Comparing the Performance of S/390, HP and Sun

(Last update 22nd June 1999)

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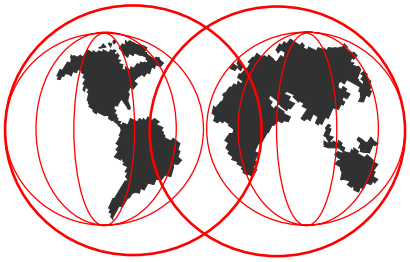


Topics

- Introduction
- Comparing the Performance of Different Architectures
- SMP curves
- HP T- and V-Class Comparisons
- Sun E10000 Comparisons
- Conclusions

UNIX Mentality

"Hardware is cheap"

- Low processor utilization
- Little emphasis on performance monitoring or tuning
- Use large memories to overcome I/O deficiencies
- Single application per server
- Don't worry about SMP ratios
- Little emphasis on workload management

"Distributed Client/Server is computing direction"

- Single application per server
- Little emphasis on workload management
- Multiple servers
- Separation of function within applications

S/390 Mentality

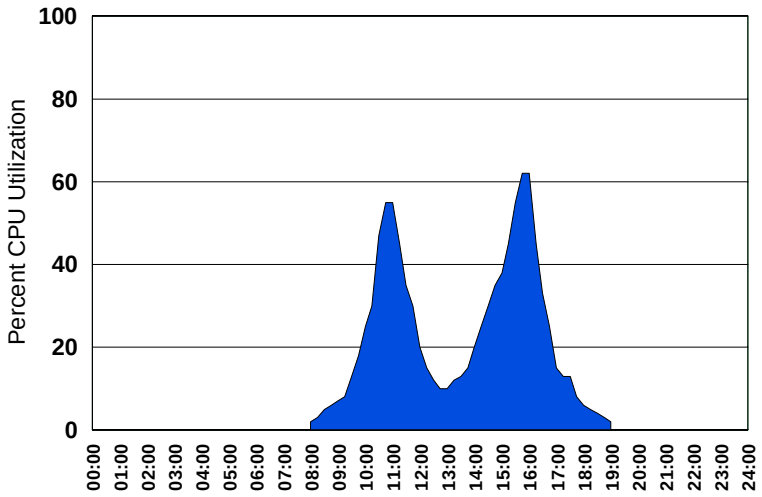
"Hardware is expensive"

- High processor utilizations
- Strong emphasis on performance monitoring and tuning
- Use large memories to reduce I/O and raise processor utilization
- Multiple applications per server
- Concerned about scalability for both SMPs and clusters
- Major emphasis on both SMP and cluster workload management

"People are expensive"

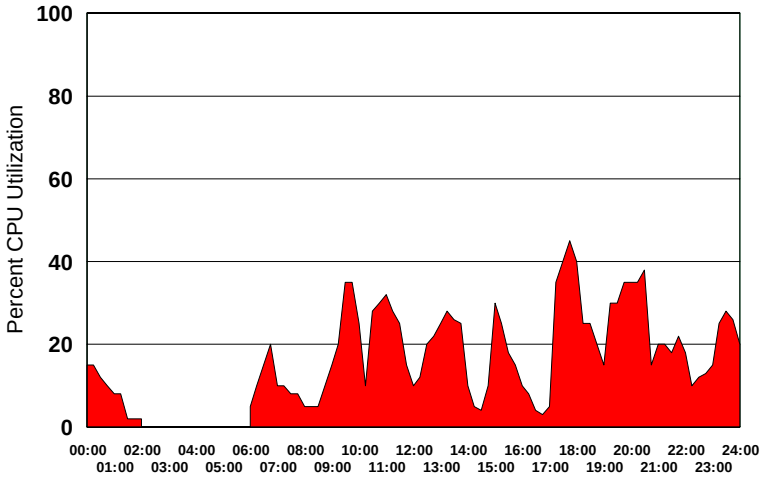
- Reduce number of systems to manage
- Automation of operations and workload management
- Multiple applications per server

Typical UNIX OLTP Profile



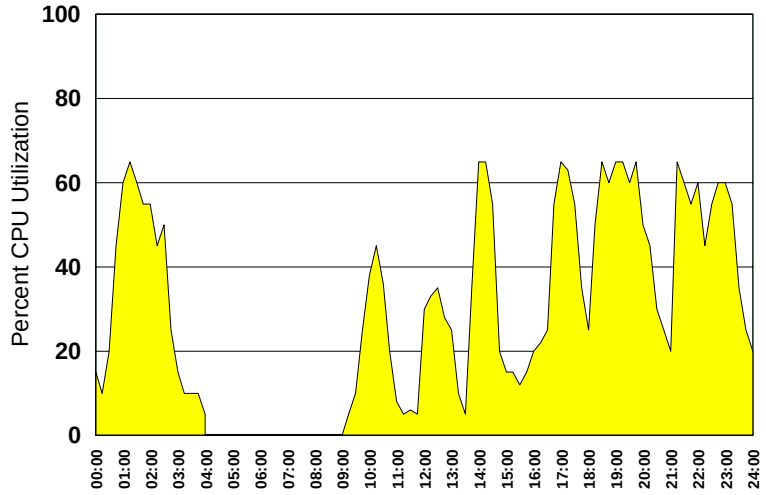
- Prime shift average utilization - 25%
- Peak utilization - 60%
- Double peak profile typical of in-house OLTP

Typical UNIX Batch Profile



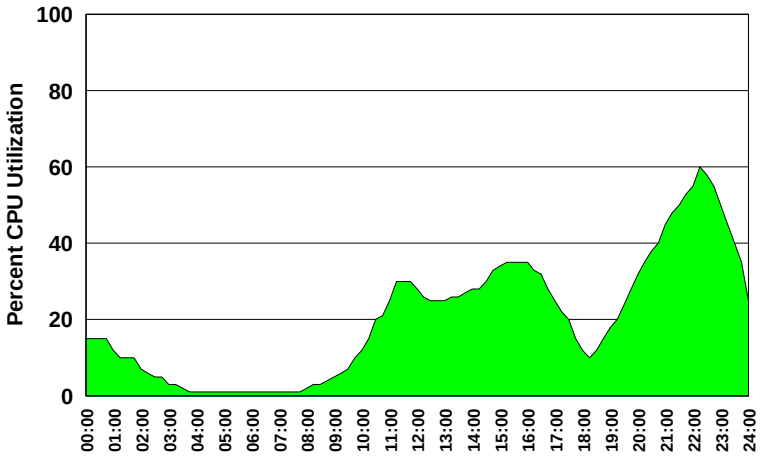
- Prime shift average utilization - 20%
- Assume single threading of batch jobs
- Large reporting/printing jobs follow completion of BI jobs on BI UNIX instance
- Database reorganizations/backups performed in 2nd shift

Typical UNIX Business Intelligence / Data Mining Profile



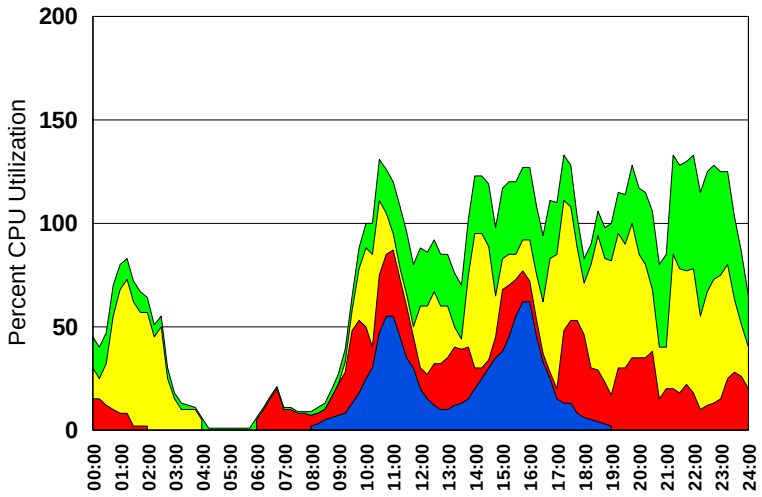
- Prime shift average utilization - 20%
- Peak utilization - 65%
- 24 hour average utilization approximately 30%
- Small jobs run in prime shift, large jobs in 2nd/3rd shift

