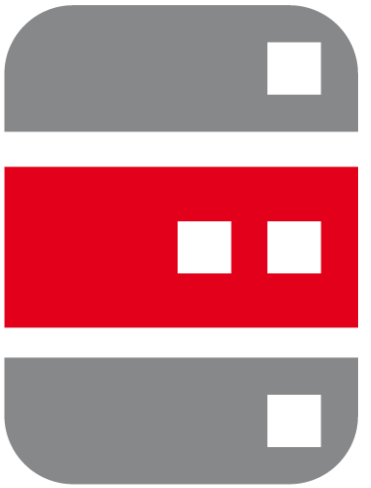
performing databases



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The (Un)loved Child of Generation Cloud - Oracle on VMware

Das (un)geliebte Kind der Generation Cloud - Oracle auf VMware

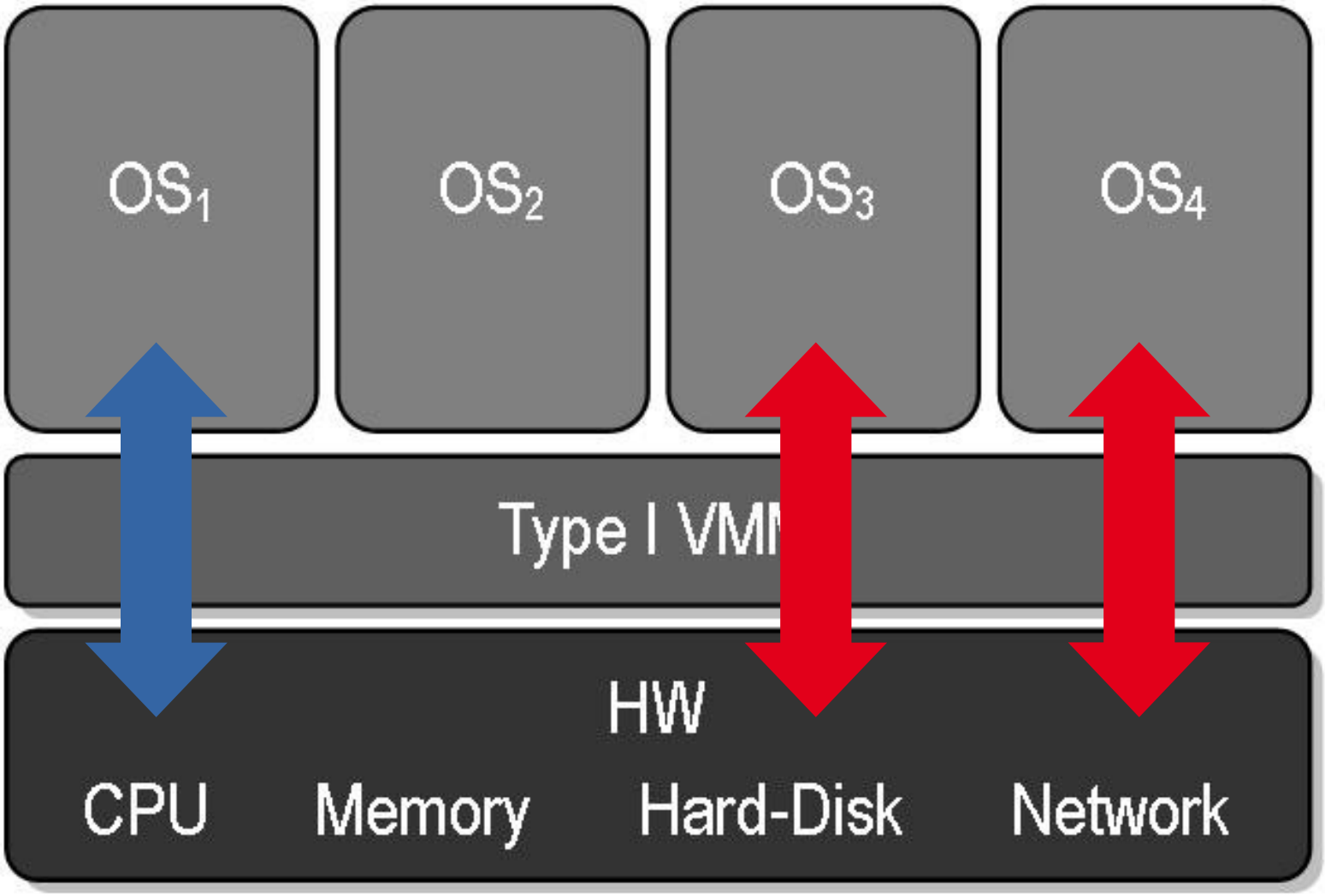
Martin Klier 

Performing Databases GmbH
Mitterteich / Germany

Basics

VMware vSphere

a Type-I-Hypervisor



CPU Extensions (VT-x, SIMD, etc.)

Para-Virtualized Controller

Oracle Architecture
(simplified)

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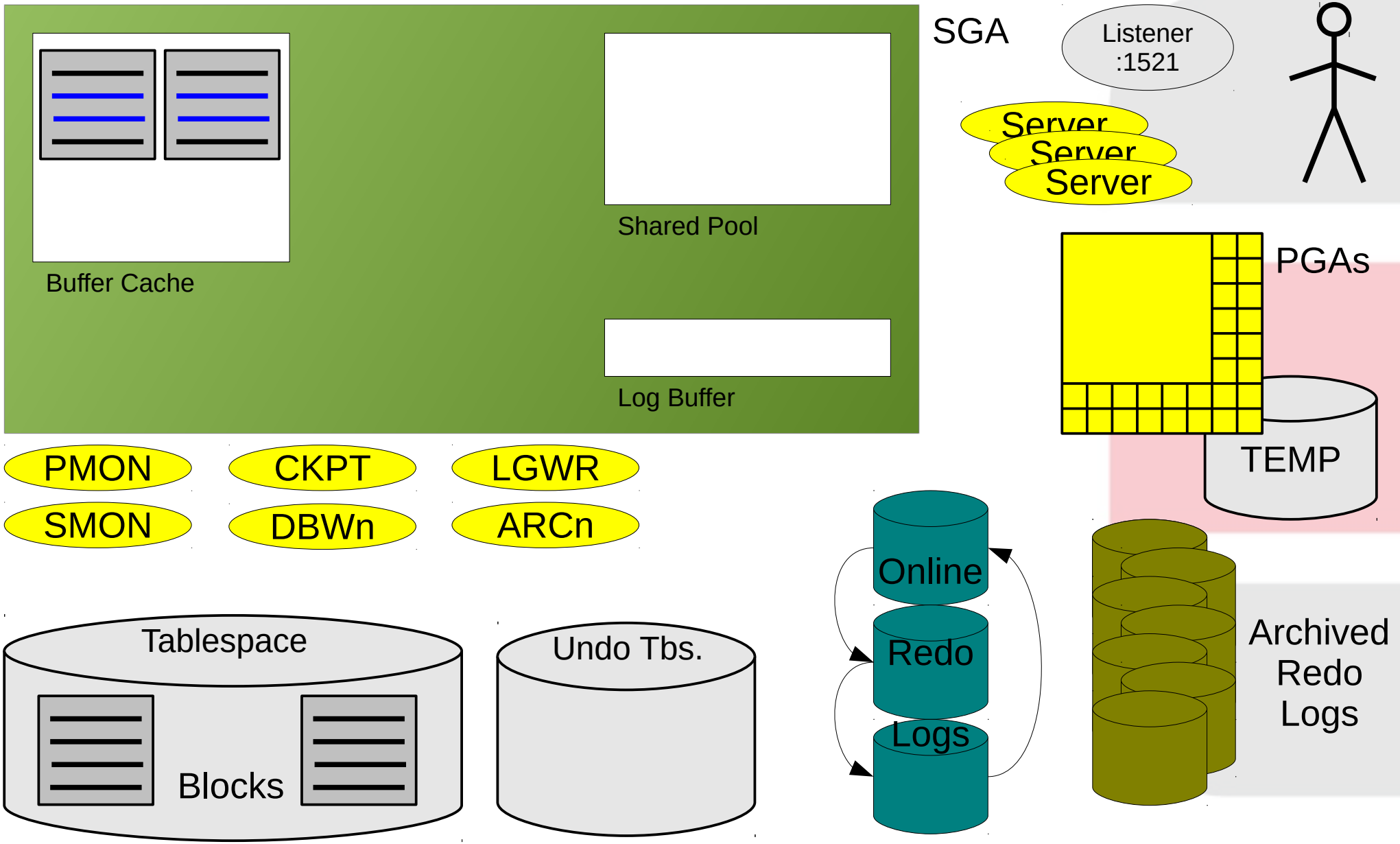

NUMA Architecture

NUMA

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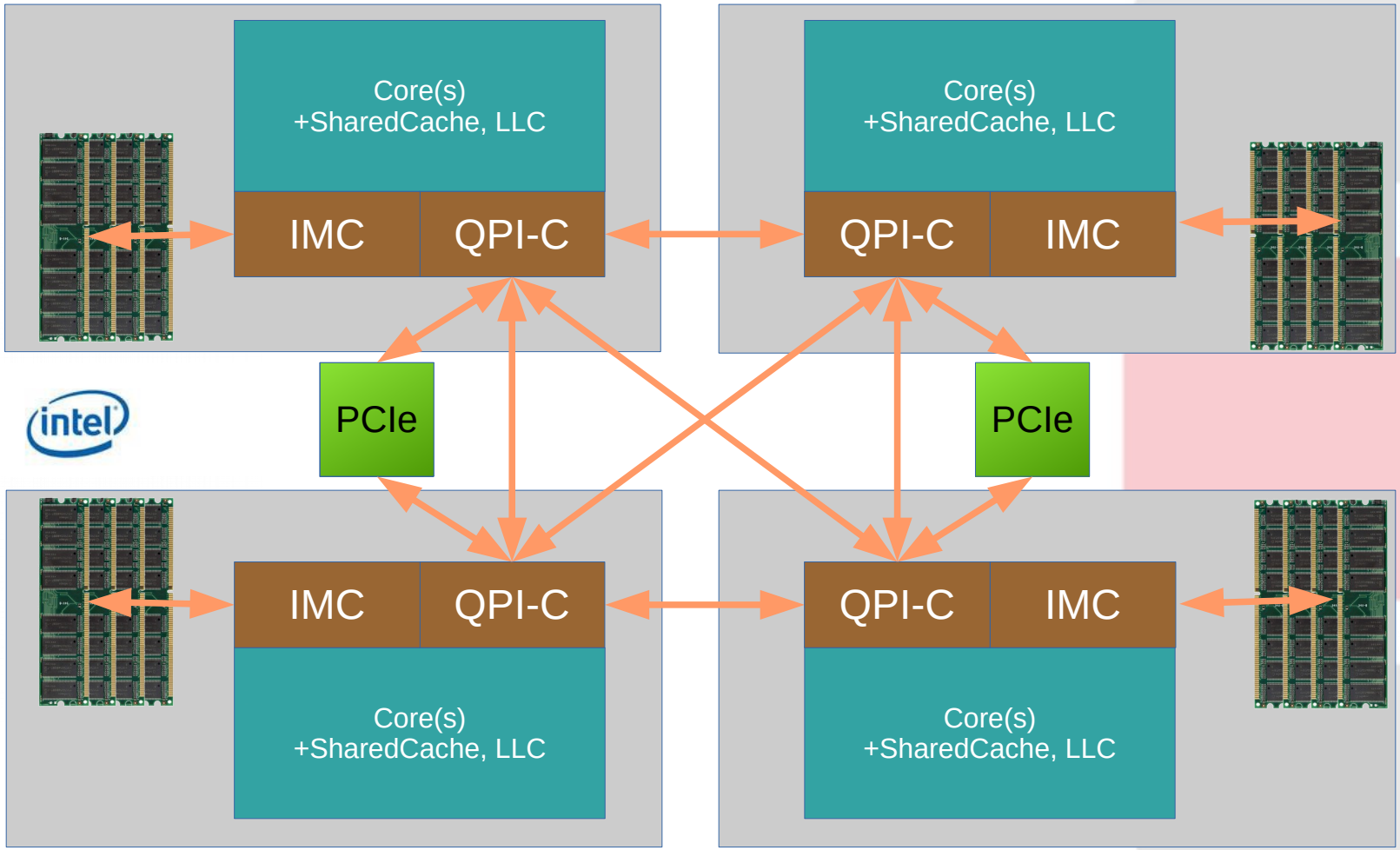
Non Unified Memory Access



