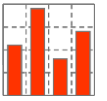


Performance Baseline of Oracle Exadata X2-2 HR HC

Part I: CPU Performance

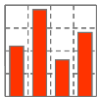
Benchmark Performance Suite Release 8.4 (Build 130630)

June 2013



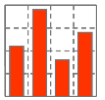
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CPU Performance



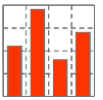
Why measure CPU Performance?

- CPU performance has a huge impact on
 - performance of most database operations
 - Oracle license (*core factor*) and maintenance cost - even with Unlimited License Agreement (ULA)



What is measured?

- CPU performance from the Oracle point of view
 - Pure processor performance
 - Including level 1, 2, 3 cache
 - No memory access
 - No I/O operations
- Speed of single thread
 - Elapsed time [s] for algorithms
 - Operations per second [ops]
- Maximum throughput of system
 - Operations per second [ops]
- Scalability
 - Throughput per process for $n = \{1, 2, 4, 8, \dots, n\}$
- Efficiency of
 - Multi threading
 - Virtualization
 - Encryption

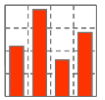


How is CPU Performance measured?

- Following data types are most important for Oracle applications
 - PLS_INTEGER
 - NUMBER (no direct mapping to hardware data type)
 - VARCHAR2
 - DATE

- Benchware uses Oracle data types in PL/SQL to measure the performance characteristics of a CPU
 - PL/SQL is the most powerful transaction programming language
 - Some important core applications are completely written in PL/SQL

CPU Performance



Overview of CPU performance tests with Test Codes

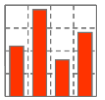
Oracle CPU Performance	Test Code for SIMPLE_INTEGER	Test Code for SIMPLE_FLOAT	Test Code for PLS_INTEGER	Test Code for NUMBER	Test Code for VARCHAR2
▪ Basic numeric operations	CPU-11	CPU-12	CPU-13	CPU-14	-

Oracle CPU Performance	Test Code for SIMPLE_INTEGER	Test Code for SIMPLE_FLOAT	Test Code for PLS_INTEGER	Test Code for NUMBER	Test Code for VARCHAR2
▪ Mixed operations with SQL built in functions	-	CPU-22	CPU-23	CPU-24	CPU-25

Oracle CPU Performance	Test Code for SIMPLE_INTEGER	Test Code for SIMPLE_FLOAT	Test Code for PLS_INTEGER	Test Code for NUMBER	Test Code for VARCHAR2
▪ Fibonacci numbers n = {39, 40, 41, 42}	-	-	-	CPU-34	-
▪ Prime numbers [2'000'000, 2'001'000]	-	-	-	CPU-44	-

Remarks:

- All CPU performance tests are using level 1, 2, 3 CPU cache and are therefore CPU bound.
- The Benchware Performance Suite uses optional encrypted tablespace to test the impact of encryption to performance.



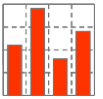
Remarks on other benchmark tools . . .

- SAP, TPC, Swingbench, Hammerora, ...
 - No specific CPU performance tests for Oracle database operations with Oracle data types , e.g. with data type NUMBER, VARCHAR2, DATE

- SPEC, CPUbench, ...
 - No specific CPU performance tests for Oracle database operations with Oracle data types, e.g. with data type NUMBER, VARCHAR2, DATE

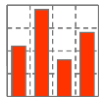
Remarks:

- *Application developers appreciate the very unique characteristics of the Oracle numeric data type NUMBER, therefore most Oracle applications use this data type as their standard numerical data type.*
- *The data type NUMBER uses a binary coded decimal implementation. This method can not be directly mapped to hardware data types and causes a lot of overhead. The performance of arithmetic operations with the data type NUMBER is therefore by factors slower than native data types like SIMPLE_INTEGER.*
- *Oracle implemented a specific software library for each processor architecture to handle numeric operations with the data type NUMBER. During our benchmarks, we experienced that the performance of the data type NUMBER does not correlate with industry standard SPEC benchmark results.*



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CPU and Server Configuration



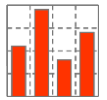
CPU architecture

CPU	Intel Xeon X5675	System A to compare	System B to compare
Launch Date	Q1 2011		
Frequency [GHz]	3.06 - 3.46		
#cores per socket	6		
#threads per core	2		
Performance numbers from other Benchmarks			
SPECint_base2006 (speed)	40.8		
SPECint_base_rate_2006 (throughput)	361		
Oracle CPU speed in sys.aux_stats\$	2795		

Remark:

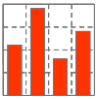
- Oracle has an internal estimation about CPU speed in sys.aux_stats\$, but none estimation about CPU throughput.
- This value does not correlate with SPECint_base2006

CPU and Server Configuration



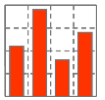
Server configuration

Server	One Exadata X2-2 Database Server	System A to compare	System B to compare
CPU type	Intel Xeon X5675		
#sockets	2		
#cores	12		
#threads	24		
Oracle Licensing			
Oracle core license factor	x 0.5		
Oracle license cost in USD <small>(list price 25th of June 2013)</small>			
▪ Enterprise Edition (47'500)	285'000		
▪ RAC Option (23'000)	138'000		
▪ Partition Option (11'500)	69'000		
▪ Diagnostic Pack (5'000)	30'000		
▪ Tuning Pack (5'000)	30'000		
Total Oracle license cost	552'000		