Typical UNIX Web Server Profile



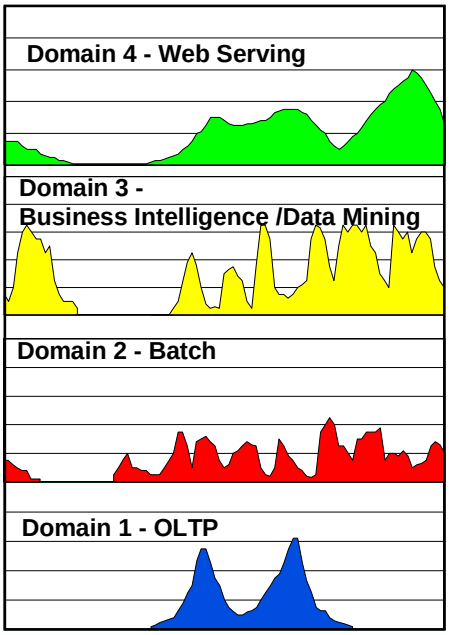
- Prime shift average utilization - 22%
- Peak utilization - 60%
- In-house and public use in prime shift
- Public use peaks between 22:00 and 24:00
- Usage extends after midnight due to time zones

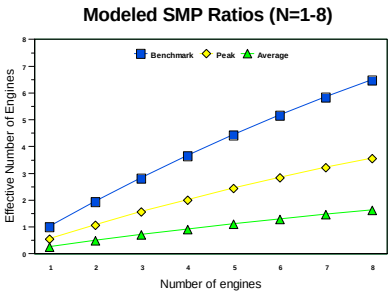
Hypothetical Server Consolidation



- If UNIX workloads **COULD** be run on a single instance, then would require a server approximately 1.33 x the capacity of a single server

Multiple UNIX Workloads using Domains

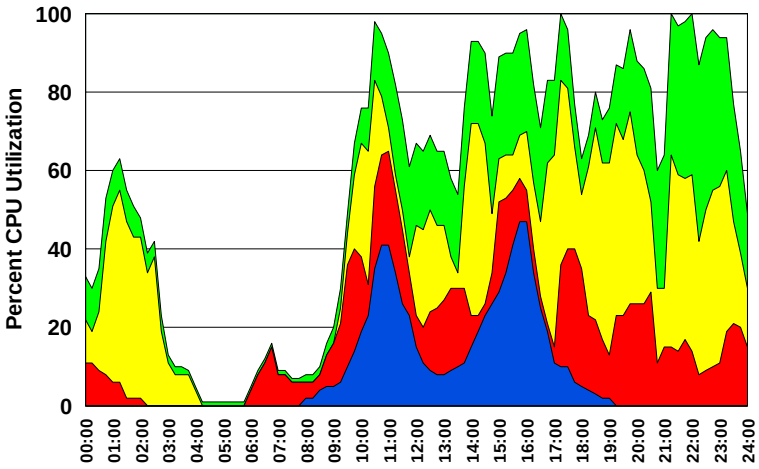




Assume 4 x 8-way domains

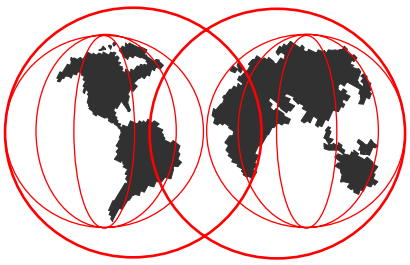
- Each domain is separate UNIX instance
- If average utilization is 25%, then a 32-way server offers only power of approximately a single 8-way
- No ability to use white space in other domains

Combined Workloads on a Single S/390



- Assume a S/390 server 1.33 x capacity of the UNIX servers
- All workloads run on a single instance of OS/390
- Prime shift average utilization - 69%, Peak utilization - 100%
- 24 hour average utilization - 57%
- OS/390 workload manager will allow additional work to fill 'white space'

Comparing Performance of Different Architectures



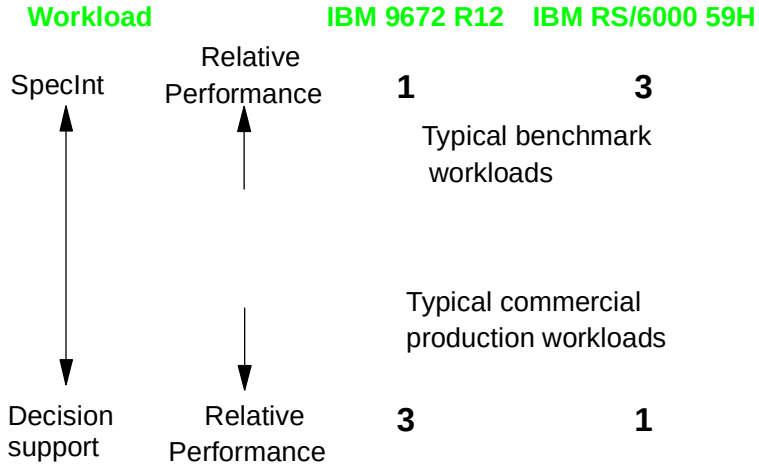
S/390 versus PCM Comparisons

Vendor	Processor	TSO	CBW2	DB2	Mixed	Variation
IBM						
	R26	210	215	226	215	+2.4 to +7.6%
	R56	505	560	564	540	+6.9 to +11.7%
	R86	689	874	815	784	+13.8 to +26.8%
Hitachi						
	SK-217	252	209	256	257	-17.1 to +2.0%
	SK-527	608	612	570	593	-6.4 to +0.6%
	SK-827	864	996	824	893	-4.6 to +15.3%

Scale based upon:
R53 = 100.0
Mixed workload of 15% TSO / 20% CICS / 20% IMS / 20% DB2 / 12.5% CB84 / 12.5% CBW2

A Single Number can be used to characterize performance

Spread of Benchmark Results versus UNIX



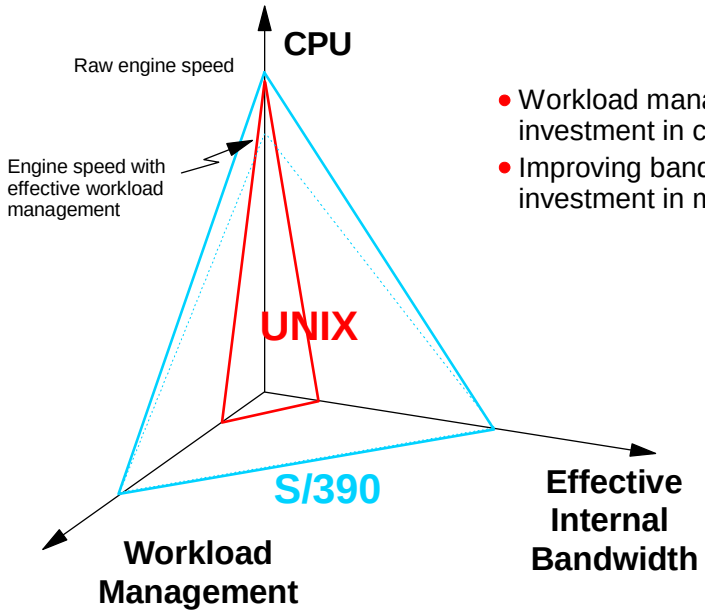
A single number **cannot** be used to characterize performance between architectures

Comparing Performance

Performance varies with:

- Workload
- SMP design
- Workload management

Three Axes of Performance

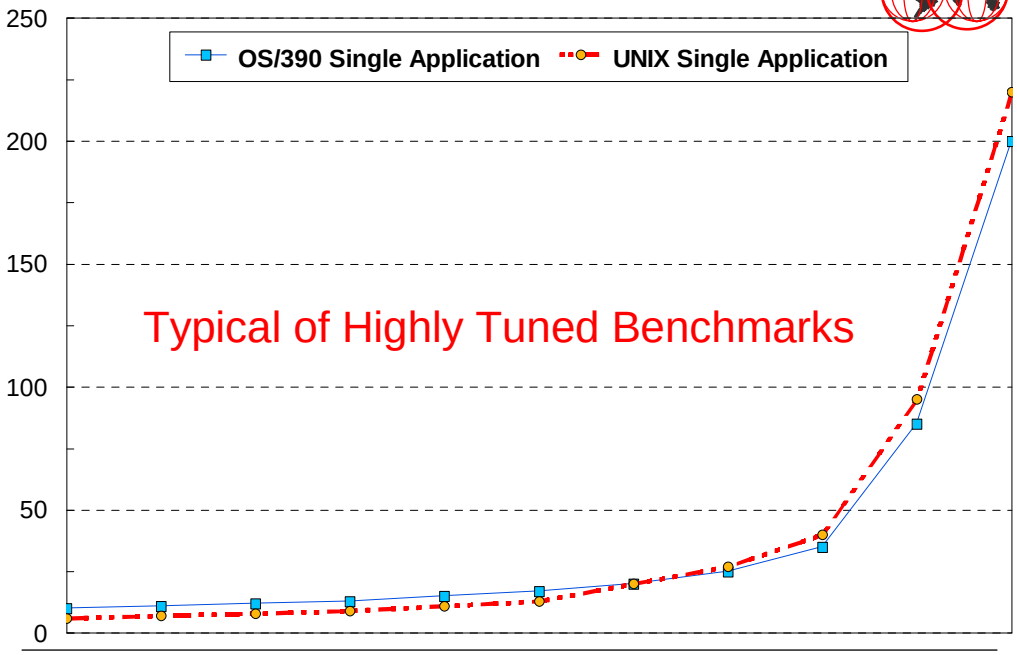


- Workload management requires investment in cycles
- Improving bandwidth requires investment in money

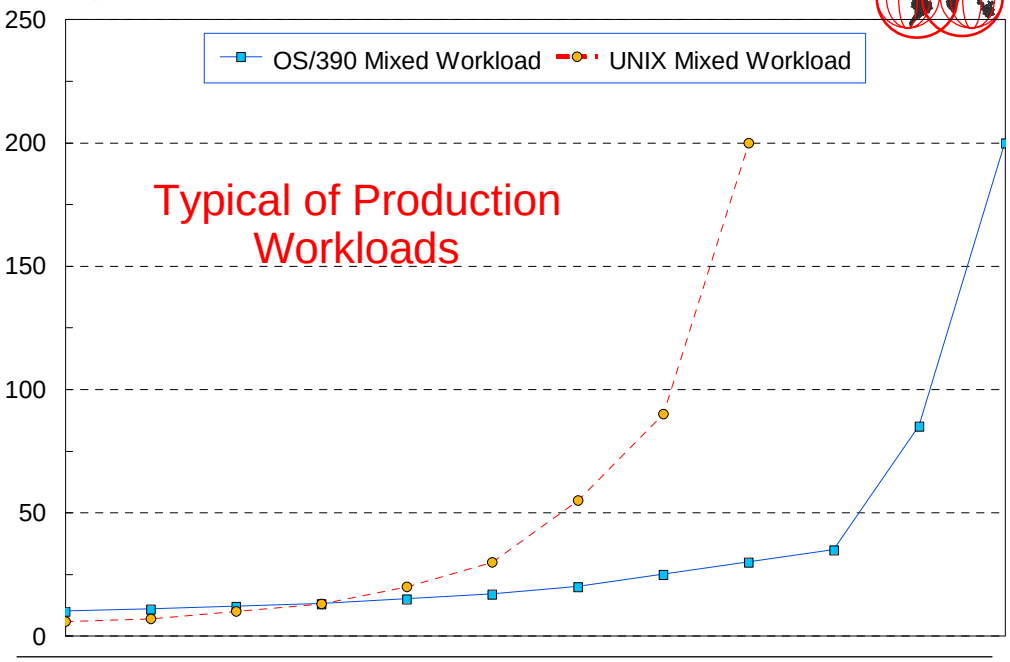
Benchmarks versus Production

- Benchmarks are:
  - Highly tuned
  - Vendor hardware and/or software may be optimized for the benchmark
  - Transaction arrival rates tend to be regular
  - I/O requests tend to be evenly distributed across paths and drives
  - Each transaction usually only has access to a small subset of the database
- Production workloads are:
  - Harder to tune unless O/S has good workload management tools
  - Vendor hardware/software optimization for benchmarks usually offers no benefit
  - Transaction arrival rates tend to be highly skewed
  - I/O requests tend to be highly skewed
  - Transaction database accesses are often scattered across large parts of the database

Single Application - Response Time versus Utilization



Mixed Workload - Response Time versus Utilization



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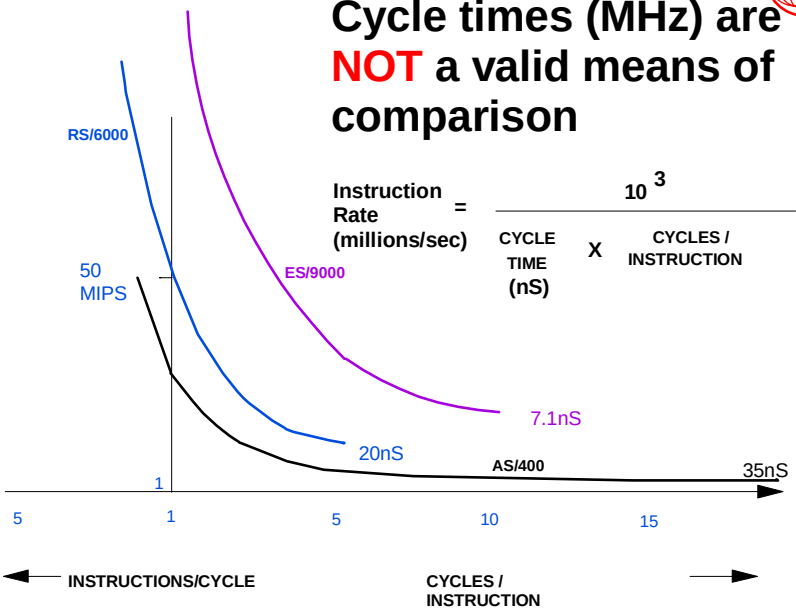
PROCESSOR PERFORMANCE

Cycle times (MHz) are NOT a valid means of comparison

$$\text{Instruction Rate (millions/sec)} = \frac{10^3}{\text{CYCLE TIME (nS)} \times \text{CYCLES / INSTRUCTION}}$$



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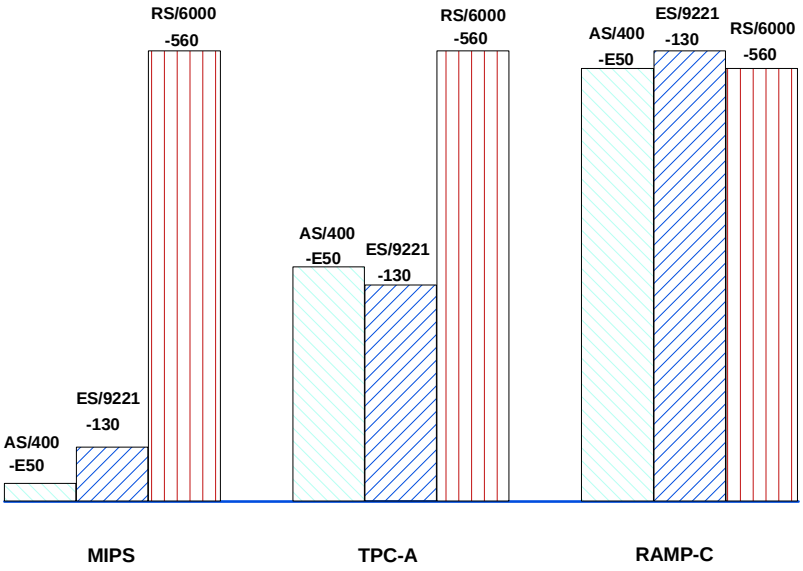
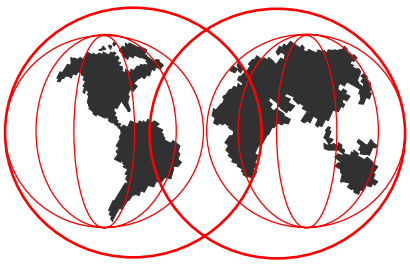
ARCHITECTURE AND PERFORMANCE