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Oracle & NUMA

Oracle & NUMA

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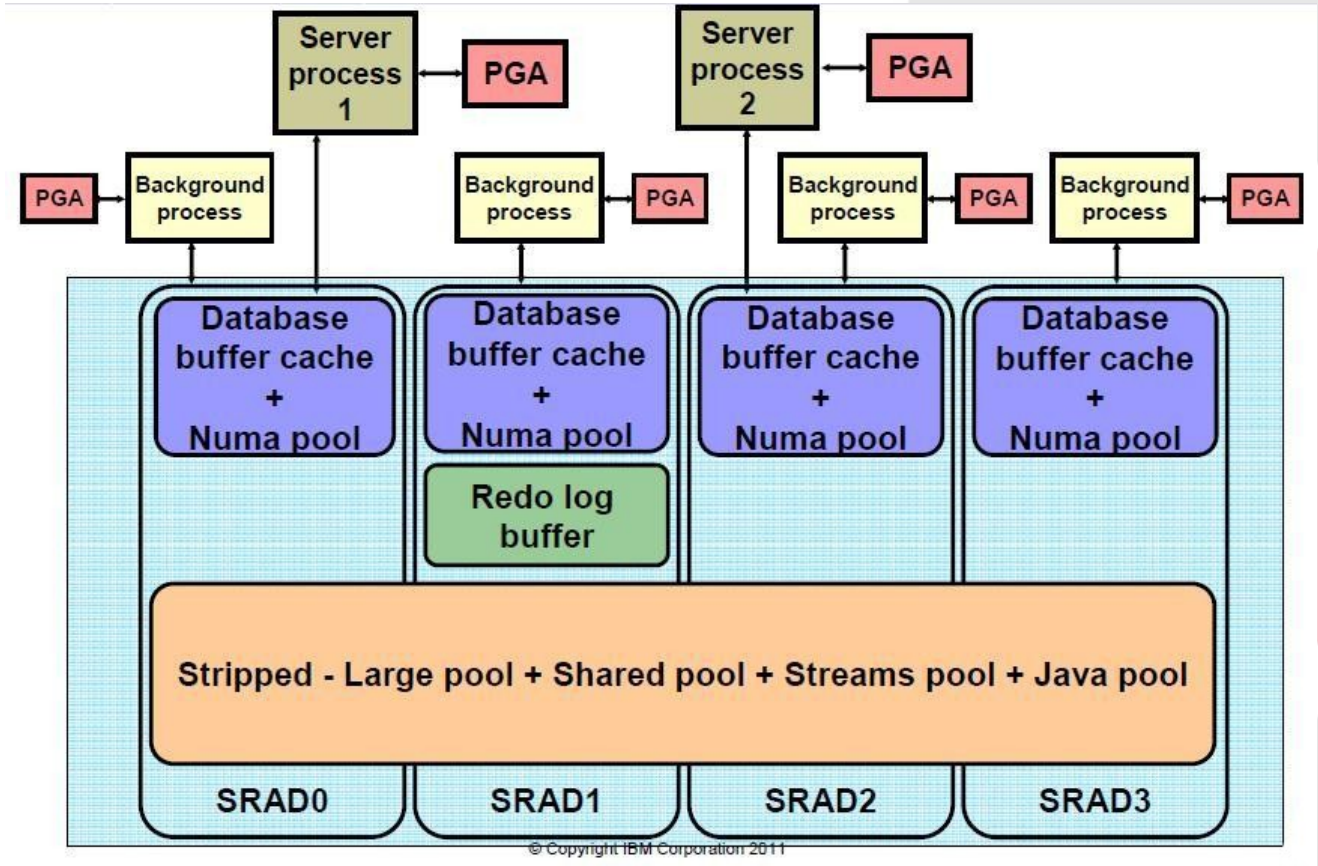
_enable_NUMA_support = TRUE

MOS Doc ID 864633.1

- Multiple Buffer Caches
- Striped pools

  => cross context :((

  => pool access :(



Oracle & NUMA

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```
[root@ora05 ~]# ipcs -ma