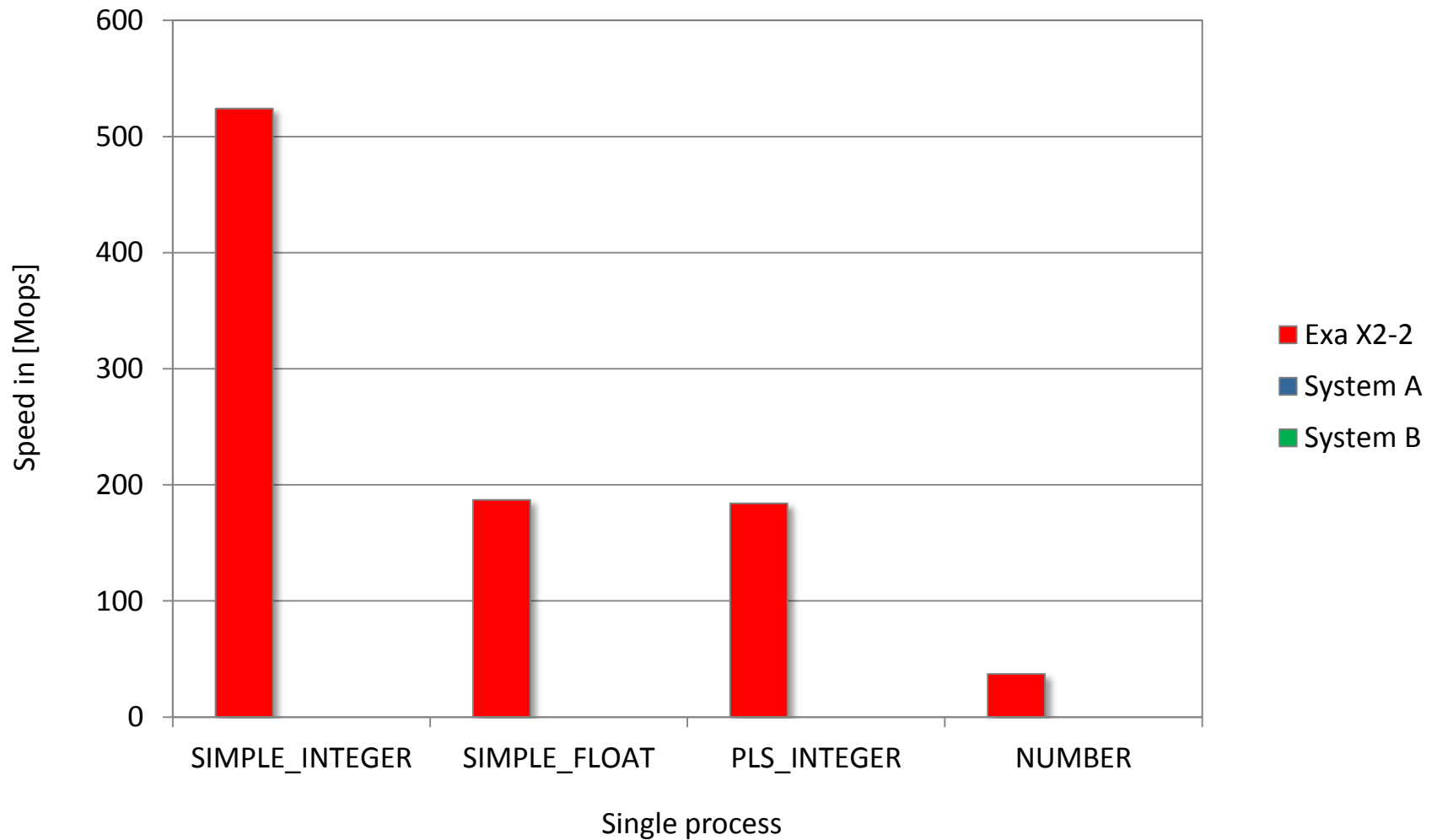


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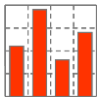
CPU Performance



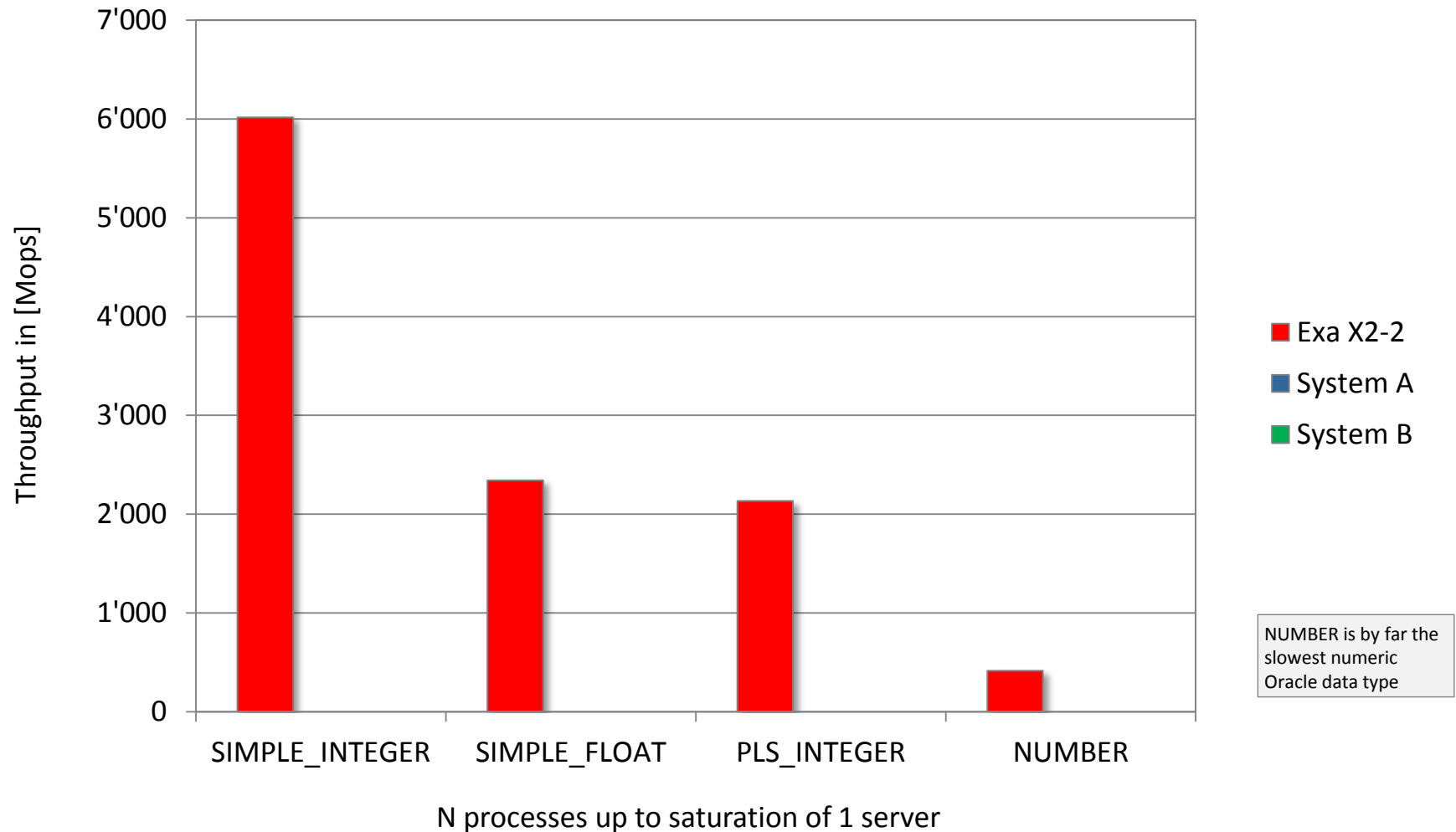
Speed of arithmetic ADD operation, different Oracle data types