SMP Curves



Simple Model of an SMP

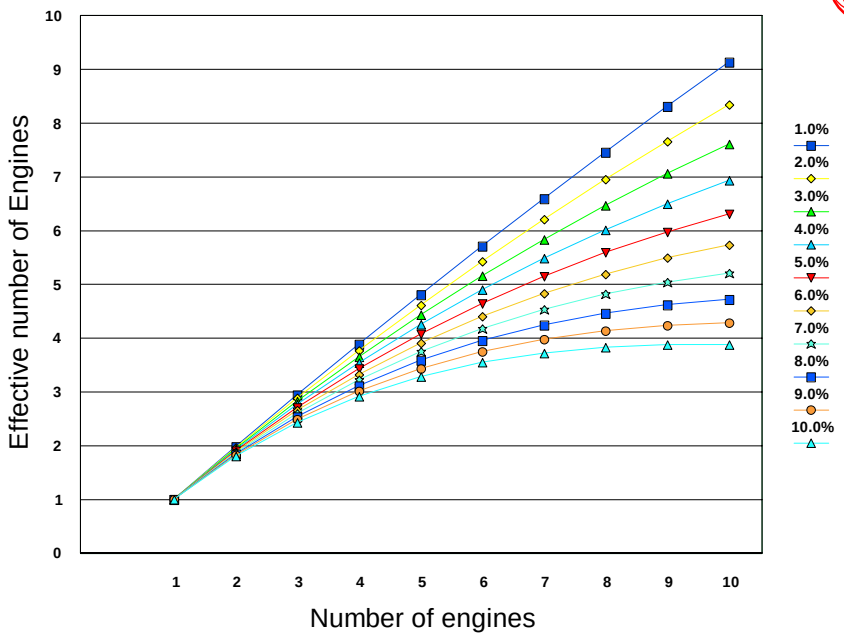
Effective number of engines

$$= N * (1\text{-hwd})^{(N-1)} * (1\text{-swd})^{(N-1)}$$

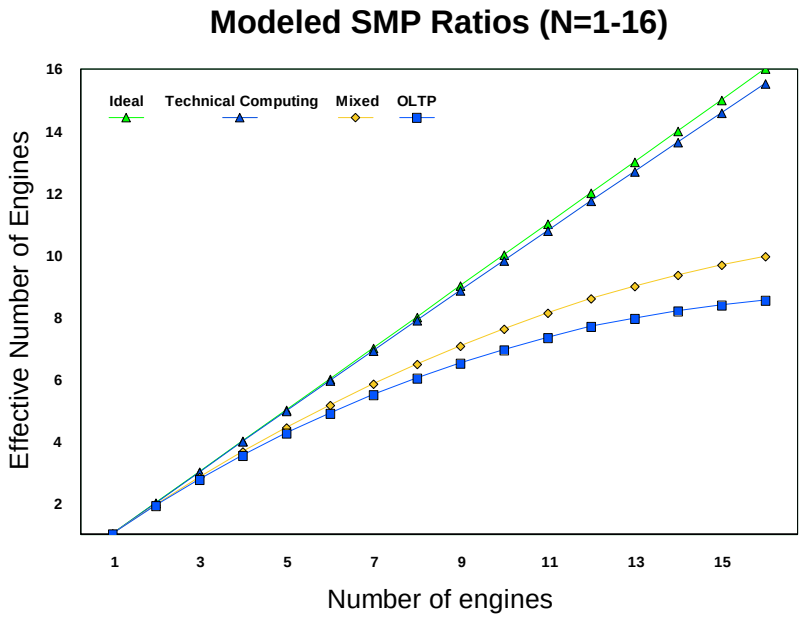
$$= N * (1\text{-MPeffect})^{(N-1)}$$

N	Number of engines in the SMP
hwd	MP degradation due to hardware
swd	MP degradation due to software
MPeffect	Total MP degradation (hardware x software)

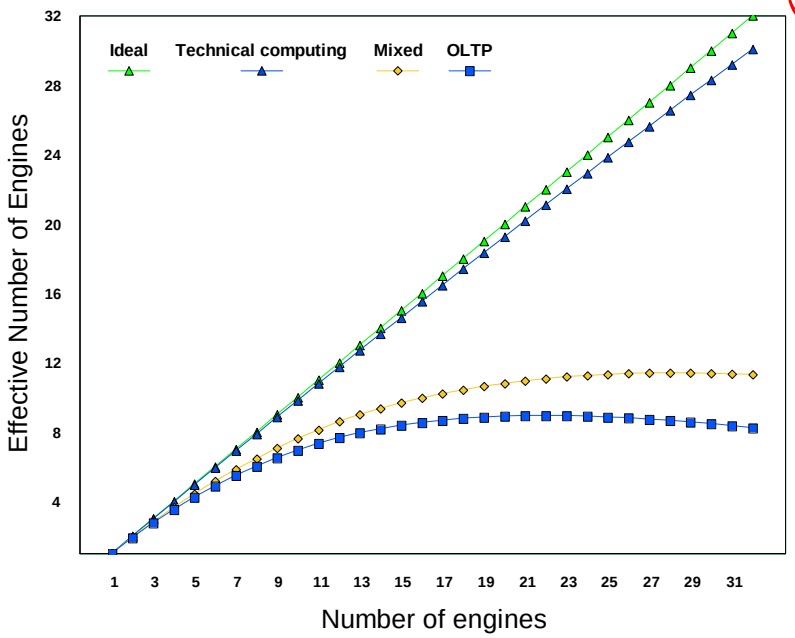
SMP Models



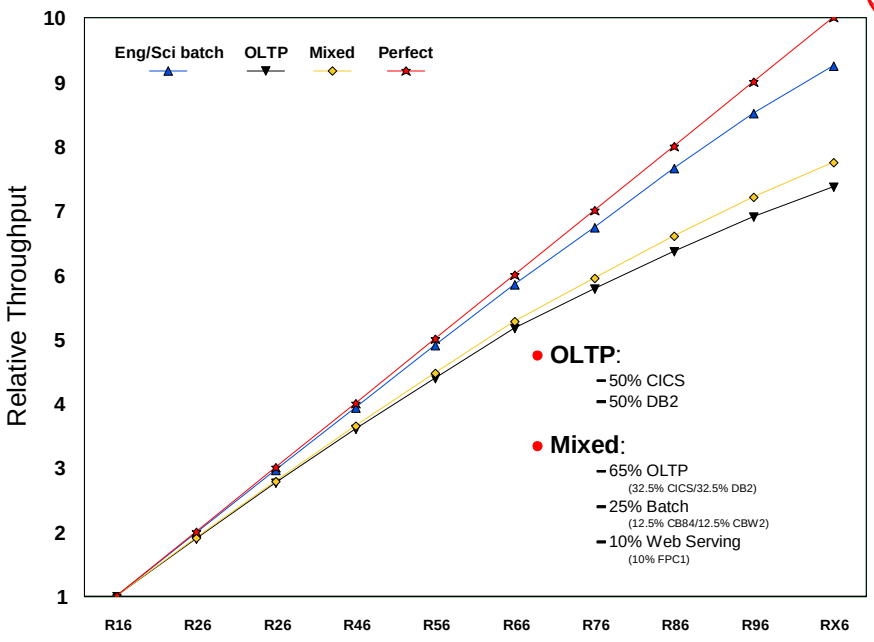
Modeled SMP Ratios (N=1-16)



