud	11,4	17,1	22,8	57,1
UpCloud	22,0	33,0	44,0	110,0

VII. Price/Performance value

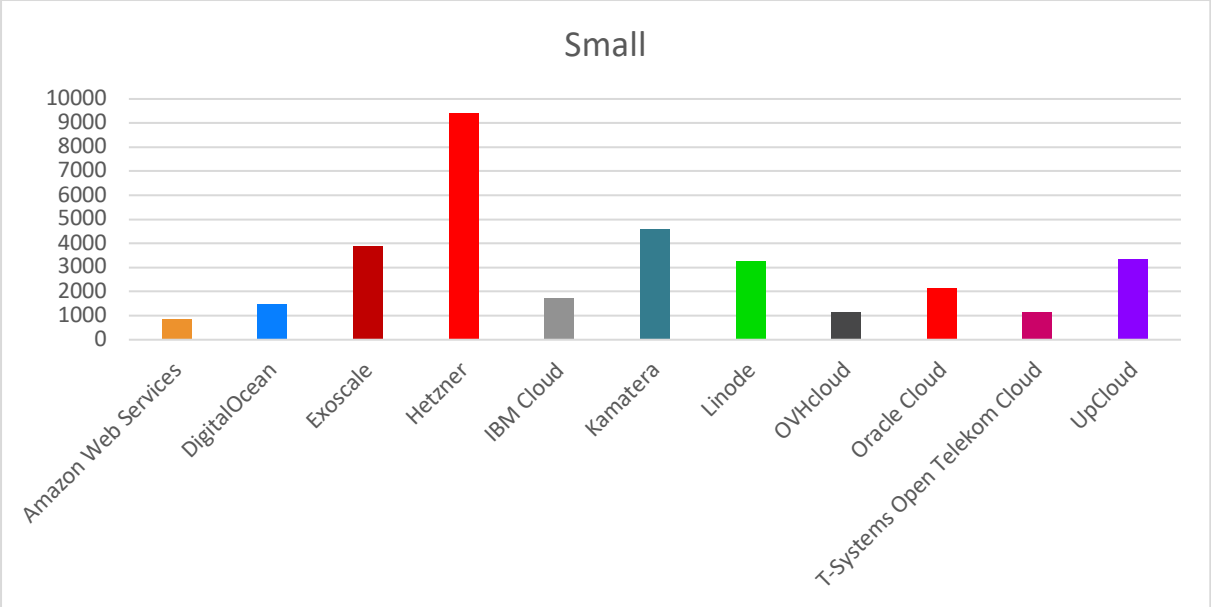
Consumers tend to search costs that match their budget but as seen in Performance section, a gap of 4x exists between the least and the best performer. Across providers, there's no correlation between performance and price, consumers cannot expect to behave the instinctive way where he/she pays more to obtain better. Moreover, compute and storage can draw a completely different profile.

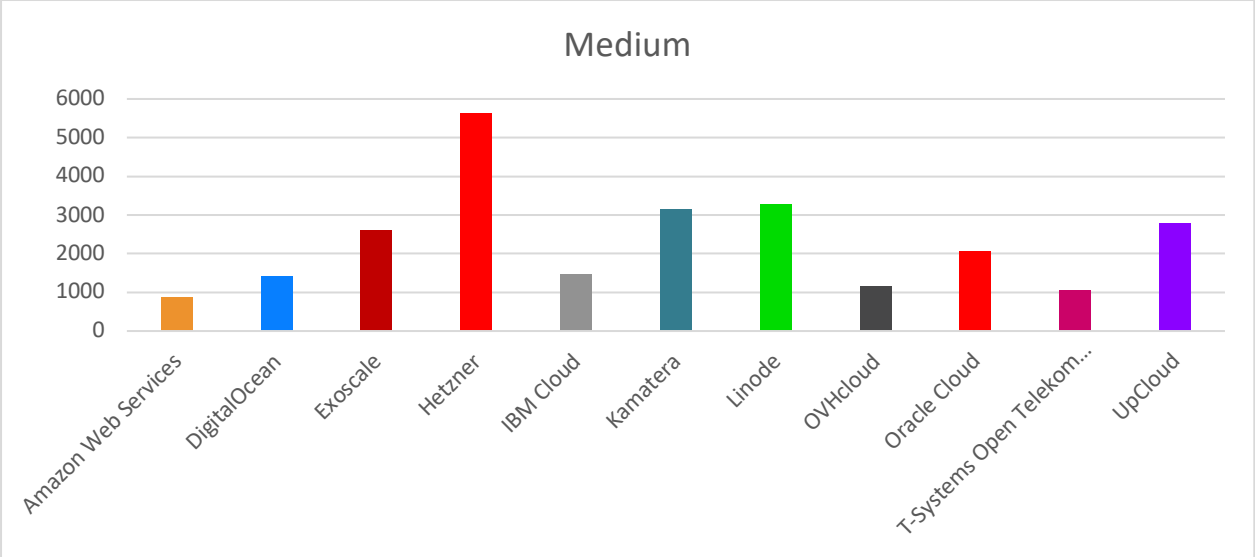
This section outlines price/performance ratio for each category. It concludes this analysis by providing high-level scores aggregating metrics with values representing the best effort by dollar spent.