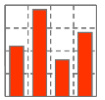
CPU Performance



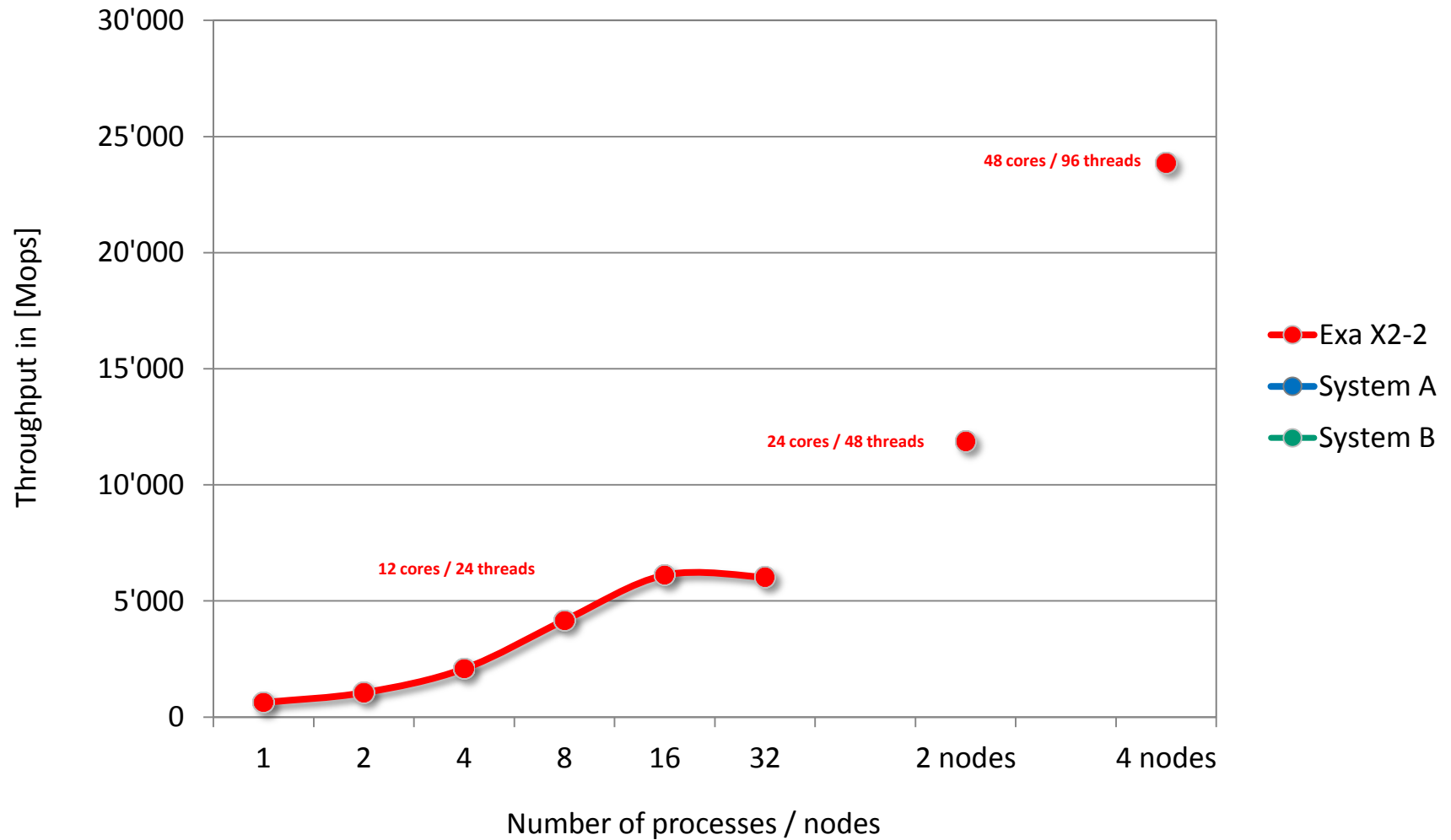
Throughput of arithmetic ADD operation, different Oracle data types



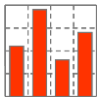
CPU Performance



Oracle CPU performance on data type SIMPLE_INTEGER add operation



CPU Performance



Oracle CPU performance on data type SIMPLE_INTEGER add operation

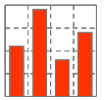
Intel Xeon
X5675 3.06 GHz

Run	Tst	Code	#N	#J	#T	CPU busy [%]	CPU user [%]	CPU sys [%]	CPU idle [%]	Throughput ops/sec [ops]	Elap time [s]
1	1	CPU-11	1	1	1	2	1	0	98	5.246E+08	122
	2	CPU-11	1	2	1	3	2	0	97	1.049E+09	122
	3	CPU-11	1	4	1	5	4	0	95	2.081E+09	123
	4	CPU-11	1	8	1	9	9	0	91	4.163E+09	123
	5	CPU-11	1	16	1	17	17	0	83	6.112E+09	125
	6	CPU-11	1	32	1	25	25	0	75	6.016E+09	128
	7	CPU-11	2	64	1	49	49	0	51	1.188E+10	128
	8	CPU-11	4	128	1	98	97	0	2	2.386E+10	128

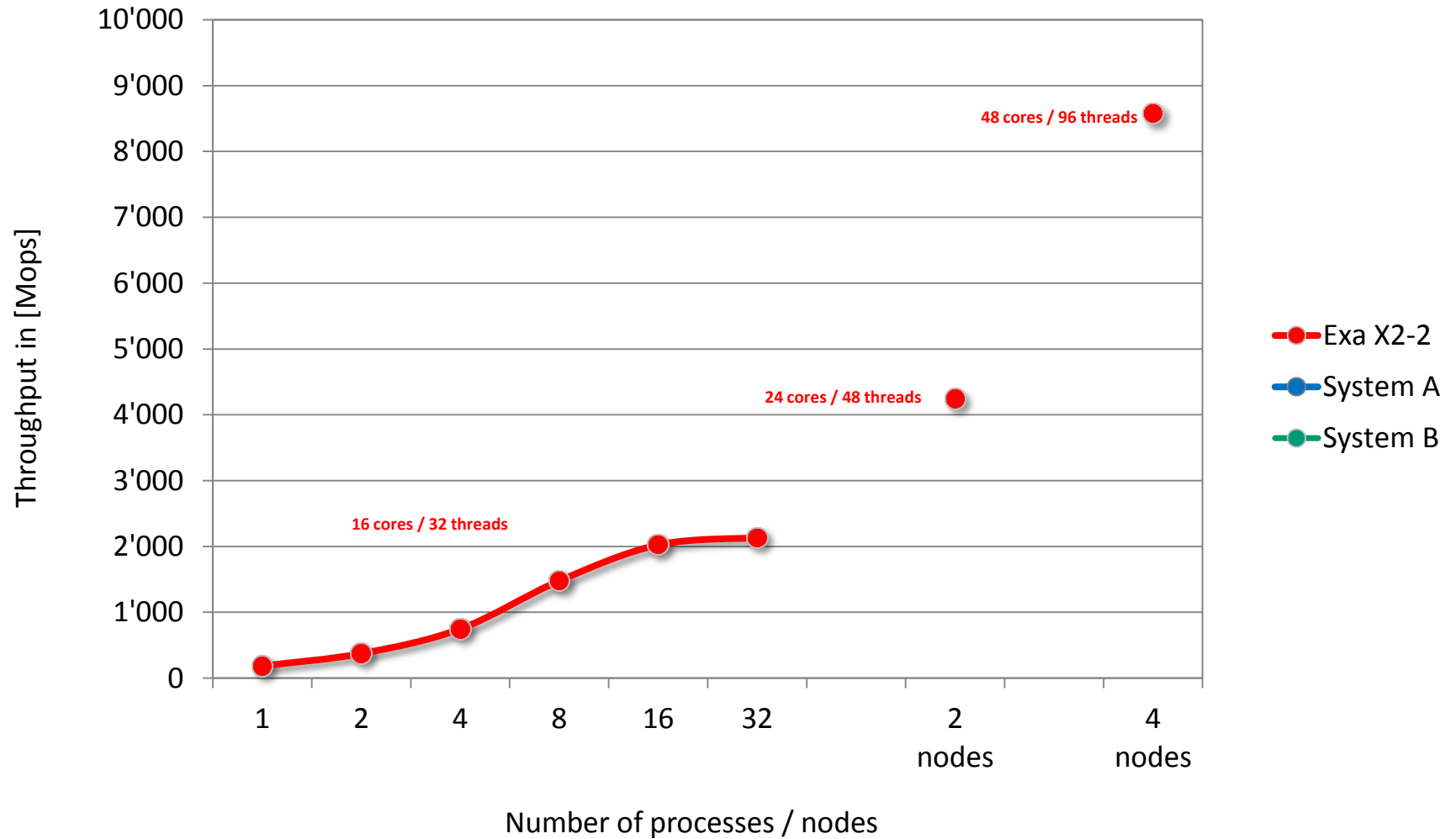
Legend:

- #N number of RAC nodes
- #J number of jobs
- #T number of threads (PX)
- [s] elapsed time in seconds
- [ops] operations per second

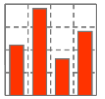
CPU Performance



Oracle CPU performance on data type PLS_INTEGER add operation



CPU Performance



Oracle CPU performance on data type PLS_INTEGER add operation

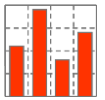
Intel Xeon
X5675 3.06 GHz

Run	Tst	Code	#N	#J	#T	CPU busy [%]	CPU user [%]	CPU sys [%]	CPU idle [%]	Throughput ops/sec [ops]	Elap time [s]
1	17	CPU-13	1	1	1	2	1	0	98	1.848E+08	92
	18	CPU-13	1	2	1	3	2	0	97	3.736E+08	91
	19	CPU-13	1	4	1	5	4	0	95	7.473E+08	91
	20	CPU-13	1	8	1	9	9	0	91	1.478E+09	92
	21	CPU-13	1	16	1	16	16	0	84	2.024E+09	123
	22	CPU-13	1	32	1	25	25	0	75	2.132E+09	125
	23	CPU-13	2	64	1	49	49	0	51	4.242E+09	126
	24	CPU-13	4	128	1	99	98	0	1	8.580E+09	125

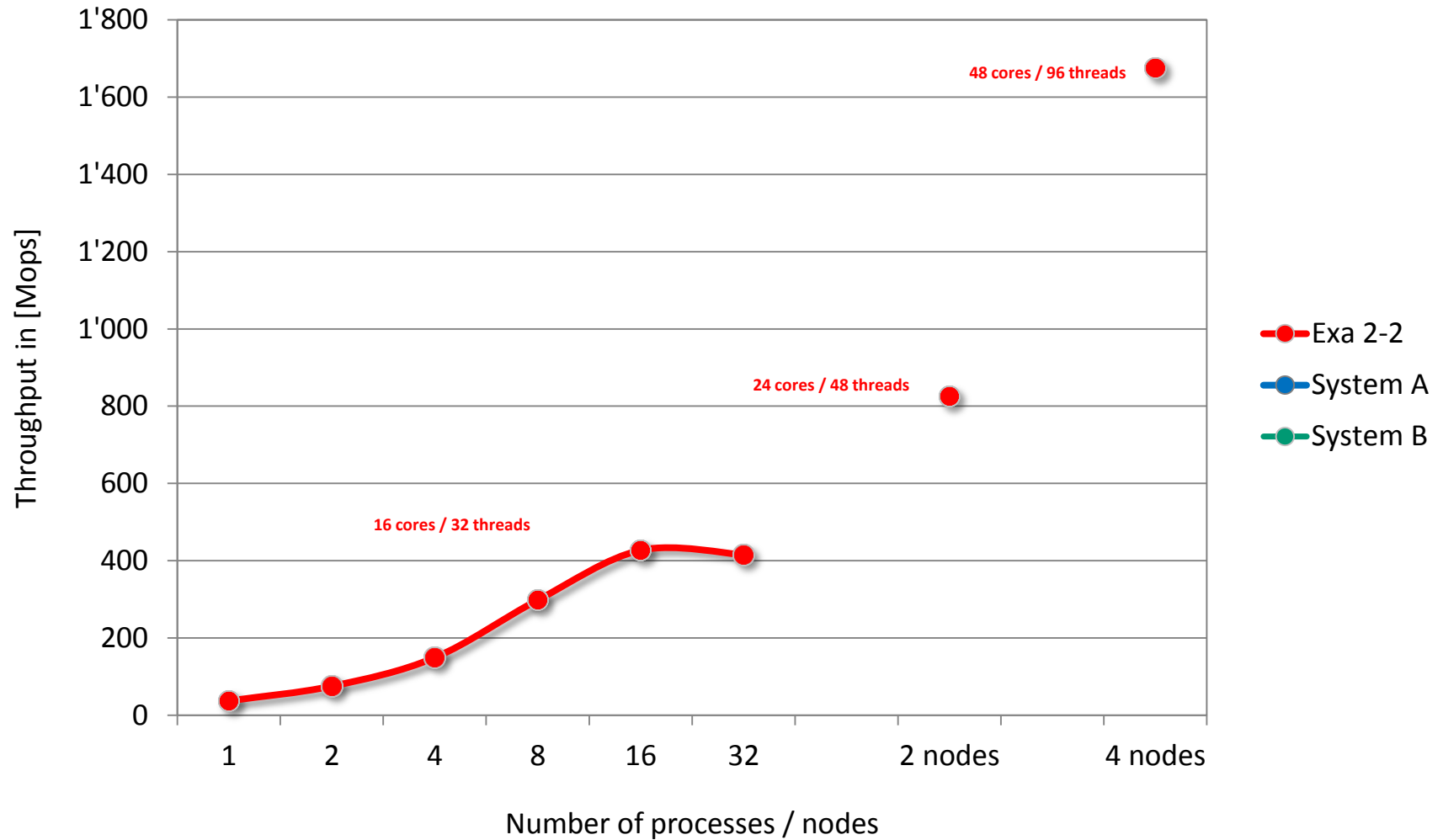
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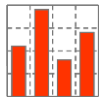
CPU Performance



Oracle CPU performance on data type NUMBER add operation



CPU Performance



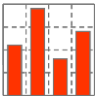
Oracle CPU performance on data type NUMBER add operation

Intel Xeon
X5675 3.06 GHz

Run	Tst	Code	#N	#J	#T	CPU busy [%]	CPU user [%]	CPU sys [%]	CPU idle [%]	Throughput ops/sec [ops]	Elap time [s]
1	25	CPU-14	1	1	1	2	2	0	98	3.756E+07	123
	26	CPU-14	1	2	1	3	2	0	97	7.512E+07	123
	27	CPU-14	1	4	1	5	4	0	95	1.490E+08	124
	28	CPU-14	1	8	1	9	9	0	91	2.981E+08	124
	29	CPU-14	1	16	1	17	17	0	83	4.277E+08	125
	30	CPU-14	1	32	1	25	25	0	75	4.157E+08	129
	31	CPU-14	2	64	1	49	49	0	51	8.263E+08	128
	32	CPU-14	4	128	1	98	98	0	2	1.675E+09	127