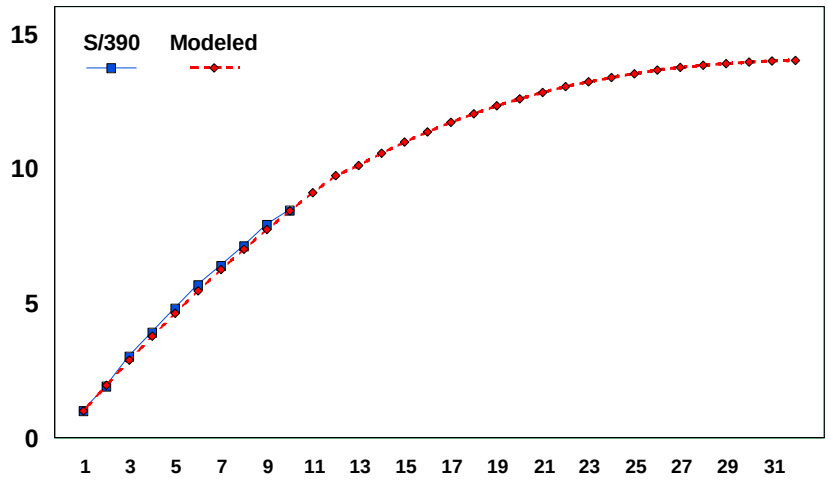
Modeled SMP Ratios (N=1-32)



SMP Ratios - 9672 G5

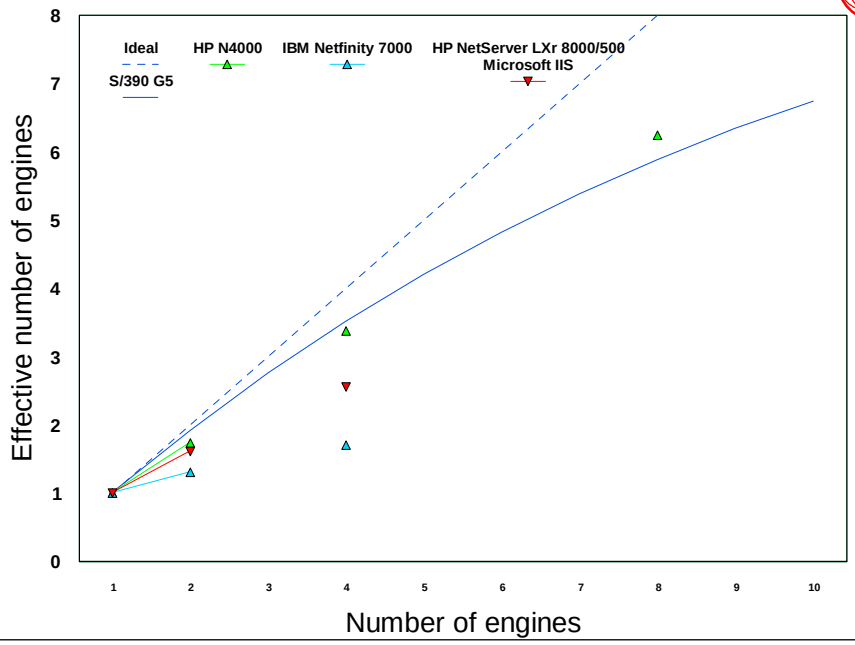


SMP Curve for Domino R4 Mail and S/390



Curve is for 20% TSO, 40% CB84 & 40% CBW2

SPECweb SMP Curves



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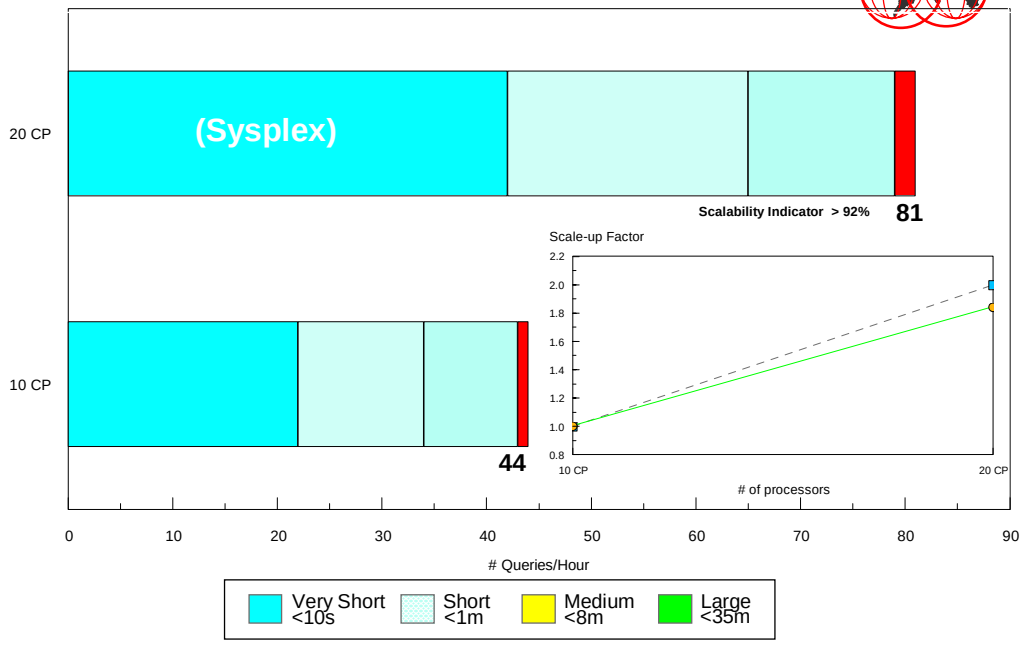
DB2 V5 on Parallel Sysplex
Scalability for Mixed Workloads



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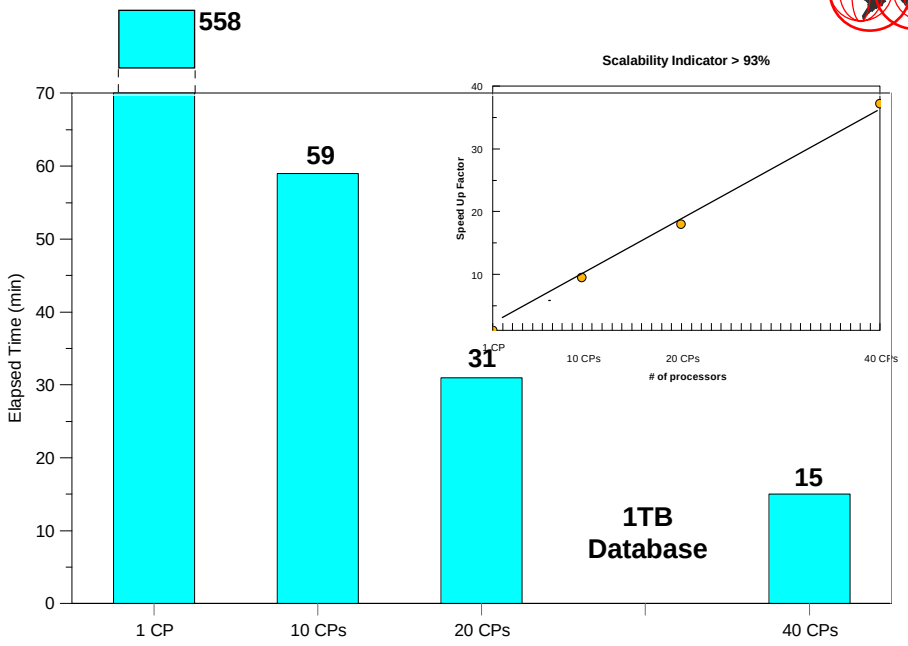
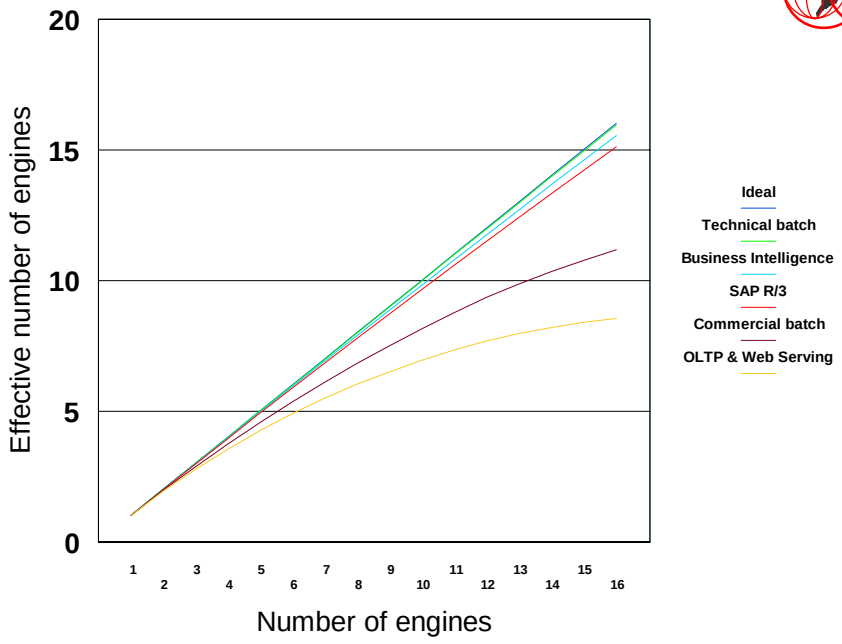
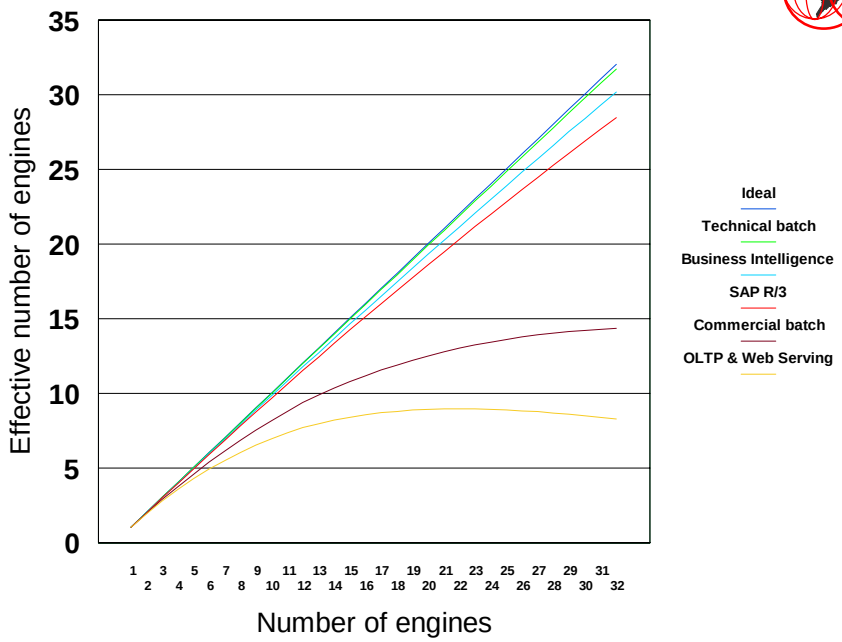
DB2 V5 Sysplex Scalability