------ Shared Memory Segments --------
key        shmid      owner      perms      bytes      nattch     status
0x740301e9 2457600    root       600        4          0
0x00000000 2752513    root       644        80         2
0x00000000 2785282    root       644        16384      2
0x00000000 2818051    root       644        280        2
0x00000000 2883588    oracle     640        4096       0
0x00000000 2916357    oracle     640        4096       0
0xed304ac0 2949126    oracle     640        4096       0
0x00000000 3735559    oracle     640        138412032  464
0x00000000 3768328    oracle     640        8388608    464
0x00000000 3801097    oracle     640        13555990528 464
0x00000000 3833866    oracle     640        13623099392 464
0x00000000 3866635    oracle     640        2684354560 464
0xc93391ac 3899404    oracle     640        2097152    464
```

One buffer cache for each node

13GB+13GB=26 GB

Oracle & NUMA

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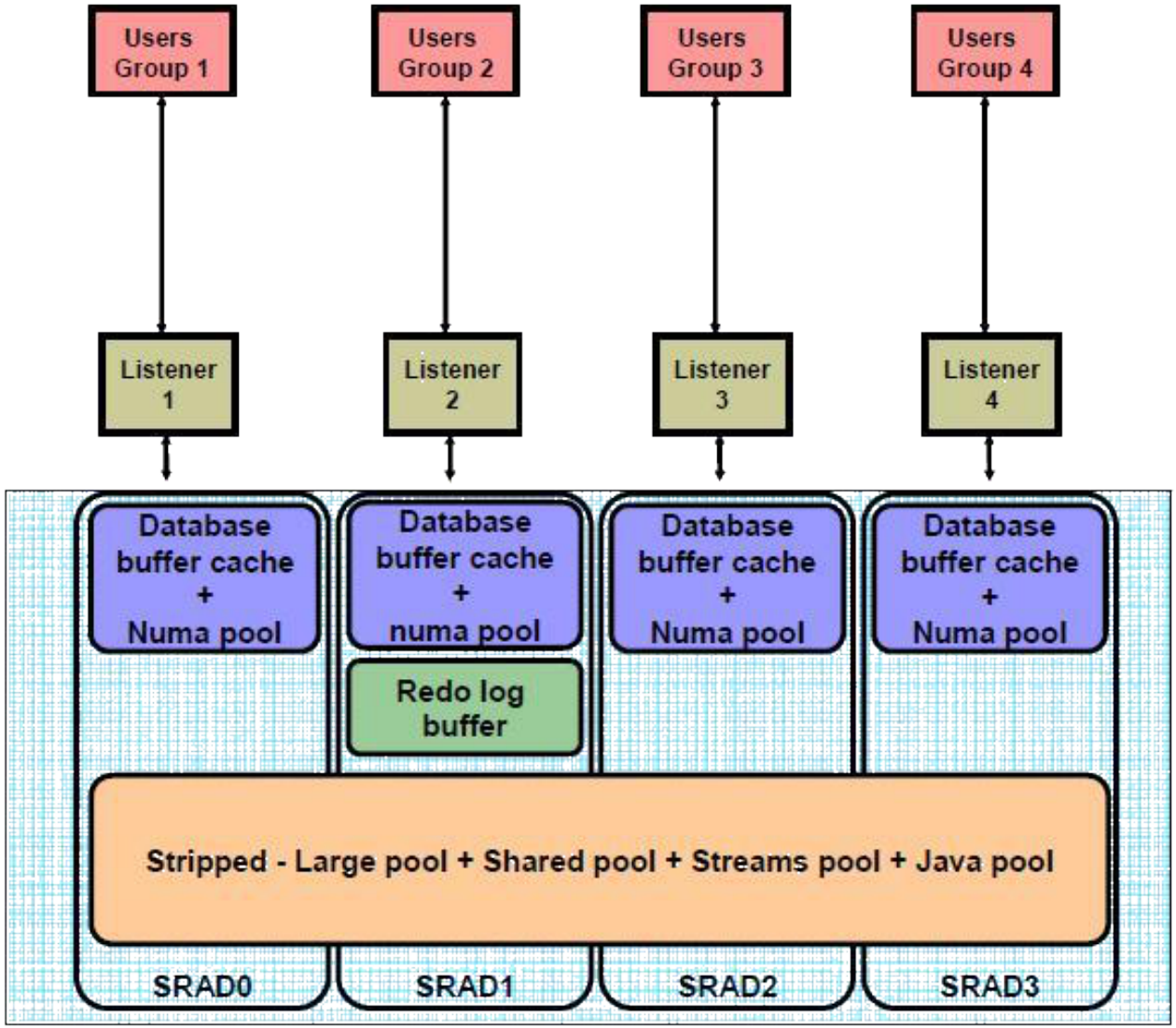

Oracle NUMA aware

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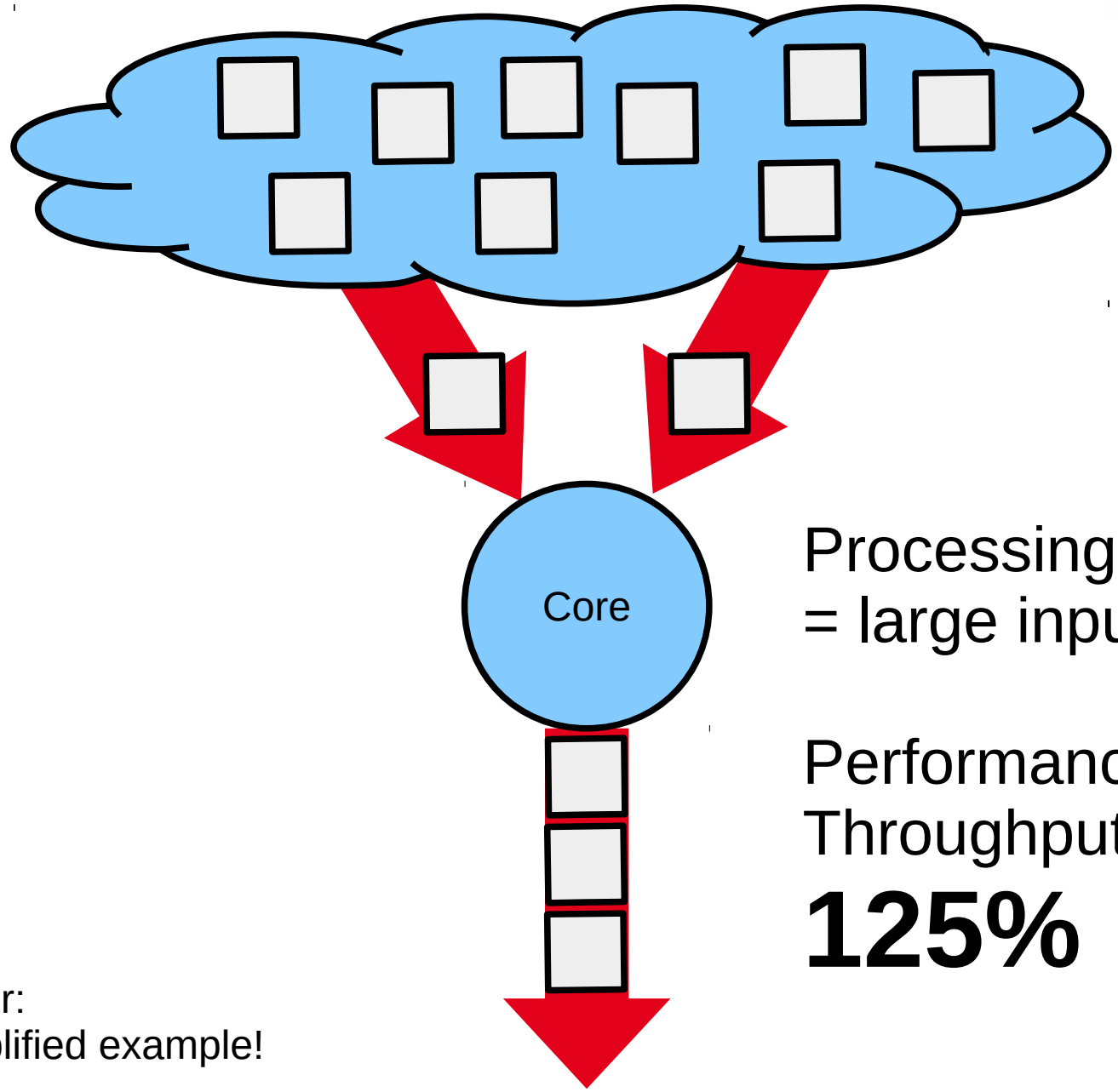
Suggestions

- Useful in big environments only (think: DB consolidation)
- Test thoroughly and quantify use vs. effort (think: bugs)
- Use only if necessary to achieve your goals!

Hyperthreading

HyperThreading (HTT)

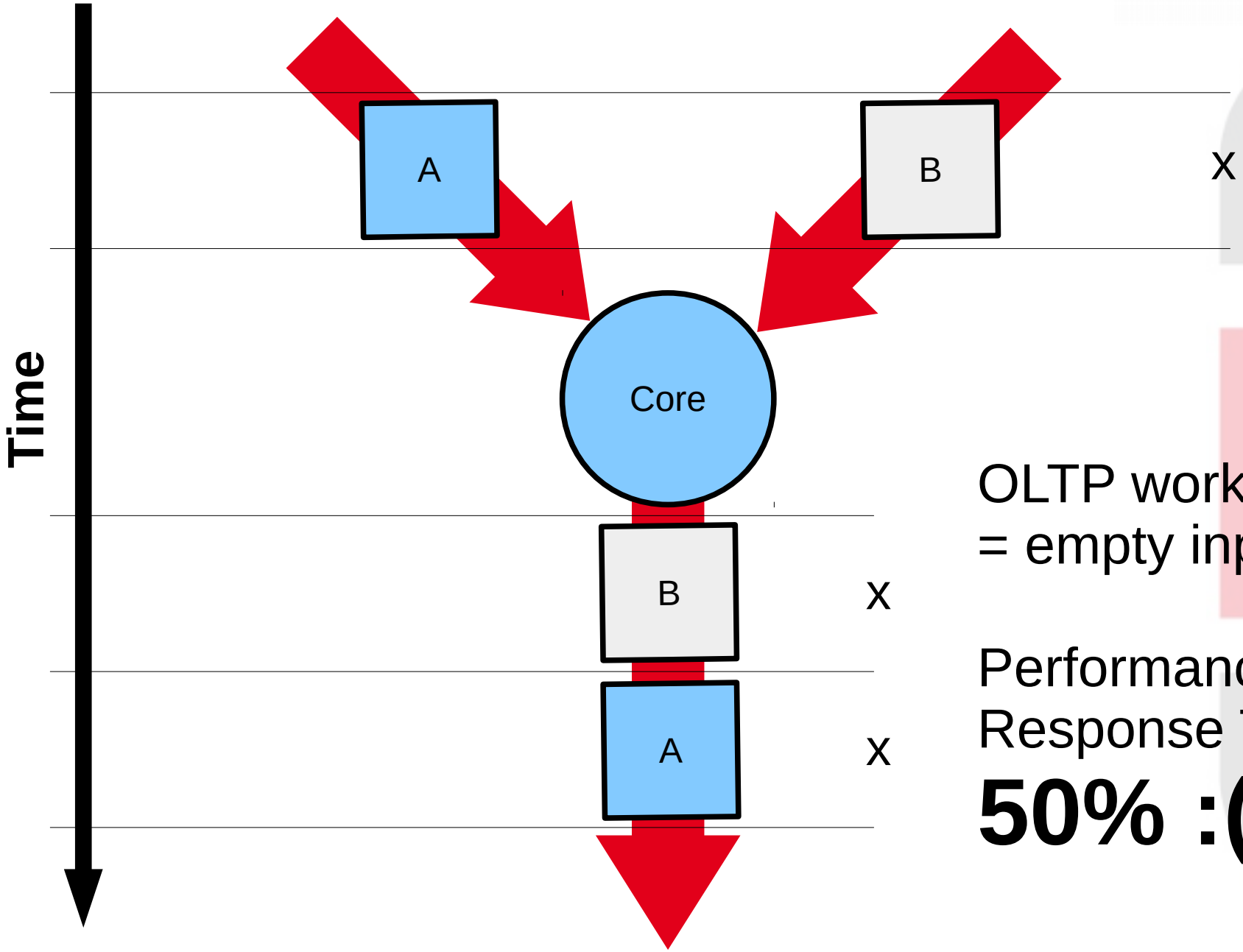


Processing big workloads
= large input queue

Performance =
Throughput
125% :)

Disclaimer:
Very simplified example!

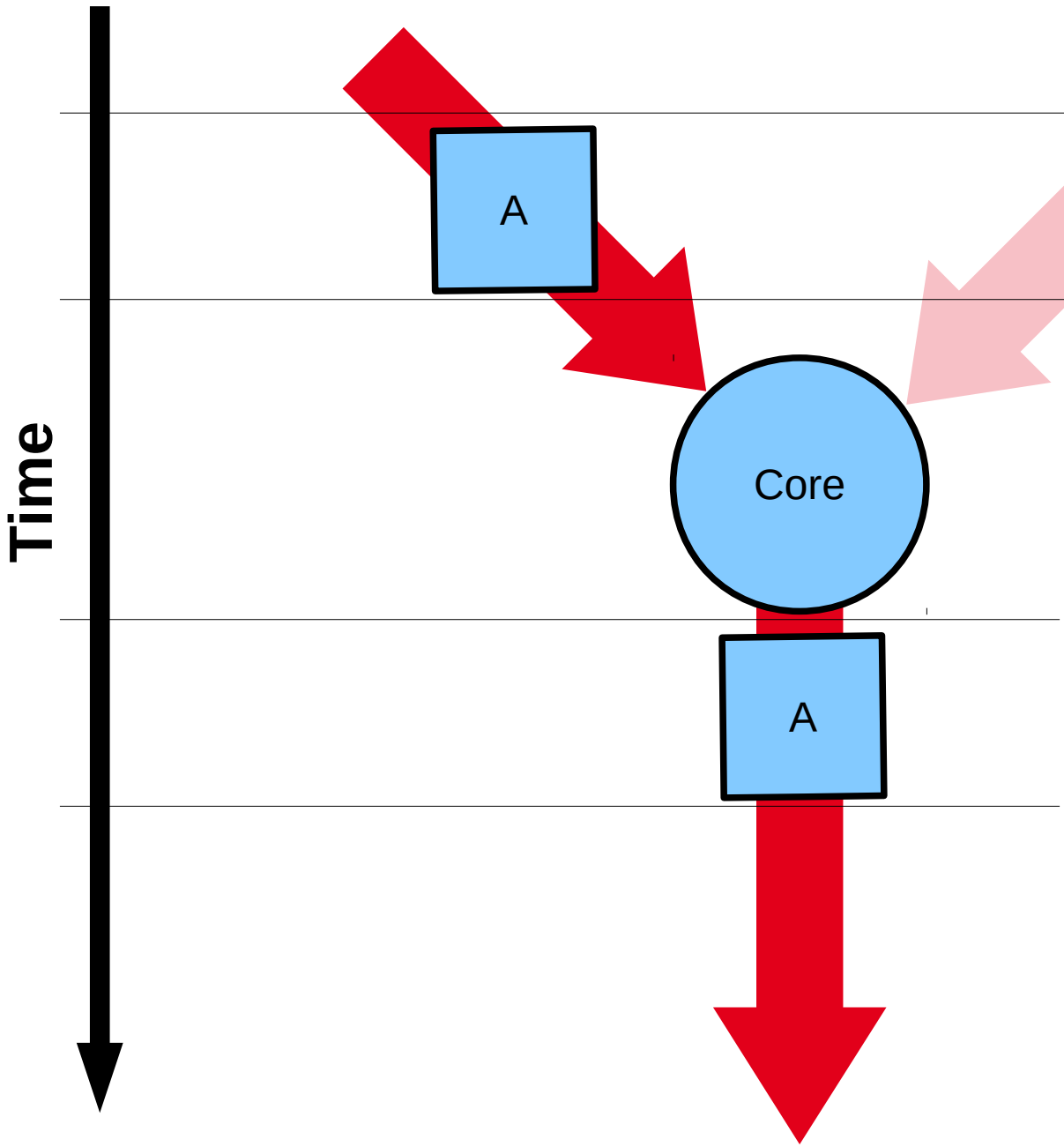
OLTP & HTT



OLTP workloads
= empty input queue

Performance =
Response Time
50% :(

OLTP & HTT



Disable HyperThreading for OLTP systems!

- in hardware BIOS
- on VMware level
(„Latency Sensitivity“ high)

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VMware vSphere (ESXi) CPU Usage

VMware CPU Usage

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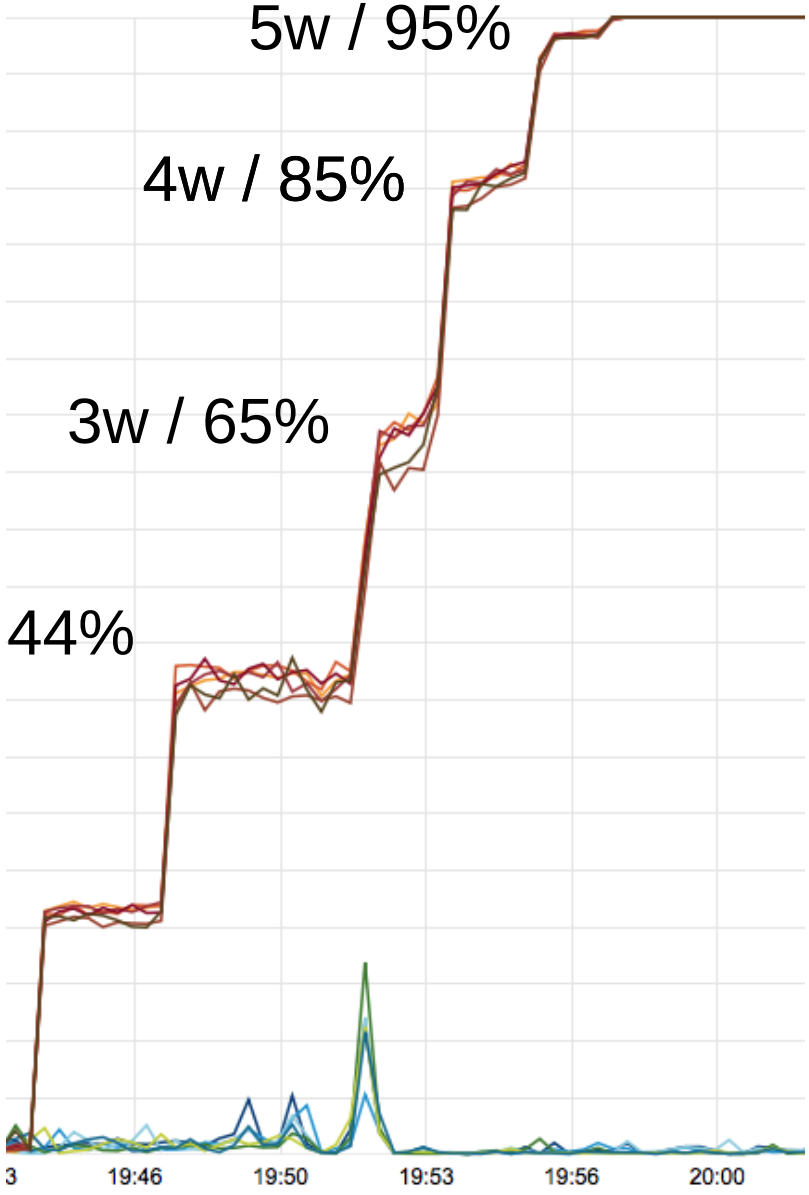