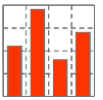
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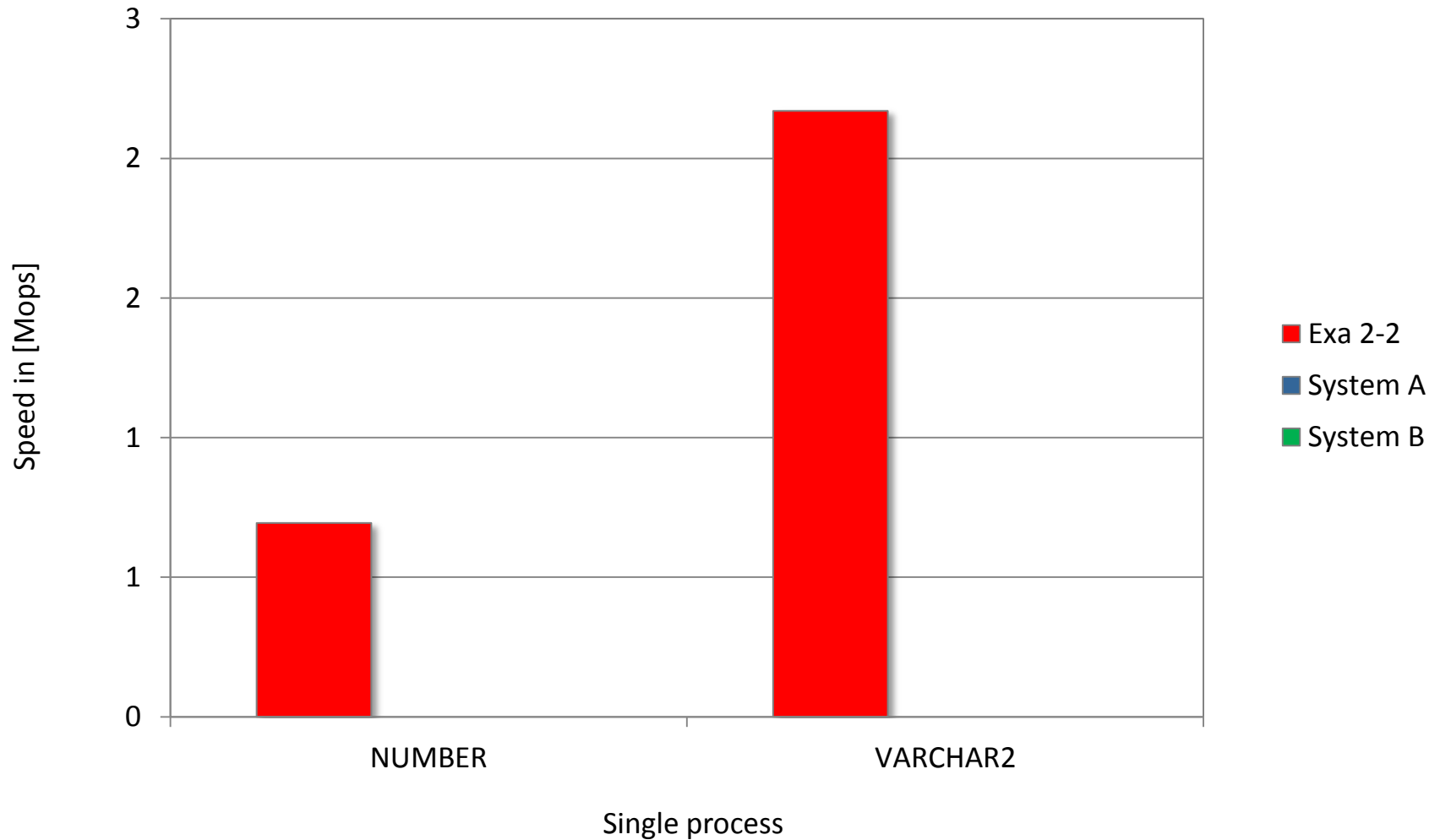


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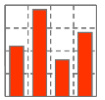
CPU Performance



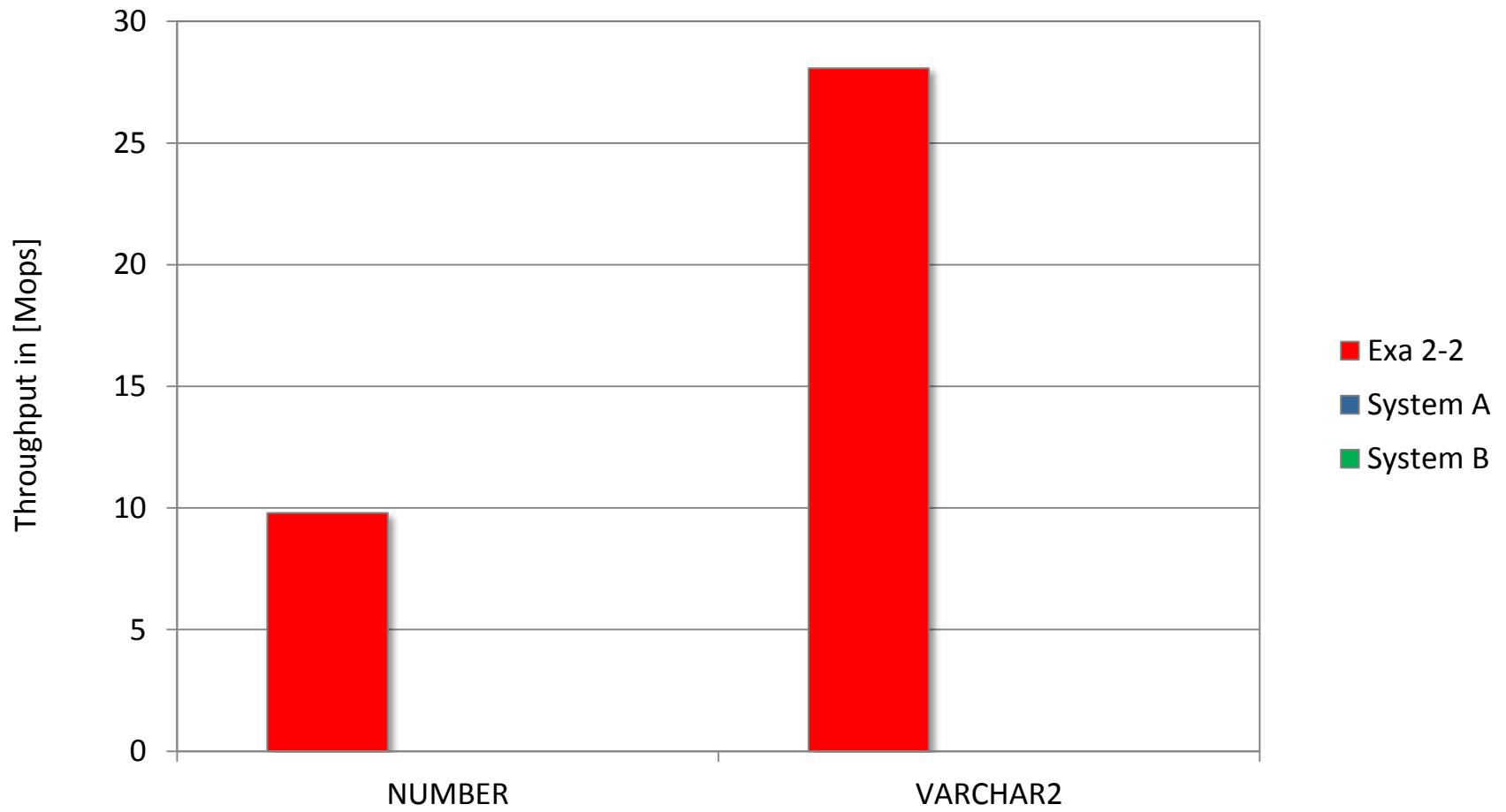
Speed of mixed arithmetic operations, different Oracle data types