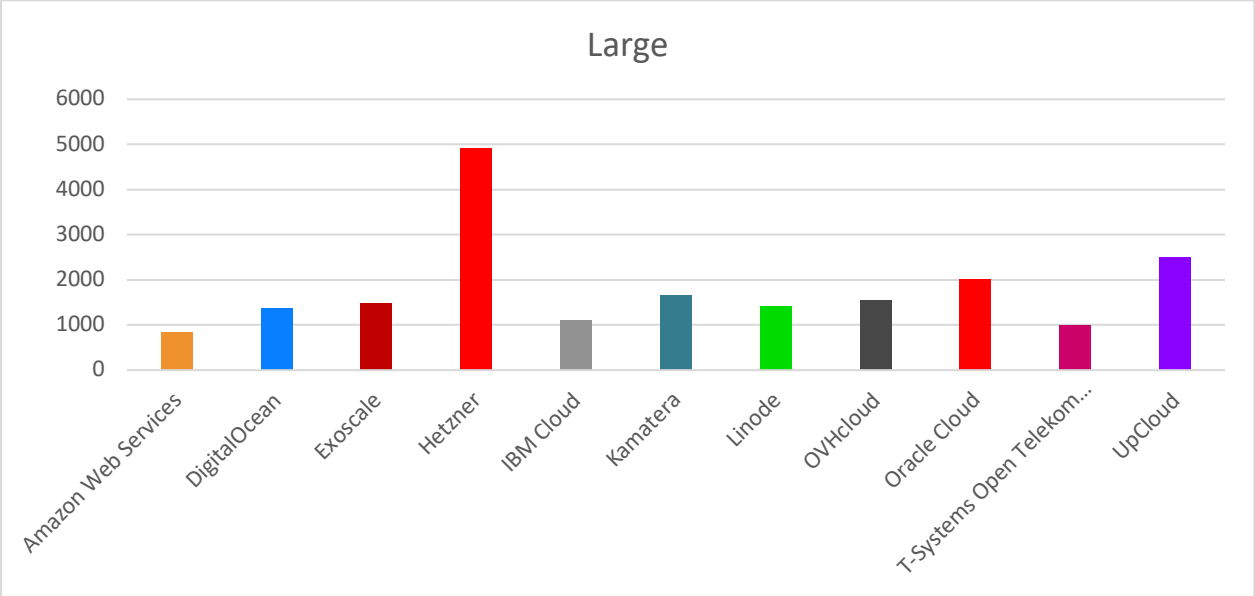
1. Overall

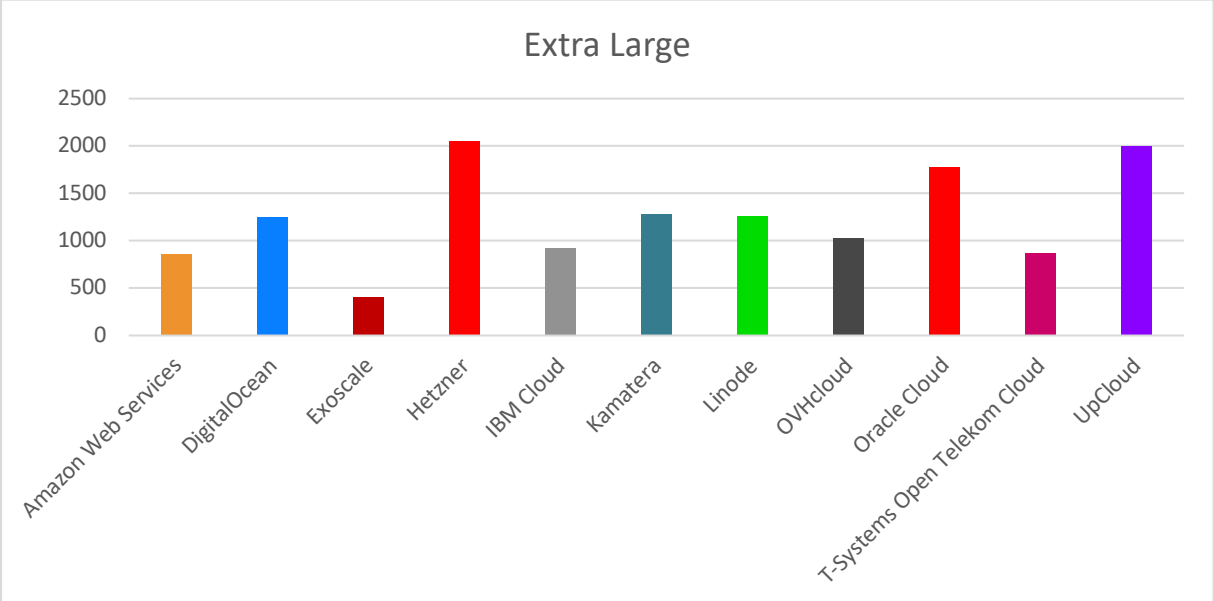


2. By category




Medium
6000
5000
4000
3000
2000
1000
0
Amazon Web Services
DigitalOcean
Exoscale
Hetzner
IBM Cloud
Kamatera
Linode
OVHcloud
Oracle Cloud
T-Systems Open Telekom...
UpCloud


Large
6000
5000
4000
3000
2000
1000
0
Amazon Web Services
DigitalOcean
Exoscale
Hetzner
IBM Cloud
Kamatera
Linode
OVHcloud
Oracle Cloud
T-Systems Open Telekom...
UpCloud


Extra Large
2500
2000
1500
1000
500
0
Amazon Web Services
DigitalOcean
Exoscale
Hetzner
IBM Cloud
Kamatera
Linode
OVHcloud
Oracle Cloud
T-Systems Open Telekom Cloud
UpCloud

VIII. About Cloud Mercato

Cloud Mercato is a research and consultancy firm dedicated to study of cloud market. We are a team expert working in cloud benchmark since 2013 helped by our automated software which actively collect and monitor key metrics for all kind of products in the cloud industry. Our neutral and objective approach helps customer to get better insights on their possibilities and vendors to know how to place and compete between all these innumerable services.

For any inquiries about our services, question about this report or any custom request, please contact Cloud Mercato at contact@cloud-mercato.com.