My Test Setup

- HP ProLiant DL380 G6
- 2x 64GB RAM
- 2 CPUs, **2x 6 cores = 2 NUMA nodes**
  Intel(R) Xeon(R) CPU X5670 @ 2.93GHz boost 3.33GHz
  „Westmere EP“ 32nm technology
- HyperThreading disabled (BIOS)

- VMware vSphere ESXi 6.0 U2
- 2 VMs / Oracle Linux 7.4 w/ UEK Kernel

VMware CPU Usage



OS: 95%

OS: 80%

OS: 65%

OS: 50%

OS: 40%

1 Worker
6 vCPU
22% each

OS Metric / Linux top
20% CPU

VMware CPU Usage

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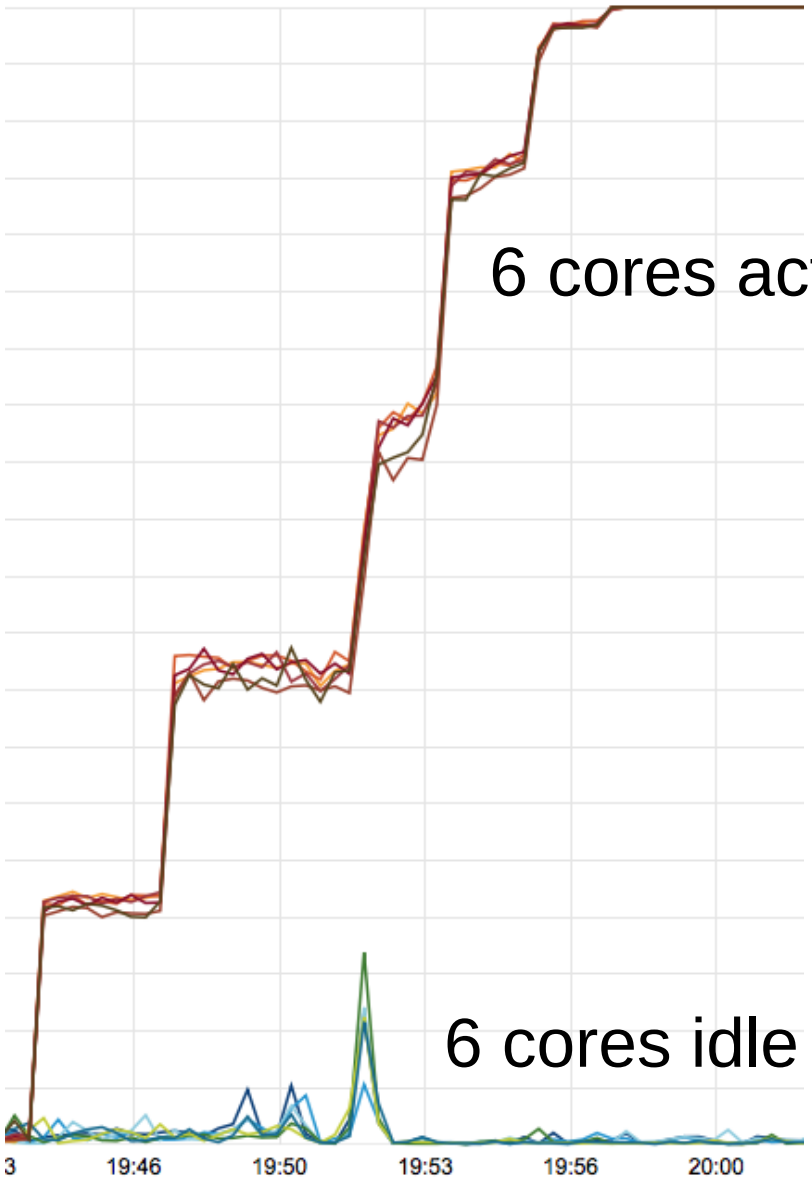

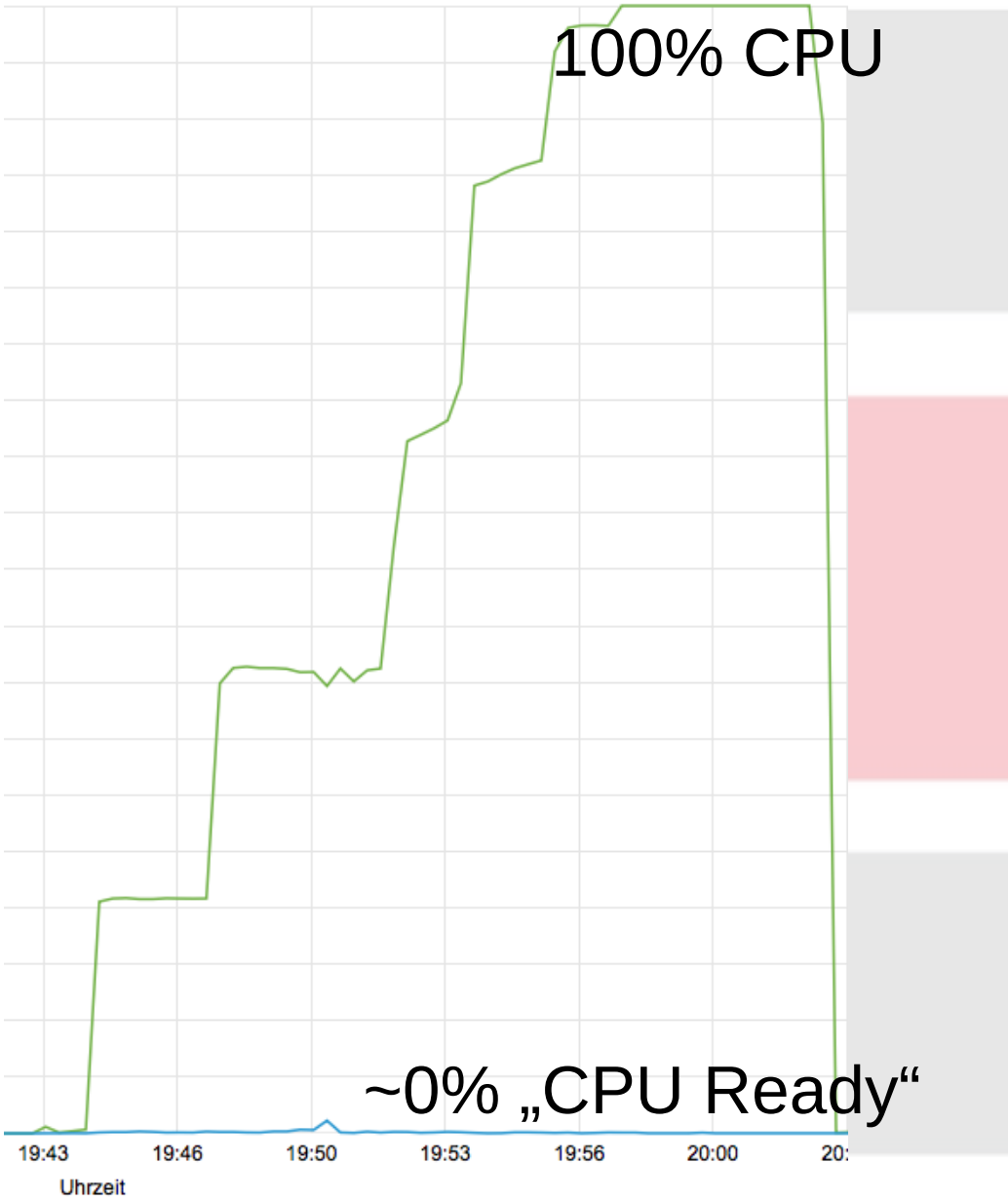

CPU Ready
=
Wait for free CPU time

VMware CPU Usage

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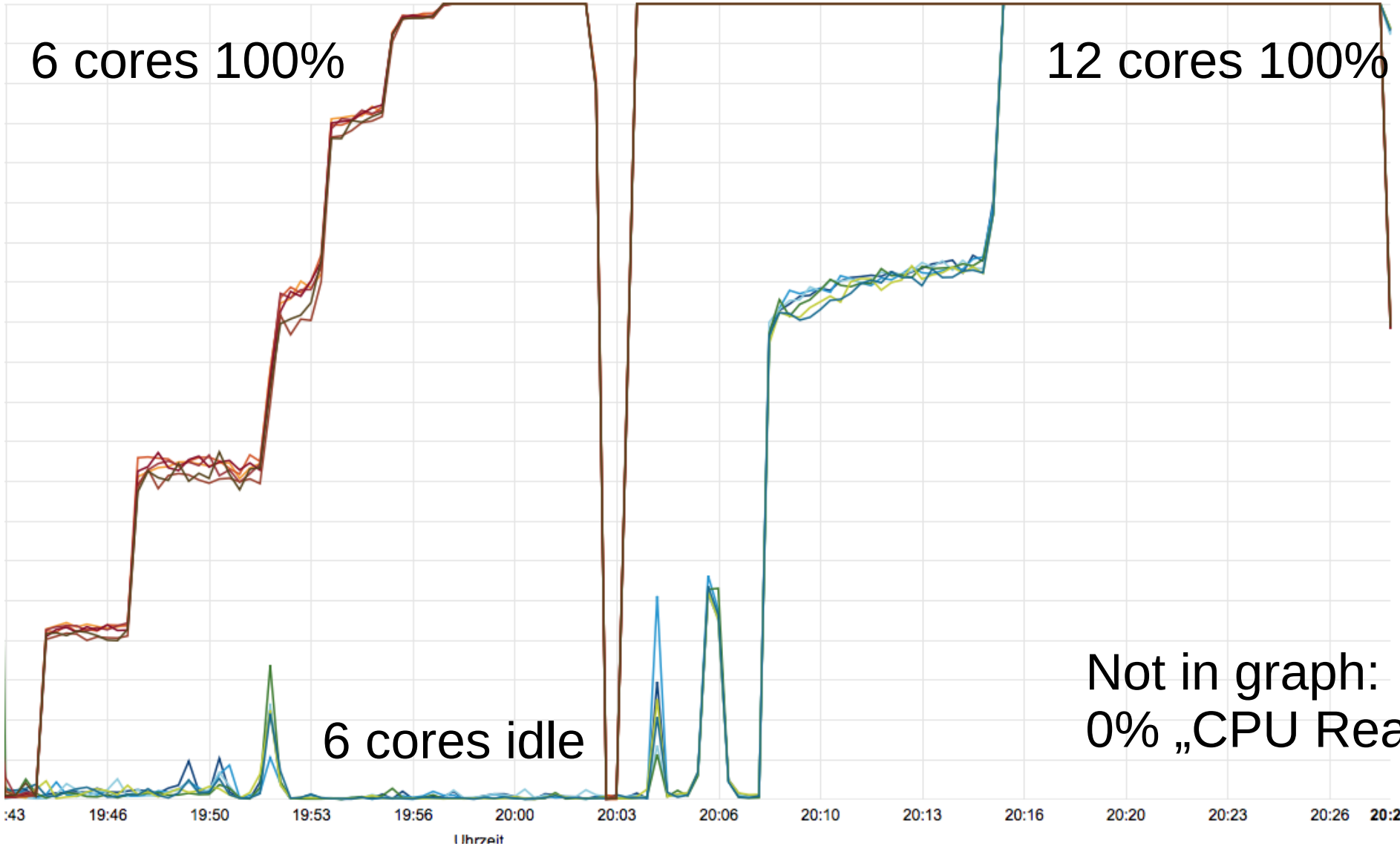

Green IT :)

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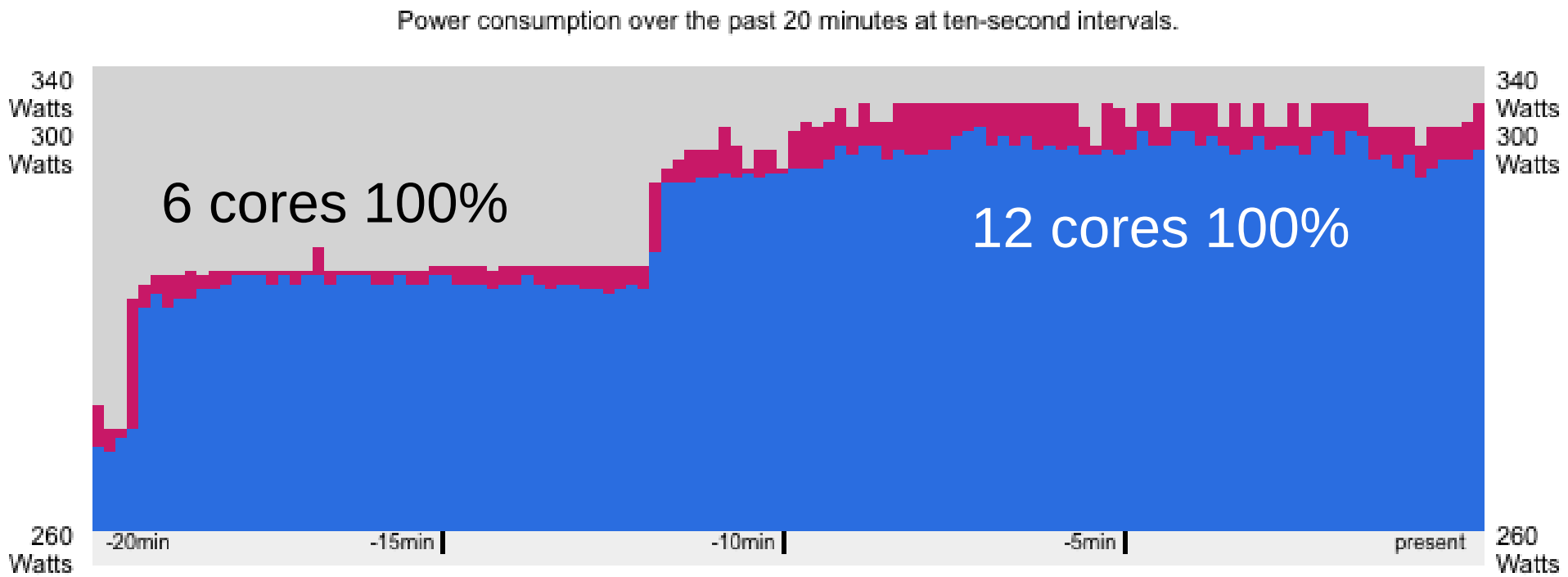

VMware CPU Usage

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8 vCores

13 workers to fill up to 100% in top