CPU Performance

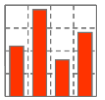


Throughput of mixed arithmetic operations, different Oracle data types

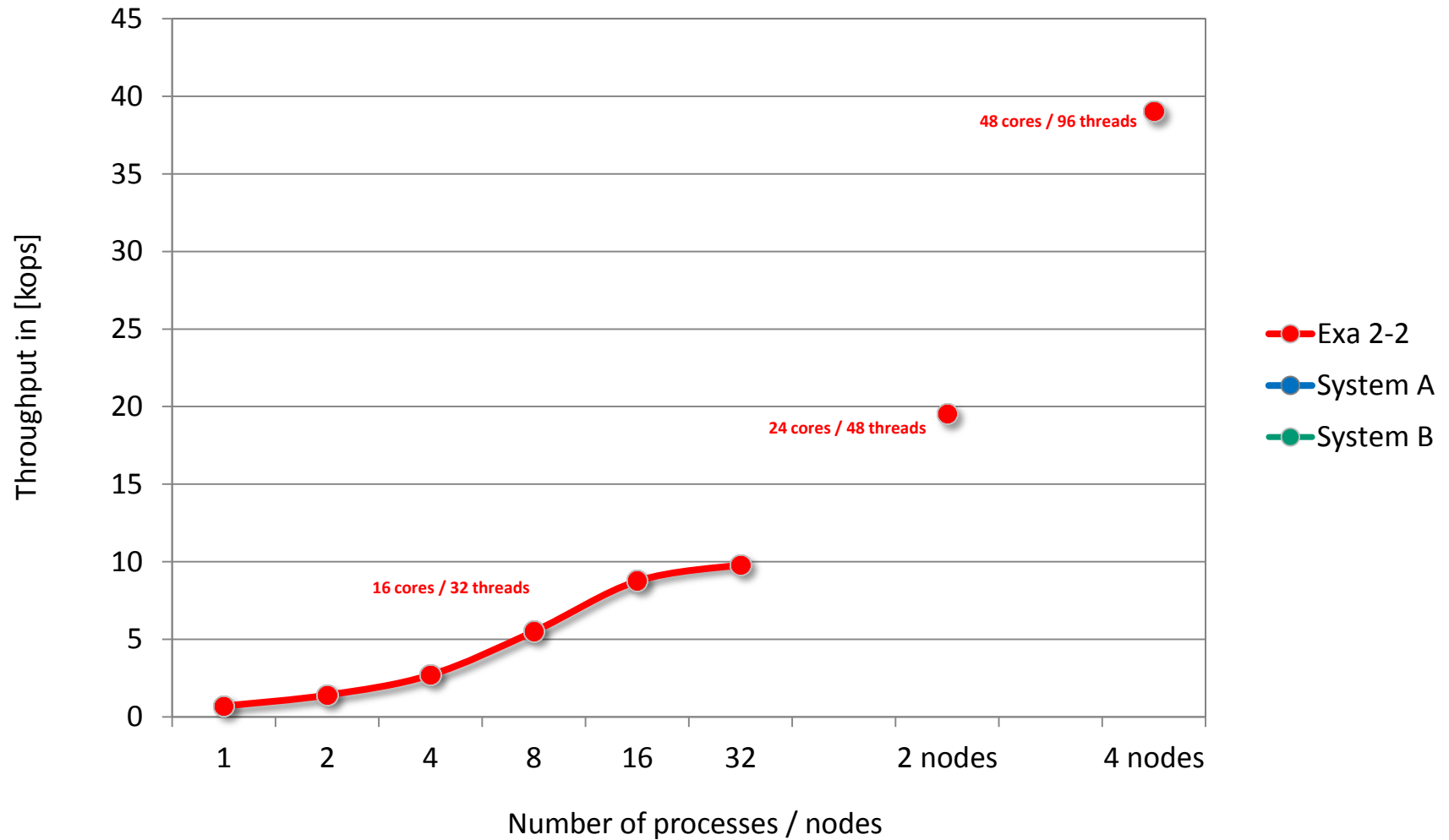


N processes up to saturation of 1 server

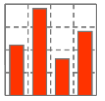
CPU Performance



Oracle CPU performance on data type NUMBER mixed operations



CPU Performance



Oracle CPU performance on data type NUMBER mixed operations

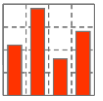
Intel Xeon
X5675 3.06 GHz

Run	Tst	Code	#N	#J	#T	CPU busy [%]	CPU user [%]	CPU sys [%]	CPU idle [%]	Throughput ops/sec [ops]	Elap time [s]
1	49	CPU-24	1	1	1	2	1	0	98	6.942E+05	121
	50	CPU-24	1	2	1	3	3	0	97	1.400E+06	120
	51	CPU-24	1	4	1	5	4	0	95	2.777E+06	121
	52	CPU-24	1	8	1	9	9	0	91	5.508E+06	122
	53	CPU-24	1	16	1	17	17	0	83	8.756E+06	127
	54	CPU-24	1	32	1	25	25	0	75	9.798E+06	129
	55	CPU-24	2	64	1	49	49	0	51	1.953E+07	129
	56	CPU-24	4	128	1	97	97	0	3	3.902E+07	130