SMP Scalability by Workload (1-16 engines)



SMP Scalability by Workload (1-32 engines)



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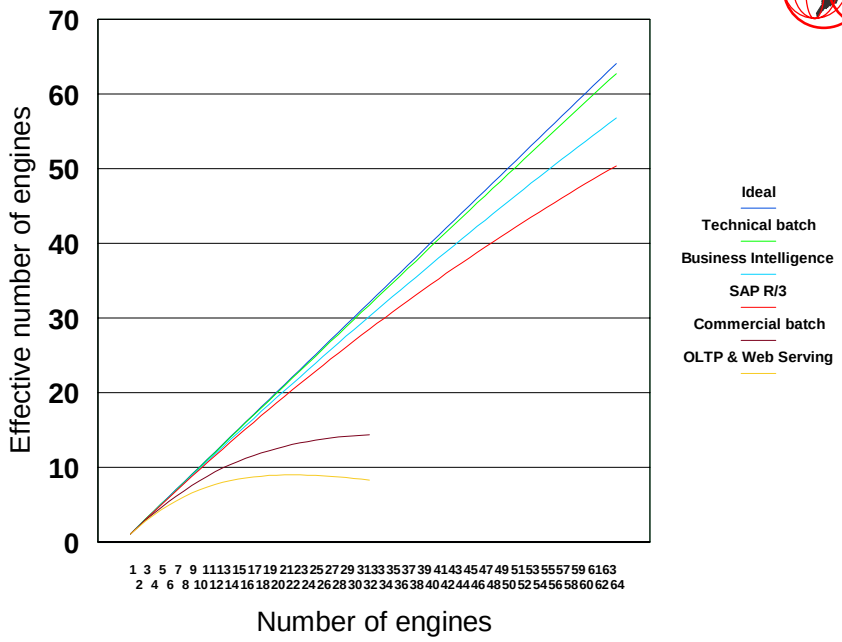
SMP Scalability by Workload (1-64 engines)



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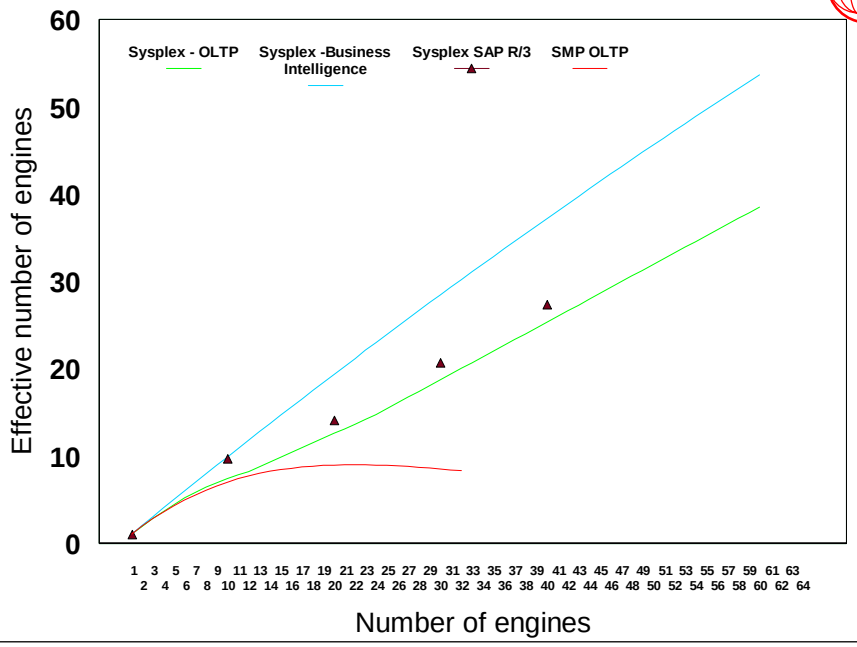
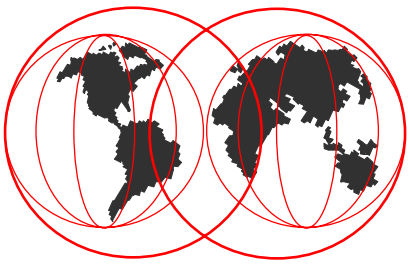
Parallel Sysplex Scalability