```
top - 15:29:01 up 24 min,  2 users,  load average: 1.24, 0.54, 0.27
Tasks: 160 total,   4 running, 156 sleeping,   0 stopped,   0 zombie
%Cpu0  :  30.0/70.0  100[
%Cpu1  :  30.3/69.7  100[
%Cpu2  :  34.7/64.4   99[
%Cpu3  :  31.0/69.0  100[
%Cpu4  :  32.0/68.0  100[
%Cpu5  :  30.7/69.3  100[
%Cpu6  :  30.4/68.6   99[
%Cpu7  :  30.0/70.0  100[
KiB Mem :  3781400 total,  3458524 free,   137844 used,   185032 buff/cache
KiB Swap:  1952764 total,  1952764 free,        0 used.  3564828 avail Mem

  PID USER      PR  NI    VIRT    RES    SHR S  %CPU %MEM     TIME+ COMMAND
 8659 root      20   0  113524   2508   1872 S  11.9  0.1   0:03.09 /bin/bash ./loader.sh
 8853 root      20   0  113524   2508   1872 S  10.9  0.1   0:03.06 /bin/bash ./loader.sh
 9148 root      20   0  113524   2500   1872 S  10.9  0.1   0:02.97 /bin/bash ./loader.sh
10140 root      20   0  113524   2496   1872 S  10.9  0.1   0:02.93 /bin/bash ./loader.sh
10896 root      20   0  113524   2492   1872 S  10.9  0.1   0:02.92 /bin/bash ./loader.sh
13837 root      20   0  113524   2488   1872 S  10.9  0.1   0:02.83 /bin/bash ./loader.sh
18933 root      20   0  113524   2476   1872 S  10.9  0.1   0:02.72 /bin/bash ./loader.sh
 9579 root      20   0  113524   2500   1872 S   9.9  0.1   0:02.97 /bin/bash ./loader.sh
11951 root      20   0  113524   2492   1872 S   9.9  0.1   0:02.86 /bin/bash ./loader.sh
12789 root      20   0  113524   2488   1872 S   9.9  0.1   0:02.82 /bin/bash ./loader.sh
14834 root      20   0  113524   2484   1872 R   9.9  0.1   0:02.79 /bin/bash ./loader.sh
15731 root      20   0  113524   2484   1872 S   9.9  0.1   0:02.76 /bin/bash ./loader.sh
16929 root      20   0  113524   2480   1872 S   9.9  0.1   0:02.77 /bin/bash ./loader.sh
   14 root      rt   0       0      0      0 S   1.0  0.0   0:05.13 [migration/1]
   18 root      20   0       0      0      0 S   1.0  0.0   0:04.86 [rcuos/1]
```

Each worker:

while true
(bc < 5.5*7.7 etc.
)

VMware CPU Usage

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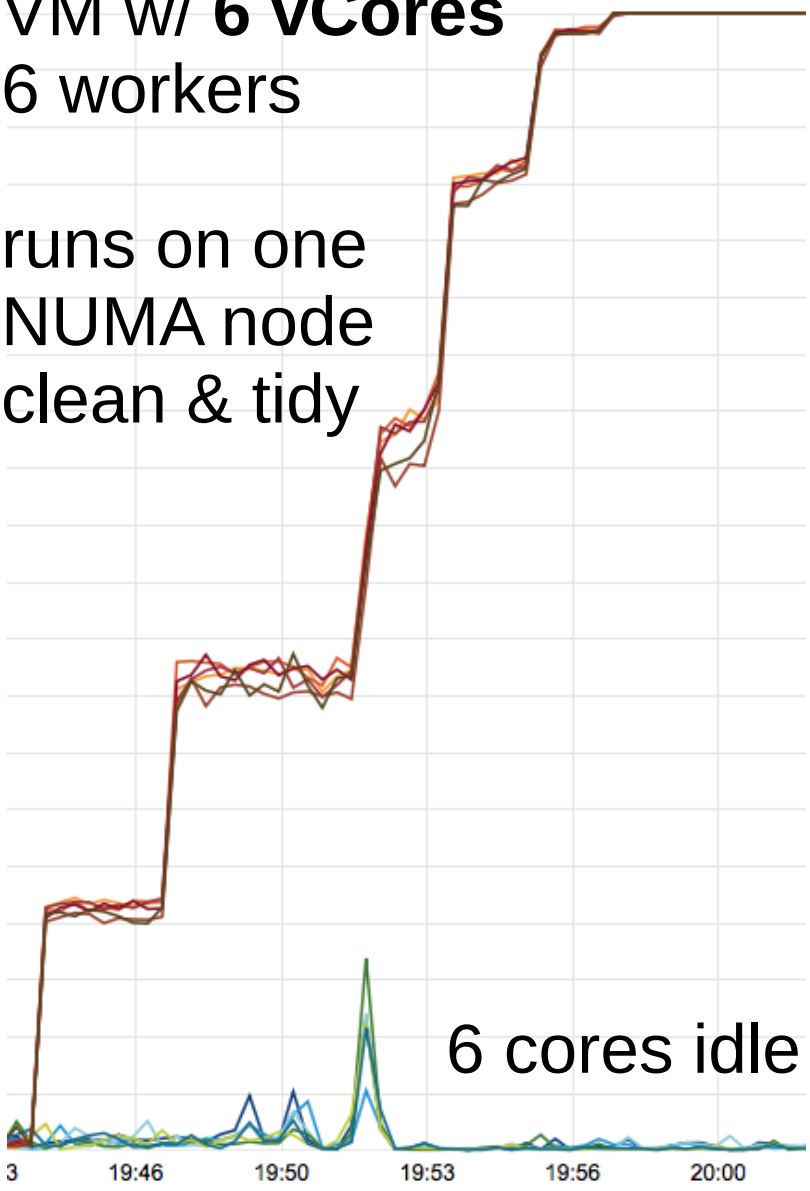
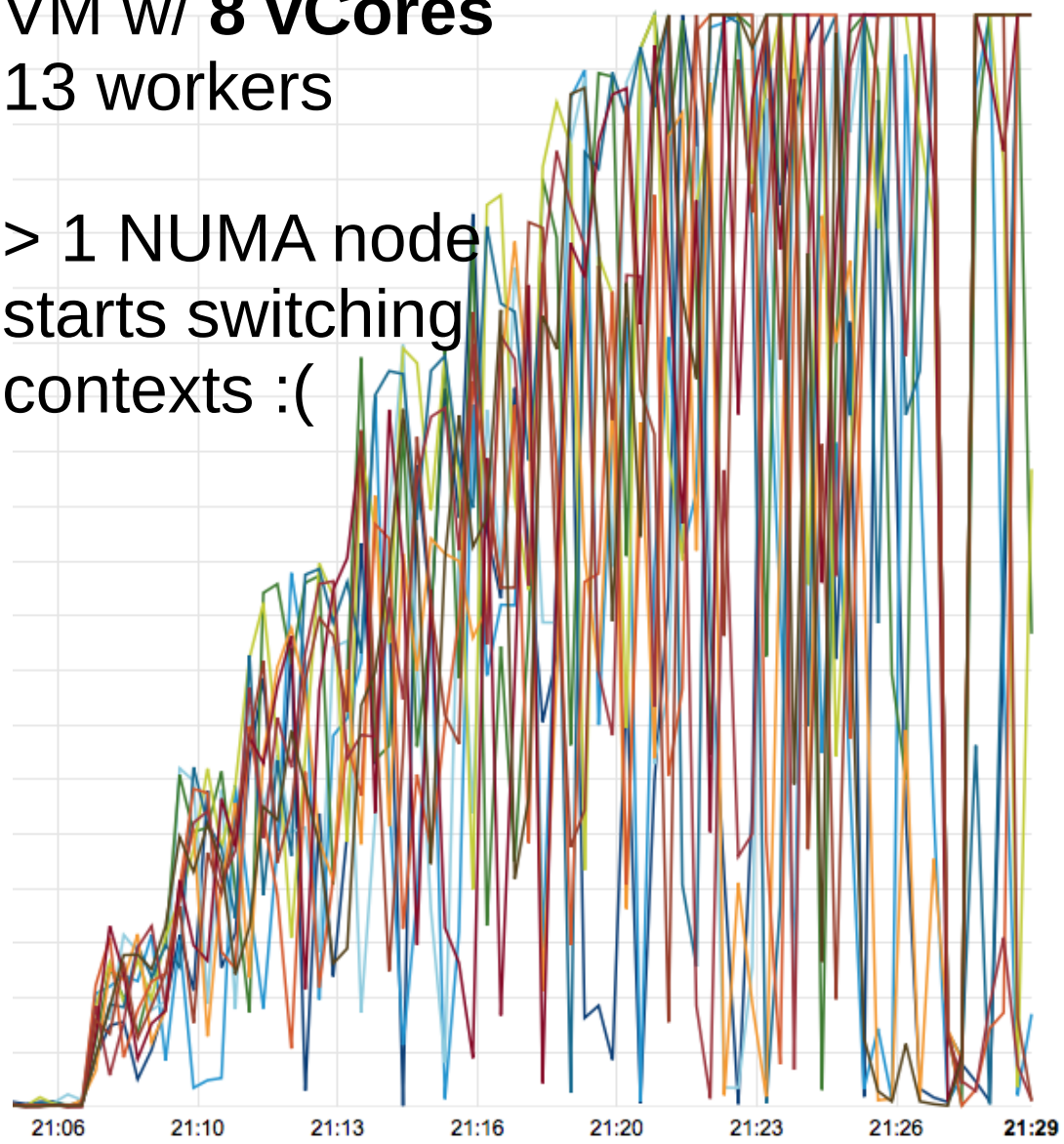
VM w/ **6 vCores**
6 workers

runs on one NUMA node
clean & tidy



VM w/ **8 vCores**
13 workers

> 1 NUMA node
starts switching
contexts :(



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Oracle Workload on ESXi

Oracle Stress in VM

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```
top - 16:41:25 up  1:14,  5 users,  load average: 2.45, 1.21, 1.39
Tasks: 244 total,   9 running, 235 sleeping,   0 stopped,   0 zombie
%Cpu0  :  94.1/5.9   100[
%Cpu1  :  95.0/5.0   100[
%Cpu2  :  94.1/5.9   100[
%Cpu3  :  93.1/6.9   100[
%Cpu4  :  93.1/6.9   100[
%Cpu5  :  93.1/6.9   100[
KiB Mem : 64943912 total, 27610432 free, 20261048 used, 17072432 buff/cache
KiB Swap:  1953788 total,  1953788 free,        0 used. 44306400 avail Mem

  PID USER      PR  NI    VIRT    RES    SHR S  %CPU %MEM     TIME+ COMMAND
14076 oracle    20   0 19.233g  68996  65624 R 100.0  0.1   1:11.69 oraclePDB12201 (DESCRIPTION=(LOCAL=YES)(ADDRESS=(PROTOCOL=beq)))
14074 oracle    20   0 19.233g  68532  65168 R 100.0  0.1   1:11.87 oraclePDB12201 (DESCRIPTION=(LOCAL=YES)(ADDRESS=(PROTOCOL=beq)))
14075 oracle    20   0 19.233g  69960  66604 R 100.0  0.1   1:11.77 oraclePDB12201 (DESCRIPTION=(LOCAL=YES)(ADDRESS=(PROTOCOL=beq)))
14077 oracle    20   0 19.233g  69948  66448 R 100.0  0.1   1:11.99 oraclePDB12201 (DESCRIPTION=(LOCAL=YES)(ADDRESS=(PROTOCOL=beq)))
14078 oracle    20   0 19.233g  69924  66428 R 100.0  0.1   1:11.50 oraclePDB12201 (DESCRIPTION=(LOCAL=YES)(ADDRESS=(PROTOCOL=beq)))
14079 oracle    20   0 19.233g  69544  66184 R 100.0  0.1   1:11.66 oraclePDB12201 (DESCRIPTION=(LOCAL=YES)(ADDRESS=(PROTOCOL=beq)))
 2598 oracle    -2   0 19.230g  56432  53760 S   2.0  0.1   0:27.34 ora_vktm_PDB12201
```