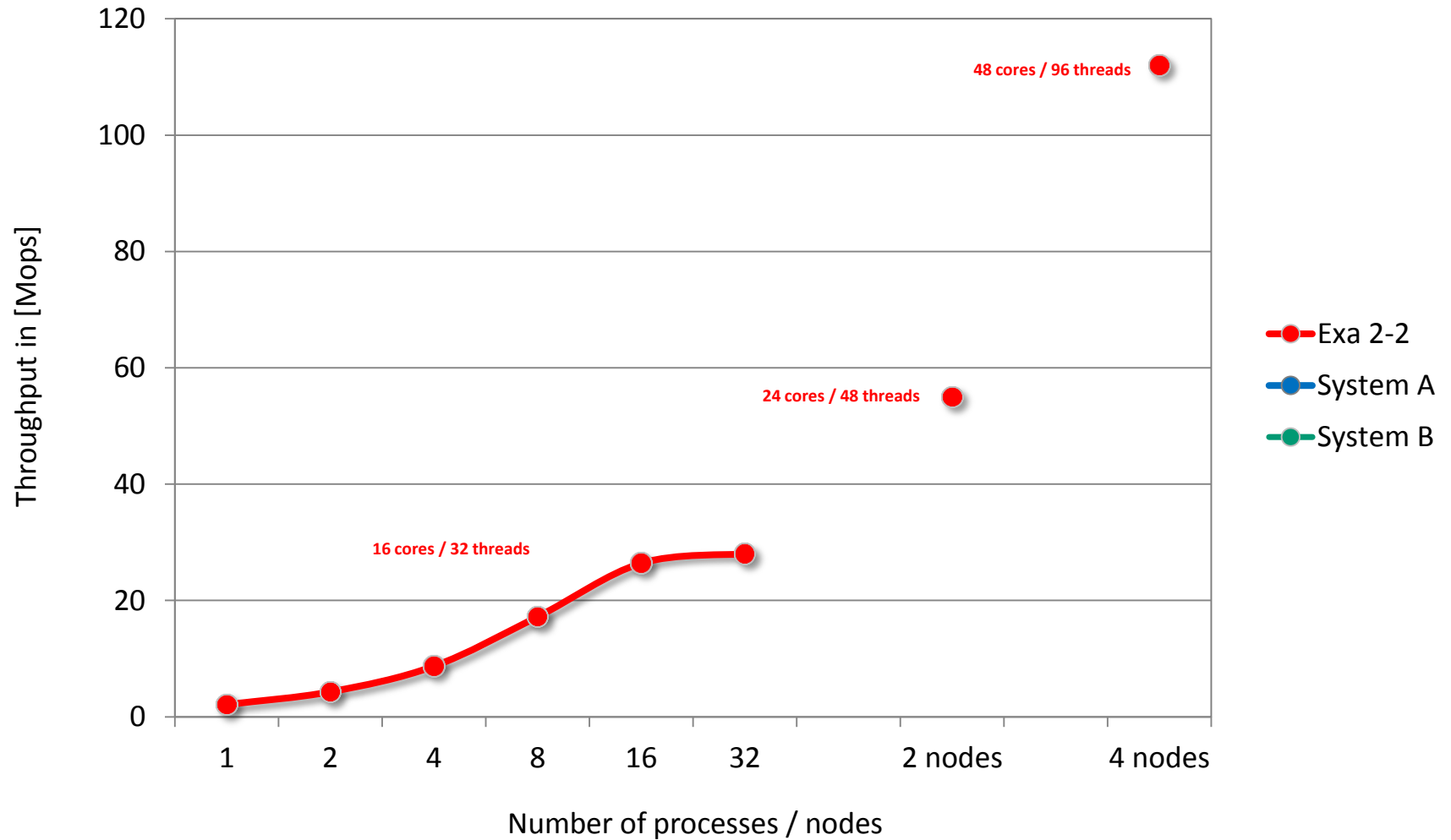
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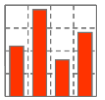
CPU Performance



Oracle CPU performance on data type VARCHAR2 mixed operation



CPU Performance



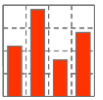
Oracle CPU performance on data type VARCHAR2 mixed operation

Intel Xeon
X5675 3.06 GHz

Run	Tst	Code	#N	#J	#T	CPU busy [%]	CPU user [%]	CPU sys [%]	CPU idle [%]	Throughput ops/sec [ops]	Elap time [s]
1	57	CPU-25	1	1	1	2	1	0	98	2.177E+06	124
	58	CPU-25	1	2	1	3	2	0	97	4.390E+06	123
	59	CPU-25	1	4	1	5	4	0	95	8.710E+06	124
	60	CPU-25	1	8	1	9	8	0	91	1.728E+07	125
	61	CPU-25	1	16	1	17	16	0	83	2.646E+07	127
	62	CPU-25	1	32	1	25	24	0	75	2.807E+07	132
	63	CPU-25	2	64	1	49	48	0	51	5.549E+07	133
	64	CPU-25	4	128	1	97	96	0	3	1.124E+08	131

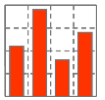
Legend:

- #N number of RAC nodes
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- #T number of threads (PX)
- [s] elapsed time in seconds
- [ops] operations per second

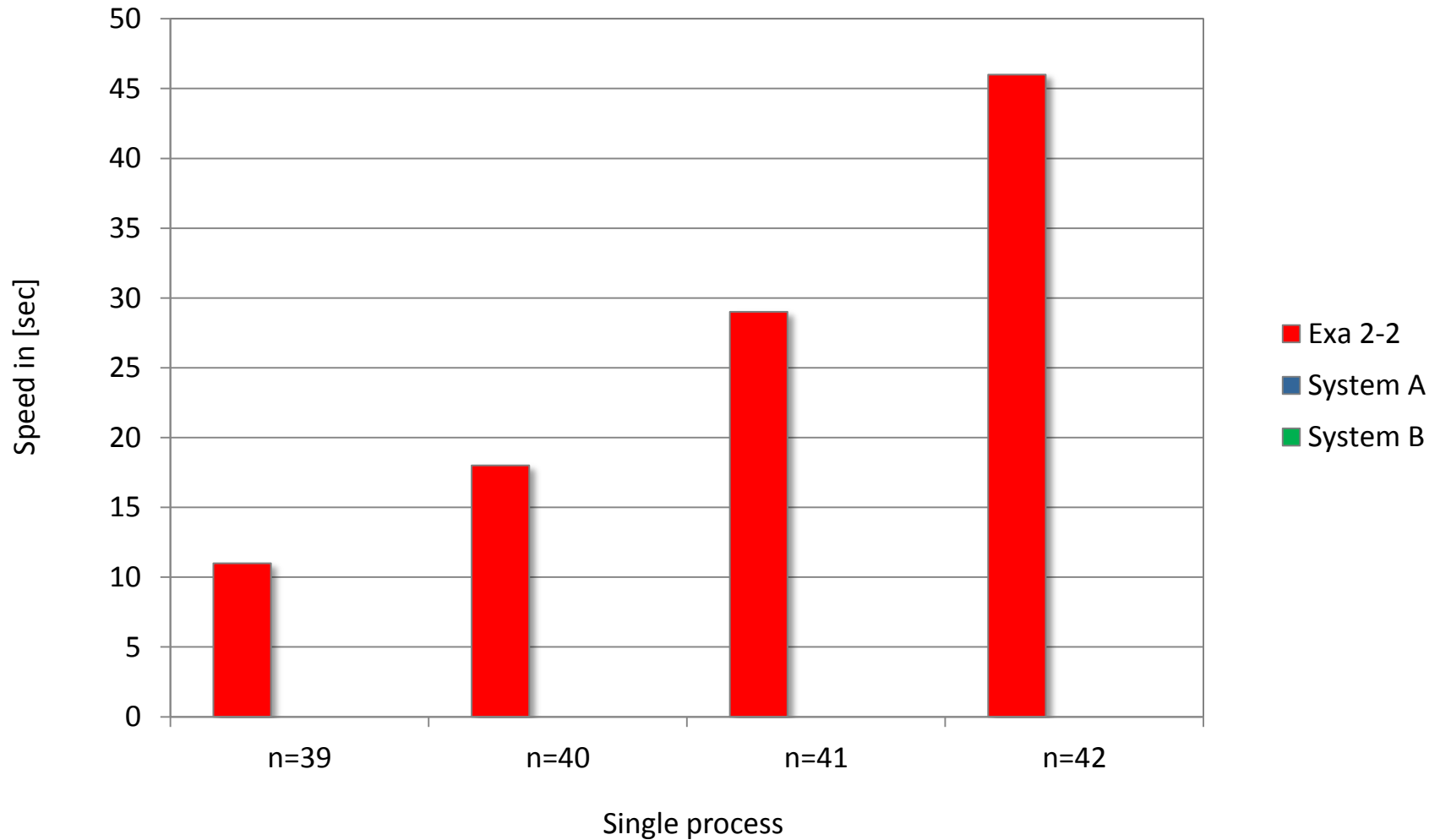


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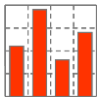
CPU Performance