HP T-Class & V-Class Series Performance Assessment



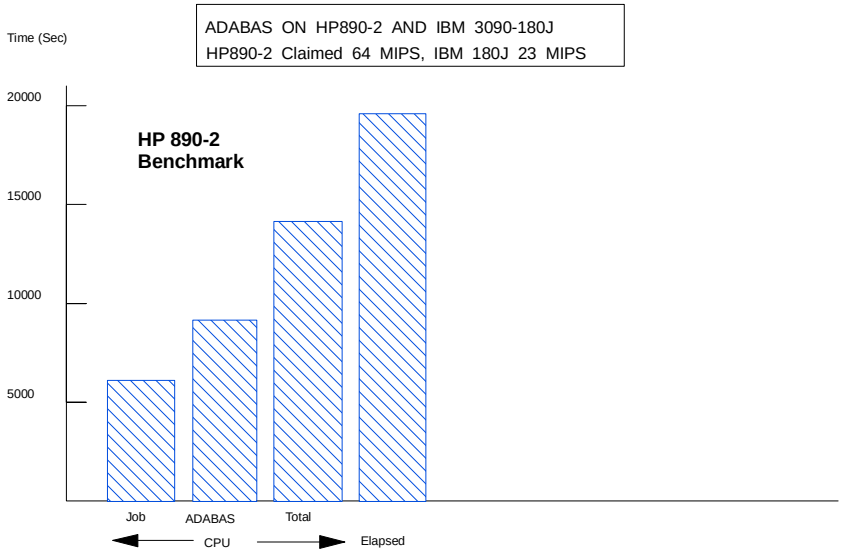
HP PERFORMANCE POSITIONING

Source HEWLETT PACKARD 1.12.92 *

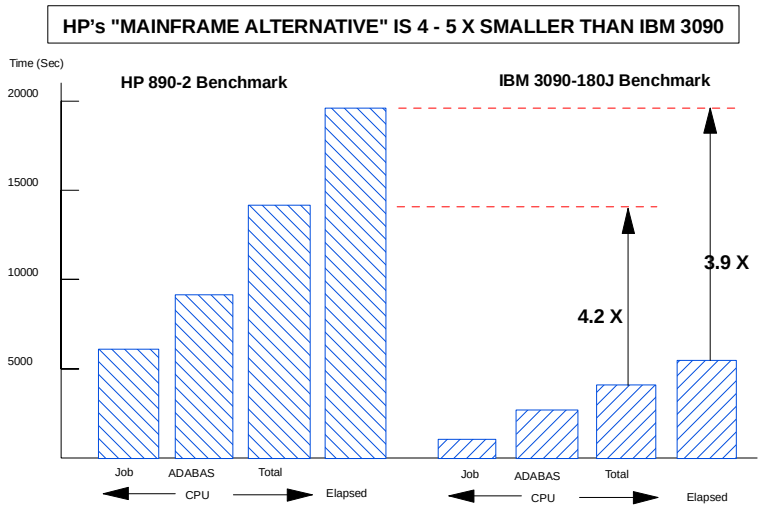
HP 9000 Model	890-1	890-2	890-3	890-4
IBM Equivalent (HP Claim)	9121-480	9021-580	9021-660	9021-720
MIPS Claimed	38	64	95	118
TPC-A Host Rate (Trans/Sec)	190	320	475	590
Calculated MP Ratio	1	1.68	2.50	3.10

* Based on Published Benchmarks and OLTP Estimates

OIL COMPANY BENCHMARK



OIL COMPANY BENCHMARK



HP SMP Ratios

Typical Number of Heavy Users

N-Way	T520 Number of Users	T520 SMP Ratio	T600 Number of Users	T600 SMP Ratio	V2200 Number of Users	V2200 SMP Ratio
1	170	**1.00**	400	**1.00**	390	**1.00**
2	300	**1.76**	700	**1.75**	700	**1.79**
4	470	**2.76**	1100	**2.75**	1350	**3.46**
6					1860	**4.77**
8	680	**4.00**	1590	**3.98**	2280	**5.85**
10					2900	**7.44**
12	790	**4.65**	1790	**4.48**	3310	**8.49**
14					3650	**9.36**
16					3840	**9.85**

Source: HP Manual

HP Performance Assessment

- Ratio of 1-way products from HP table:

Product	Ratio	MIPS
T520	1.00	**21.0**
T600	2.35	**49.4**
V2200	2.29	**48.2**

- Ratio of SPECIntRate95 Benchmarks:

Product	Ratio	MIPS
T520	1.00	**21.0**
T600	2.25	**47.2**
V2200	2.65	**55.6**

- Ratio derived from SAP SD Benchmarks:

Product	Ratio	MIPS
RX5	1.00	**60.9**
T600	0.77	**44.9**
V2200	1.00	**62.8**
V2250	1.29	**81.4**

HP Performance Assessment (2)

- Ratio derived from TPC-C Benchmarks:

	Oracle 8i	Ratio	Sybase	Ratio	MIPS
V2200 16-way	40,794.36	1.00	39,469.47	1.00	**61.0**
V2250 16-way			52,117.8	1.320	**80.5**
V2500 32-way 440MHz	92,832.96	2.276			**138.8**

- Ratio derived from clock speeds:

	MHz	Ratio	Mips
V2200	200	1.00	**61**
V2250	240	1.20	**73**
V2500	440	2.20	**134**

HP Ranges - T600

Assumption: T600 Uni same as G3 uni (47 mips)

N-Way	SAP R/3 (benchmark)	OLTP (Peak)	OLTP (Average)
1	47	26	12
2	94	50	23
3	140	73	32
4	186	94	42
5	231	114	50
6	277	133	57
7	322	150	64
8	366	166	71
9	410	181	76
10	454	195	81
11	498	208	86
12	541	219	90

Note: Peak utilization = 55%
Average utilization = 25%

HP Ranges - V2200

Assumption: V2200 Uni same as G4 uni (61 mips)

N-Way	SAP R/3 (benchmark)	OLTP (Peak)	OLTP (Average)
1	**61**	**34**	**15**
2	**122**	**64**	**29**
3	**182**	**93**	**42**
4	**241**	**119**	**54**
5	**300**	**142**	**65**
6	**359**	**164**	**75**
7	**417**	**184**	**84**
8	**475**	**202**	**92**
9	**533**	**218**	**99**
10	**589**	**232**	**106**
11	**646**	**245**	**112**
12	**702**	**257**	**117**
13	**758**	**267**	**121**
14	**813**	**276**	**126**
15	**868**	**284**	**129**
16	**922**	**291**	**132**

Note: Peak utilization = 55%
Average utilization = 25%

HP Ranges - V2250

Assumption: V2250 Uni approximately 79 mips

N-Way	SAP R/3 (Benchmark)	OLTP (Peak)	OLTP (Average)
1	79	43	20
2	157	83	38
3	235	120	55
4	312	154	70
5	389	185	84
6	465	213	97
7	541	238	108
8	615	261	119
9	690	282	128
10	763	301	137
11	837	318	144
12	909	333	151
13	981	346	157
14	1053	358	163
15	1123	368	167
16	1194	377	171

Note: Peak utilization = 55%
Average utilization = 25%

HP Ranges - V2500 (1-16 way)

Assumption: V2500 Uni approximately 134 mips

N-Way	SAP R/3 (Benchmark)	OLTP (Peak)	OLTP (Average)
1	134	74	34
2	267	142	65
3	399	205	93
4	530	264	120
5	660	318	144
6	789	367	167
7	917	413	188
8	1044	454	207
9	1170	493	224
10	1295	527	240
11	1419	559	254
12	1542	588	267
13	1664	613	279
14	1785	636	289
15	1906	657	299
16	2025	675	307

Note: Peak utilization = 55%
Average utilization = 25%

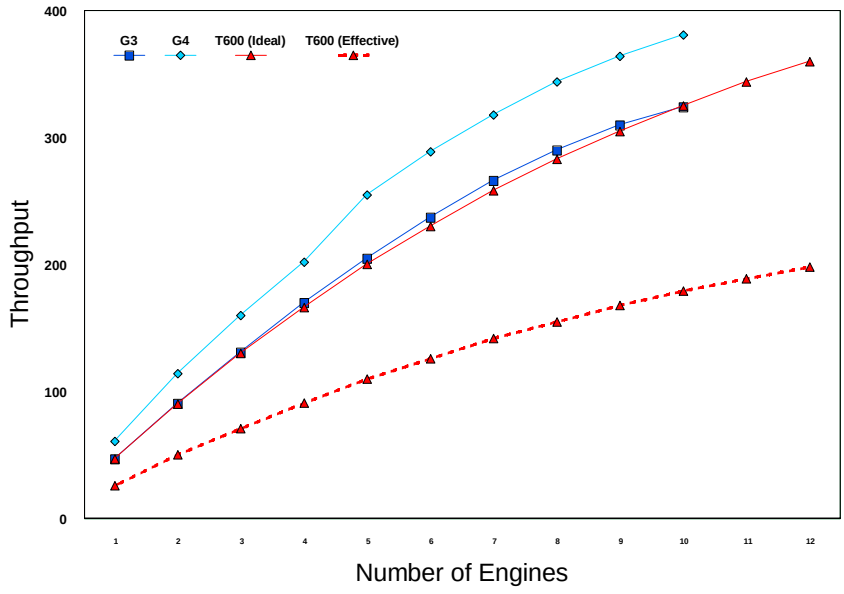
HP Ranges - V2500 (17-32-way)