loop
(select 1 row;
   update this row;
   commit)

6 workers
each on a different set of 10k rows

runs ~20min until Free Buffer Waits

Anti-Load in VM

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```
top - 15:36:29 up  6:39,  2 users,  load average: 0.24, 0.08, 0.06
Tasks: 198 total,   6 running, 191 sleeping,   0 stopped,   1 zombie
%Cpu0  :  12.2/36.6   49[
%Cpu1  :  13.8/36.2   50[
%Cpu2  :  12.2/44.6   57[
%Cpu3  :  13.3/34.4   48[
%Cpu4  :  11.1/37.0   48[
%Cpu5  :  10.5/43.4   54[
%Cpu6  :  14.5/47.0   61[
%Cpu7  :  13.3/53.3   67[
%Cpu8  :  17.3/52.0   69[
%Cpu9  :  16.0/51.9   68[
%Cpu10 :  13.3/55.4   69[
%Cpu11 :  15.5/48.8   64[
KiB Mem :  3765012 total,  3154872 free,   163420 used,   446720 buff/cache
KiB Swap:  1952764 total,  1952764 free,        0 used.  3505280 avail Mem

  PID USER      PR  NI    VIRT    RES    SHR S  %CPU %MEM     TIME+ COMMAND
 6333 root      20   0  113524   2688   2108 S  22.8  0.1   0:05.37 /bin/bash ./loader.sh
 6890 root      20   0  113524   2684   2108 S  21.8  0.1   0:05.03 /bin/bash ./loader.sh
23999 root      20   0  113396   2620   2108 S  20.8  0.1   0:04.92 /bin/bash ./loader.sh
27403 root      20   0  113396   2612   2108 S  19.8  0.1   0:04.99 /bin/bash ./loader.sh
 5624 root      20   0  113524   2696   2108 S  18.8  0.1   0:05.14 /bin/bash ./loader.sh
 8387 root      20   0  113524   2676   2108 S  18.8  0.1   0:04.93 /bin/bash ./loader.sh
34049 root      20   0  113396   2596   2108 R  17.8  0.1   0:04.44 /bin/bash ./loader.sh
15880 root      20   0  113396   2648   2108 S  16.8  0.1   0:05.02 /bin/bash ./loader.sh
    7 root      20   0       0      0      0 R  15.8  0.0   0:05.75 [rcu_sched]
21966 root      20   0  113396   2624   2108 R  15.8  0.1   0:04.77 /bin/bash ./loader.sh
 5923 root      20   0  113524   2692   2108 S  14.9  0.1   0:04.81 /bin/bash ./loader.sh
 7542 root      20   0  113524   2680   2108 S  13.9  0.1   0:04.56 /bin/bash ./loader.sh
30760 root      20   0  113396   2604   2108 S  13.9  0.1   0:04.49 /bin/bash ./loader.sh
18607 root      20   0  113396   2636   2108 S  12.9  0.1   0:05.30 /bin/bash ./loader.sh
   56 root      rt   0       0      0      0 S   9.9  0.0   0:01.53 [migration/7]
 5448 root      20   0  113524   2696   2108 S   9.9  0.1   0:05.13 /bin/bash ./loader.sh
```

Not nearly full power (CPU load 55%)

Owner will feel no guilt

14 workers (bc)
55% avg. load
over 12 vCores
we know:
Will heavily switch CPU context!

Oracle vs. Anti-Load

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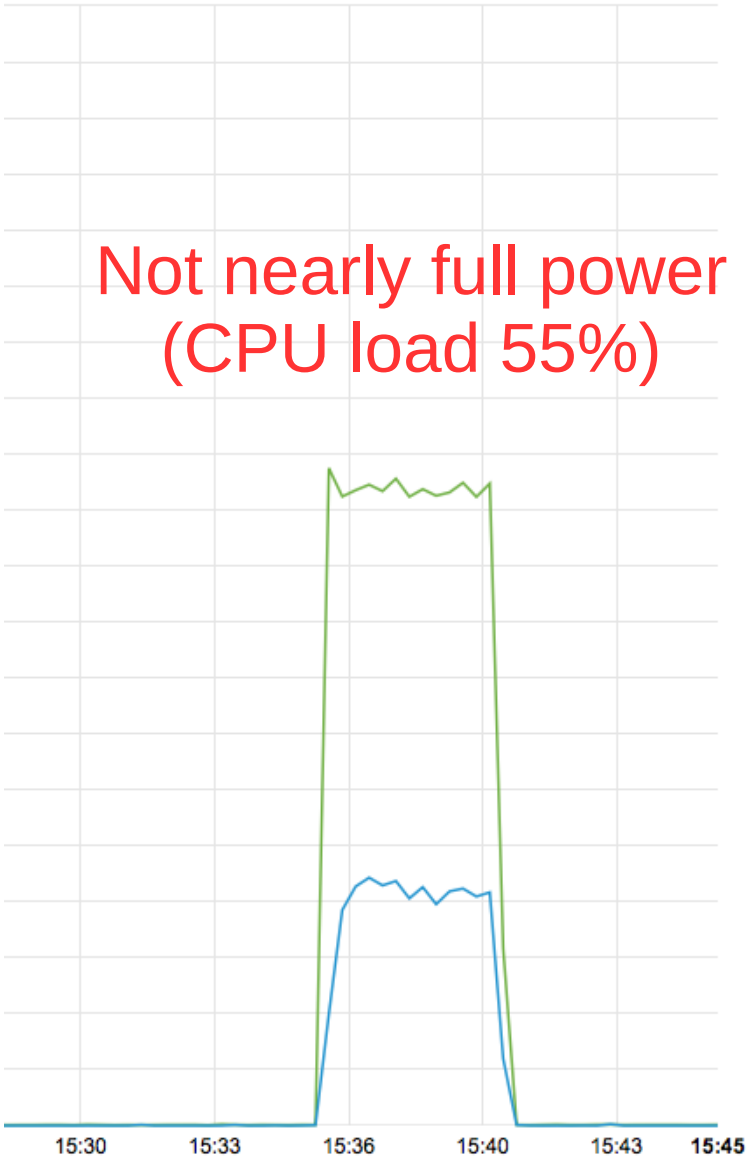
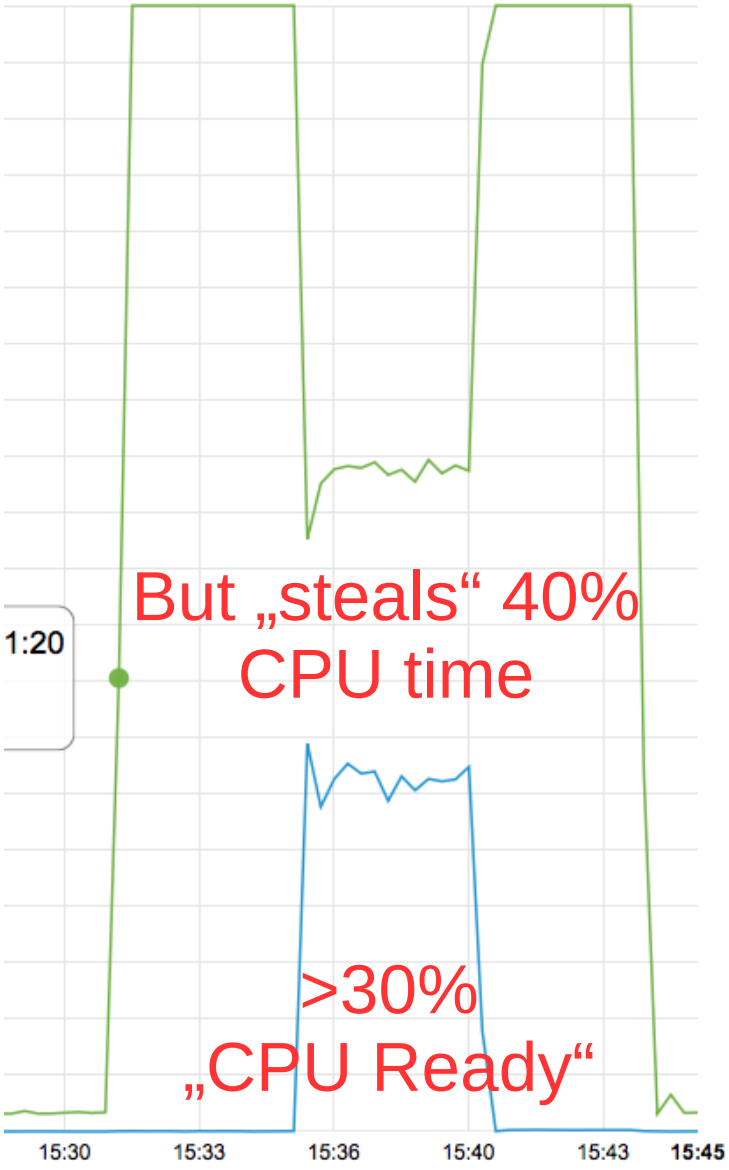
Anti-Load VM CPU

Not nearly full power
(CPU load 55%)



Oracle VM CPU



So far, much was measured w/ help of the VMware Admin :(

SMS

=

Surrogate Measure Sucks

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Let's do it ourselves
Let's do what we do best

Use Oracle

AWR Diff Report

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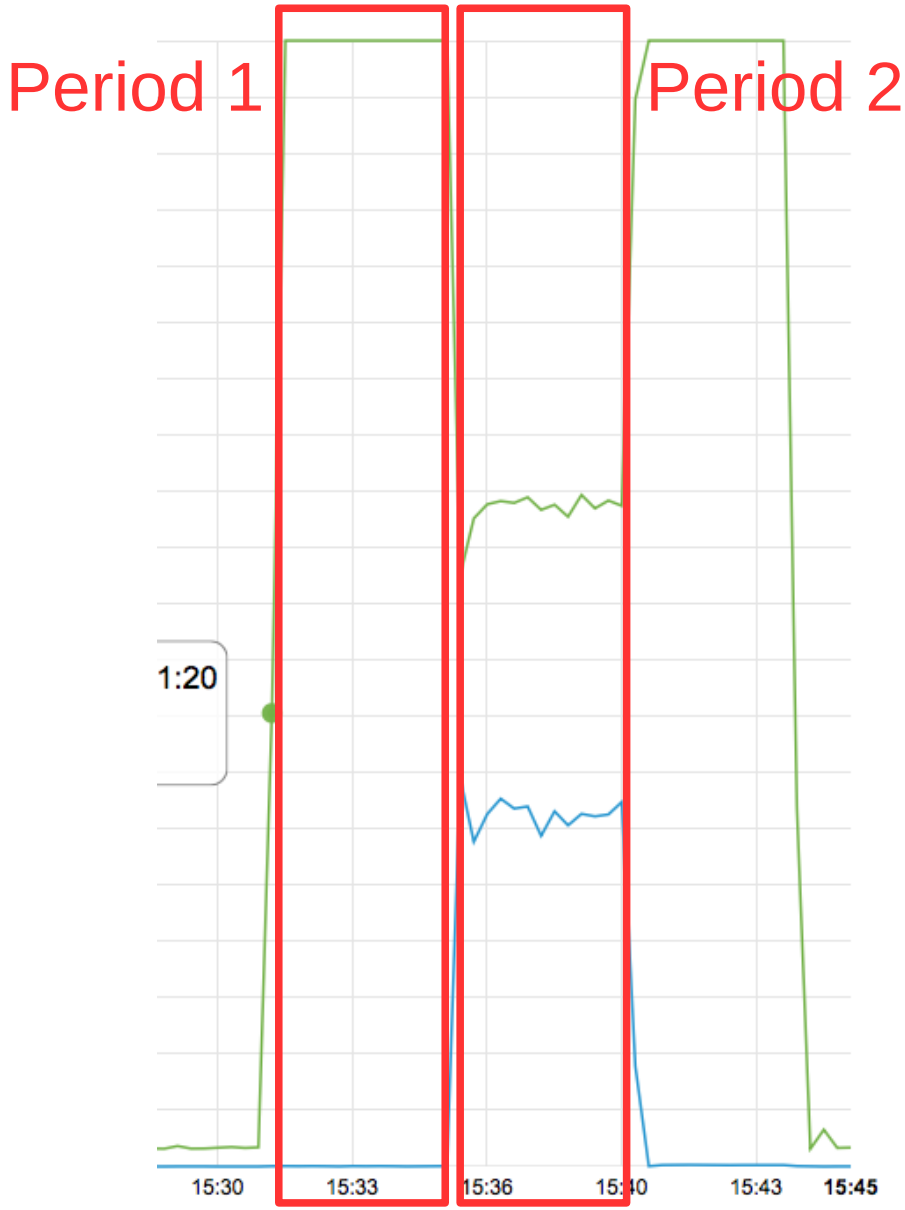

AWR Diff Report

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Workload Comparison

	1st Per Sec	2nd Per Sec	%Diff
DB time:	5.9	5.8	-1.2
CPU time:	5.9	5.5	-6.5
Background CPU time:	0.0	0.1	450.0
Redo size (bytes):	17,639,257.8	10,080,982.1	-42.8
Logical read (blocks):	409,888.3	234,796.8	-42.7
Block changes:	149,455.3	85,418.5	-42.8

39% less buffer gets
with SAME CPU TIME
and WORKLOAD

(Linux sees 100% all times)

409.888,3 BG / 5,9 s = 69.473 BG/s
234.796.8 BG / 5,5 s = 42.690 BG/s = 61%

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and use your brain!

Simple Benchmark

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```
38  ############## 1.547463
39  ############## 1.54470933
39  ############## 1.54470933
40  ############## 1.541621
41  ############## 1.5444705
42  ############## 1.54240183
43  ############## 1.54291683
44  ############## 1.54445533
44  ############## 1.54445533
45  ############## 1.5499345
46  ############## 1.547596
47  ############## 1.547272
48  ############## 1.54804967
48  ############## 1.54804967
49  ################# 1.7625875
49  ################# 1.7625875
49  ################# 1.7625875
50  ################################ 3.44203833
50  ################################ 3.44203833
51  ################################ 3.26774017
51  ################################ 3.26774017
51  ################################ 3.26774017
52  ################################# 3.62154467
52  ################################# 3.62154467
53  ################################## 3.70635533
53  ################################## 3.70635533
54  ################################# 3.60270667
54  ################################# 3.60270667
55  ################################ 3.21821567
56  ################### 2.05004033
56  ################### 2.05004033
57  ############## 1.4670215
58  ############# 1.42301867
59  ############# 1.41232367
60  ############# 1.403707
61  ############# 1.40650833
62  ############# 1.40582217
```