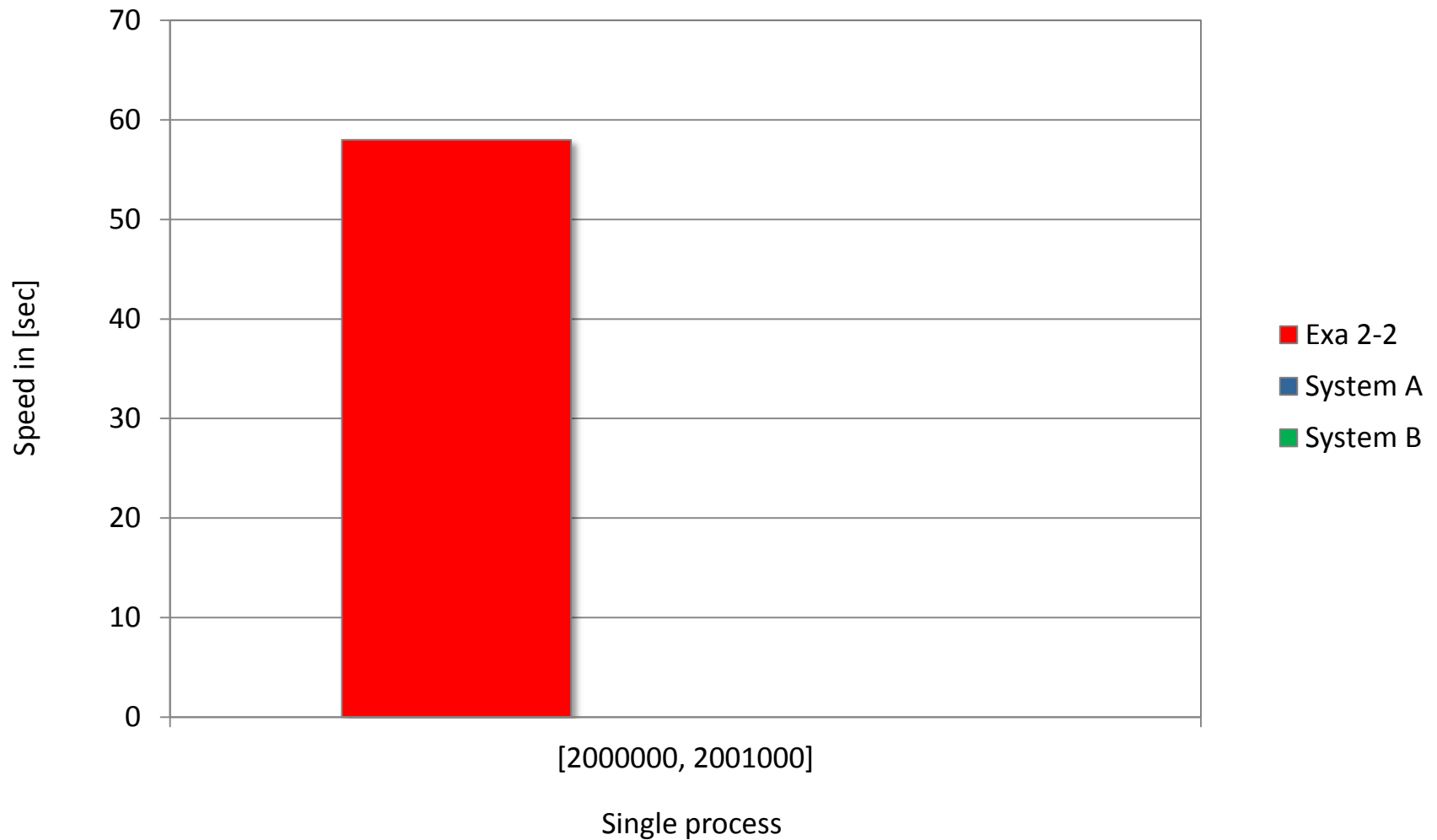
Calculation of fibonacci numbers

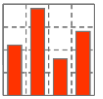


CPU Performance



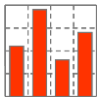
Calculation of prime numbers in given interval





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Performance Results



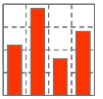
Reviewing CPU Performance

	Metric	One Exadata X2-2 Database Server	System A to compare	System B to compare
#cores		12		
#threads		24		
Basic arithmetic ADD operation	Metric	One Exadata X2-2 Database Server	System A to compare	System B to compare
Speed				
▪ SIMPLE_INTEGER	[Mops]	524		
▪ SIMPLE_FLOAT	[Mops]	187		
▪ PLS_INTEGER	[Mops]	184		
▪ NUMBER	[Mops]	37		
Throughput				
▪ SIMPLE_INTEGER	[Mops]	6'112		
▪ SIMPLE_FLOAT	[Mops]	2'341		
▪ PLS_INTEGER	[Mops]	2'132		
▪ NUMBER	[Mops]	427		

Legend:

[Mops] million operations per second

Performance Results



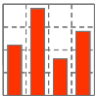
Reviewing CPU Performance

	Metric	One Exadata X2-2 Database Server	System A to compare	System B to compare
#cores		12		
#threads		24		
Mixed arithmetic operations	Metric	One Exadata X2-2 Database Server	System A to compare	System B to compare
Speed				
▪ SIMPLE_FLOAT	[Mops]	9.5		
▪ PLS_INTEGER	[Mops]	0.7		
▪ NUMBER	[Mops]	0.7		
Throughput				
▪ SIMPLE_FLOAT	[Mops]	125		
▪ PLS_INTEGER	[Mops]	9.7		
▪ NUMBER	[Mops]	9.7		

Legend:

[Mops] million operations per second

Performance Results



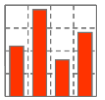
Reviewing CPU Performance

	Metric	One Exadata X2-2 Database Server	System A to compare	System B to compare
#cores		12		
#threads		24		
Mixed string operation	Metric	One Exadata X2-2 Database Server	System A to compare	System B to compare
Speed				
▪ VARCHAR2	[Mops]	2.1		
Throughput				
▪ VARCHAR2	[Mops]	28		

Legend:

[Mops] million operations per second

Performance Results



Reviewing CPU Performance

	Metric	One Exadata X2-2 Database Server	System A to compare	System B to compare
#cores		12		
#threads		24		
Algorithms	Metric	One Exadata X2-2 Database Server	System A to compare	System B to compare
Speed, calculation of fibonacci numbers				
▪ N = 39	[s]	11		
▪ N = 40	[s]	18		
▪ N = 41	[s]	29		
▪ N = 42	[s]	46		
Speed, calculation of prime numbers				
▪ Interval [2000000, 2001000]	[s]	58		

Legend:

[s] elapsed time in seconds

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