cloud-mercato.com

If you are a Cloud Service Provider and you are interested to be included in our research and documents, do not hesitate to contact us.

i. Appendix

1. Server specifications

	NAME	vCPU	RAM	Storage Type
Amazon Web Services	c5.large	2	4	General Purpose SSD
	c5.xlarge	4	8	
	c5.2xlarge	8	16	
	c5.4xlarge	16	32	
DigitalOcean	Optimized 2CPU 4GB	2	4	Block storage
	Optimized 4CPU 8GB	4	8	
	Optimized 8CPU 32GB	8	16	
	Optimized 16CPU 32GB	16	32	
Exoscale	Medium	2	4	High Performance SSD
	Large	4	8	
	Huge	8	32	
	Large	16	128	
IBM Cloud	2 Cores 4GB	2	4	Portable Storage SAN
	4 Cores 8GB	4	8	
	8 Cores 16GB	8	16	
	16 Cores 32GB	16	32	
Hetzner	CX21	2	4	Standard Persistent SSD
	CX41	4	8	
	CX51	8	16	
	CCX41	16	64	
Kamatera	2ACPU 4GB	2	4	Cloud Block Storage
	4ACPU 8GB	4	8	
	8ACPU 16GB	8	16	
	16ACPU 32GB	16	32	
Linode	Linode 4GB	2	4	Block Storage
	Linode 8GB	4	8	
	Linode 32GB	8	32	
	Linode 64GB	16	64	
Oracle Cloud	VM.Standard.E2.1	2	4	Block volume
	VM.Standard.E2.2	4	8	
	VM.Standard.E2.4	8	16	
	VM.Standard.E2.8	16	32	
OVHCloud	C2-7	2	7.5	High-speed
	C2-15	4	15	
	C2-30	8	30	
	C2-60	16	60	
T-Systems Open Telekom Cloud	s2.large.2	2	4	Ultra-High I/O
	s2.xlarge.2	4	8	
	s2.2xlarge.2	8	16	