First value: ID of test iteration
bar: Visualization
Decimal value: Seconds for
10.000 x SELECT+UPDATE
of different single rows
(Avg. per iteration over all workers,
all workers on different rows)

**Guess,
what happened
here? :(**

Simulated User Experience of a DB on VMware (if built poorly)

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Knowledge is important
Proof is better

Prepare to Prove

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What you need in your VM (Linux)

- VMware tools
  (VMware recommends package from your distributor)
- Phython environment (usually present)
- git (or copy yourself)
- build environment like make (Oracle needs that anyway)
- vmguestlib with vmguest-stats (made by Dag Wieers)
  uses an API provided by vSphere (via VMW tools)

```
$ git clone git://github.com/dagwieers/vmguestlib
$ cd vmguestlib
$ python setup.py install
```

vmguest-stats

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```
[root@oracle-vm1 vmguestlib]# ./vmguest-stats -c
Wed Dec 13 12:12:26 2017
VM Processor
    Processor Time: 639.07 %
    CPU stolen time: 1.09 %
    Effective VM Speed: 18737 MHz
    Host processor speed: 2932 MHz

    Limit: unlimited
    Reservation: 0 MHz
    Shares: 6000
```

```
[root@oracle-vm1 vmguestlib]# ./vmguest-stats -c | egrep 'Proc
    Processor Time: 627.54 %
    CPU stolen time: 0.80 %
    Processor Time: 595.20 %
    CPU stolen time: 0.50 %
    Processor Time: 684.35 %
    CPU stolen time: 0.50 %
    Processor Time: 653.78 %
    CPU stolen time: 0.60 %
    Processor Time: 586.93 %
    CPU stolen time: 0.50 %
    Processor Time: 681.80 %
    CPU stolen time: 0.70 %
    Processor Time: 607.68 %
```

vmguest-stats

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```
[root@oracle-vm1 vmguestlib]# ./vmguest-stats -c | egrep 'Processor Time|CPU stolen time'
     Processor Time: 658.49 %
     CPU stolen time: 0.83 %
     Processor Time: 653.23 %
     CPU stolen time: 0.20 %
     Processor Time: 672.85 %
     CPU stolen time: 0.60 %
     Processor Time: 606.09 %
     CPU stolen time: 0.30 %
     Processor Time: 729.38 %
     CPU stolen time: 0.50 %
     Processor Time: 613.57 %
     CPU stolen time: 2.99 %
     Processor Time: 620.96 %
     CPU stolen time: 0.70 %
     Processor Time: 677.84 %
     CPU stolen time: 0.20 %
     Processor Time: 651.60 %
     CPU stolen time: 0.80 %
     Processor Time: 673.25 %
     CPU stolen time: 26.35 %
     Processor Time: 498.80 %
     CPU stolen time: 134.50 %
     Processor Time: 477.25 %
     CPU stolen time: 150.70 %
     Processor Time: 476.75 %
     CPU stolen time: 147.90 %
     Processor Time: 463.11 %
     CPU stolen time: 167.40 %
     Processor Time: 487.55 %
     CPU stolen time: 158.37 %
     Processor Time: 452.34 %
     CPU stolen time: 158.92 %
     Processor Time: 468.36 %
     CPU stolen time: 173.65 %
```

```
Processor Time: 651.60 %
CPU stolen time: 0.80 %
Processor Time: 673.25 %
CPU stolen time: 26.35 %
Processor Time: 498.80 %
CPU stolen time: 134.50 %
```

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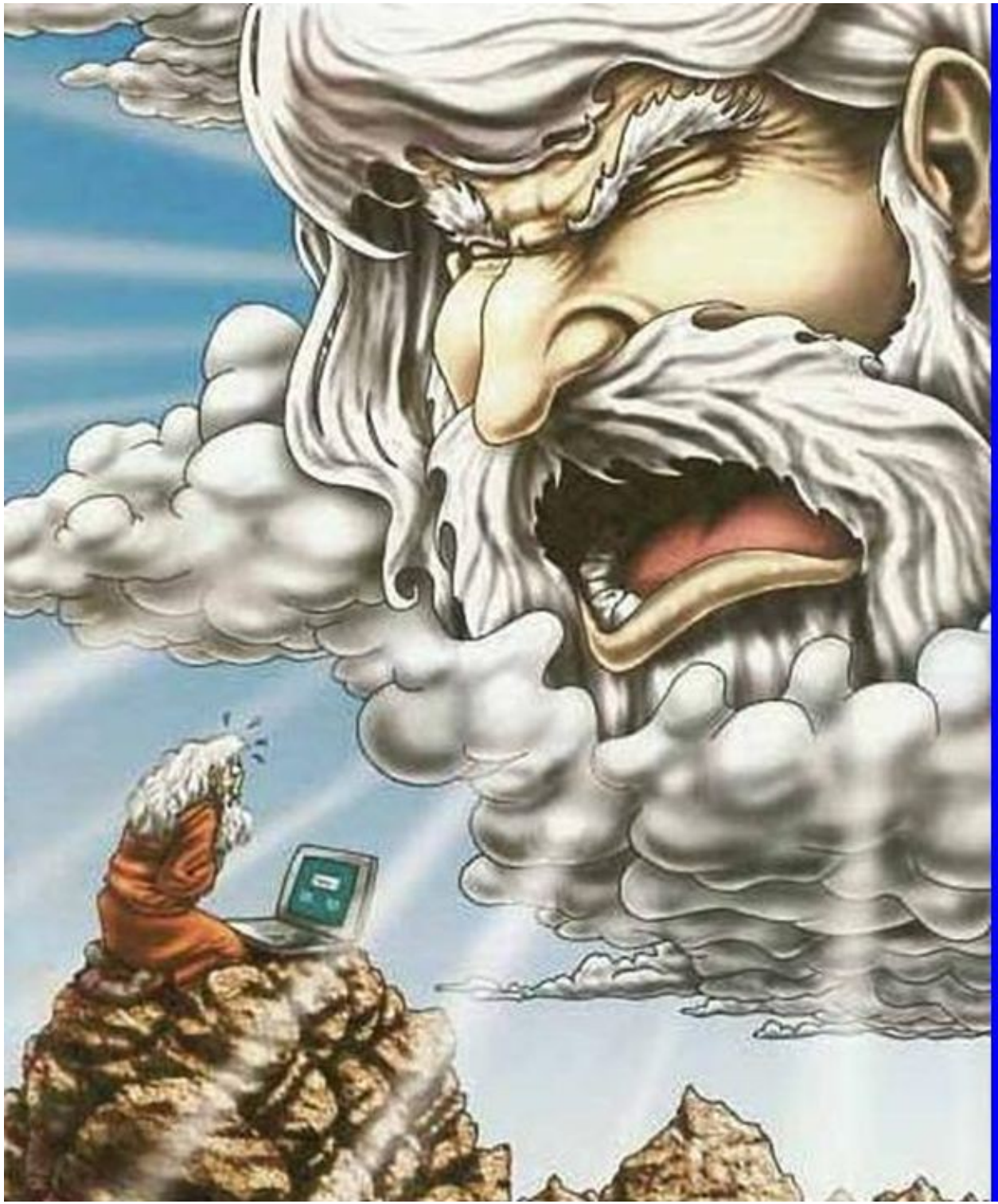
Countermeasures



©ms

Abgestürzt ???

Schon wieder ???!!!

Jetzt reicht´s mir aber !

Ich werde die Erfindung des Computers um 3000 Jahre verschieben !!

Und die 10 Gebote kannst du von mir aus in Steintafeln ritzen, Moses !!!

Ten Commandments for OLTP on VMware

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And the Lord said:

1) Thou shalt not overcommit your machine!
2) Thou shalt not use Hyperthreading, because HTT is CPU overcommitment
3) Thou shalt make 100% CPU + RAM reservations
4) Thou shalt disable CPU Hot Add (enable breaks vNUMA)
5) Thou shalt disable RAM Hot Add (enable breaks vNUMA)
6) Thou shalt not use more vCores in your VM than a NUMA node of the host has
7) Thou shalt not use more RAM in your VM than a NUMA node of the host has
8) Thou shalt configure VMs to Latency Sensitivity „HIGH“
9) Thou shalt disable all BIOS based Energy Saving Options
10) Thou shalt use Paravirtual Drivers at any cost

And peace be on earth.

(More) Ressource Consumption

Makes you (more) vulnerable

Speaker

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- Martin Klier
- Solution Architect and Database Expert

- My focus
  - Performance Optimization
  - High Availability
  - Architecture DBMS

- Linux since 1997
- Oracle Database since 2003

Speaker

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- Meet & Greet

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Israel Oracle User Group
ארגון משתמשי אורקל בישראל
Tel Aviv, January 2018

IOUG
Independent oracle users group
COLLABORATE
Las Vegas, April 2018

IT-Tage 2017
Frankfurt, December 2018

DOAG
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- Contact: martin.klier@performing-db.com
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Q & A

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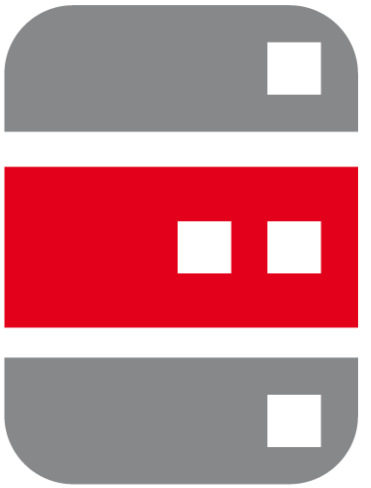

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