	s2.4xlarge.2	16	32	
Upcloud	2xCPU-4GB	2	4	MaxIOPS
	4xCPU-8GB	4	8	
	Custom 8xCPU-16GB	8	16	
	Custom 16xCPU-32GB	16	32	

2. Server additionnal features

- DigitalOcean:
  - Each instance has a root SSD volume given for free. Their sizes have a ratio of 12.5GB per vCPU, then 25, 50, 100 and 200GB
- Exoscale:
  - Tested volumes are the root
- Hetzner:
  - Each instance has a root SSD volume given for free. Their sizes are respectively 40, 160, 240 and 200GB
- Linode:
  - Each instance has a root SSD volume given for free. Their sizes have a ratio of 20GB per GB of RAM, then 80, 160, 640 and 360GB
- OVHCloud:
  - Each instance has a root SSD volume given for free. Their sizes 50GB for all
- UpCloud:
  - UpCloud non-custom instances have a root SSD volume given for free. They have a size of 80GB for 2xCPU-4GB and 160GB for 16xCPU-8GB

a. CPU specifications

	MODEL NAME	FREQUENCY	REALEASE
Amazon Web Services	Intel Xeon Platinum 8124M Intel Xeon Platinum 8275CL	3.0	
Exoscale	Intel Core Processor (Broadwell, no TSX)	2.4	
DigitalOcean	Intel(R) Xeon(R) CPU E5-2697A v4	2.6	Q1 2016
	Intel(R) Xeon(R) Platinum 8168	2.7	Q3 2017
Hetzner	Intel Xeon Processor (Skylake, IBRS)	2.3	
IBM Cloud	Intel(R) Xeon(R) Gold 6140	2.3	Q3 2017
	Intel(R) Xeon(R) CPU E5-2683 v4	2.1	Q1 2016
Kamatera	Intel(R) Xeon(R) CPU E5-2660 v3	2.6	Q3 2014

	Intel(R) Xeon(R) CPU E5-2697A v4		Q1 2016
Linode	AMD EPYC 7601	2.2	Q3 2017
	AMD EPYC 7501	2.0	
	Intel(R) Xeon(R) Platinum 8168	2.7	
Oracle Cloud	AMD EPYC 7551	2.0	Q3 2017
OVHCloud	Intel Core Processor (Haswell, no TSX)	3.1	
T-Systems Open Telekom Cloud	Intel(R) Xeon(R) Gold 6161 CPU	2.2	
UpCloud	Intel(R) Xeon(R) Gold 6136	3.0	Q3 2017

3. Test scripts

The pieces of code below are part of our methodology and runnable in a Linux command line environment, you can copy them as they are and must set the following variable to make them operate correctly:

- cpu_number: The number of vCPU available on machine
- rw: Access mode 'read' or 'write'
- device_path: Absolute path to the raw device, i.e. /dev/vdb

Feel free to reproduce our results from these snippets.

a. Storage IOPS

```
fio --numjobs=$cpu_number \
        --bs=4k --rw=rand$rw \
        --ioengine=libaio --iodepth=32 \
        --direct=1 --invalidate=1 --end_fsync=1 \
        --time_based --runtime=60 --timeout=60 \
        --filename=$device_path \
        --group_reporting --output-format=json --name=fio
```

b. Storage bandwidth

```
fio --numjobs=$cpu_number \
        --bs=1m --rw=$rw \
        --ioengine=libaio --iodepth=32 \
        --direct=1 --invalidate=1 --end_fsync=1 \
        --time_based --runtime=60 --timeout=60 \
        --filename=$device_path
        --group_reporting --output-format=json --name=fio
```