Assumption: V2500 Uni approximately 134 mips

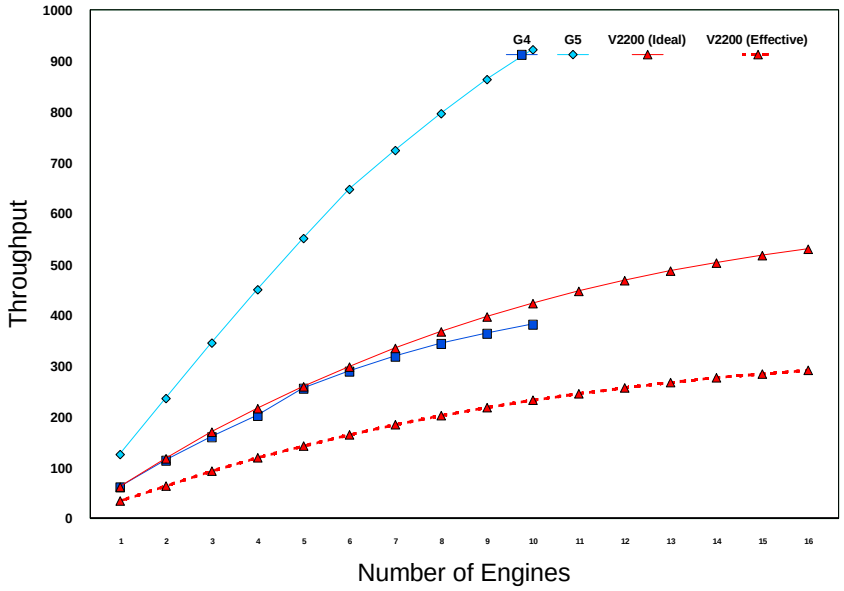
N-Way	SAP R/3	OLTP (Peak)	OLTP Average)
17	2143	691	314
18	2261	705	320
19	2377	717	326
20	2493	727	331
21	2608	736	334
22	2721	743	338
23	2834	748	340
24	2946	752	342
25	3057	755	343
26	3168	756	344
27	3277	757	344
28	3385	756	344
29	3493	755	343
30	3600	752	342
31	3706	749	340
32	3811	745	339

Note: Peak utilization = 55%
Average utilization = 25%

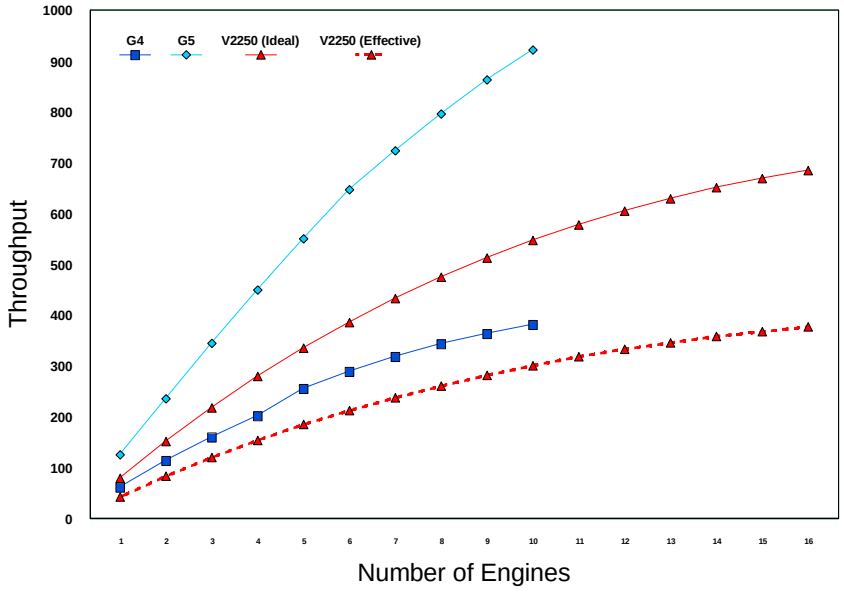
HP T600 Performance - OLTP Workloads



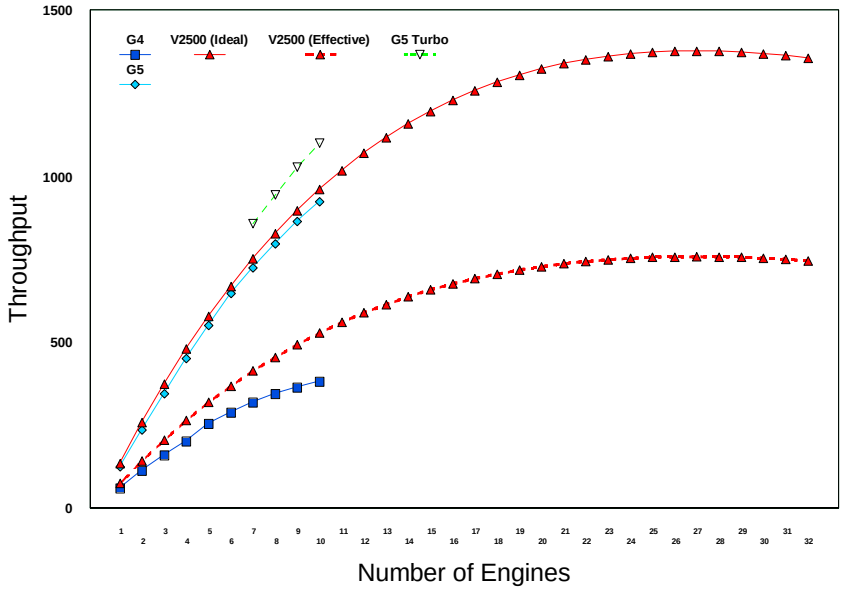
HP V2200 Performance - OLTP Workloads



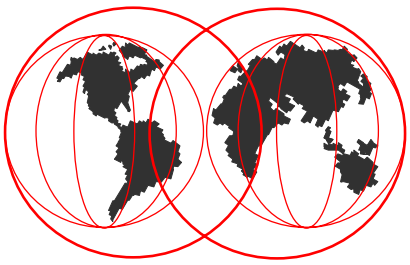
HP V2250 Performance - OLTP Workloads



HP V2500 Performance - OLTP Workloads



SUN E10000
Performance Assessment



SUN UE10000 Estimating

- SAP R/3 SD benchmark

	RX5	UE10000 336MHz	UE10000 250 MHz
# engines	10	64	
%CPU	99%	82%	
SAP SD Users	3300	14400	
SD users at 100%	3333	17561	
SD users/engine	345	349	
Engine speed	**60.9**	**62.2**	**46.3**

- TPC-D

Server	QthD@300GB	# of engines	Database
UE10000 336 MHz	3343.9	64	Informix
HP EPS22 (16 nodes x 4-way, PA8000 180MHZ (T600 technology)	2829.0	64	Informix

Estimated engine speed 336MHz UE10000 **56** mips
250MHz UE10000 42 mips

SUN UE10000 Performance Assessment

- TPC-C

Server	tpmC	# of engines	Mips
UE6000 16-way Oracle 7.3 (c/s)	23143.65	16	**36**
HP V2200 16-way Sybase	39469.47	16	61
HP V2250 16-way Sybase	52117.80	16	81

Summary

Technique	250 MHz engine	336 MHz engine
SPECInt_rate95 (using unpublished S/390 measurement)	40	
SAP SD Benchmarks		**62**
TPC-D	41	**56**
TPC-C	36	

Assume:
250 MHZ engine **42** Mips
336 MHz engine **56** Mips

SUN UE10000 250 MHz Models

Assumption: 250 MHz uni approximately 42 mips

N-Way	SAP R/3 (Benchmark)	OLTP (Peak)	OLTP (Average)
4	166	82	37
8	327	139	63
12	483	177	80
16	635	200	91
20	781	213	97
24	923	217	99
28	1061	215	98
32	1194	209	95
36	1323	199	91
40	1448	188	85
44	1569	176	80
48	1686	163	74
52	1799	150	68
56	1908	137	62
60	2013	125	57
64	2115	113	51

Note: Peak utilization = 55%
Average utilization = 25%

SUN UE10000 336 MHz Models

Assumption: 336 MHz uni approximately 56 mips

N-Way	SAP R/3 (Benchmark)	OLTP (Peak)	OLTP (Average)
4	221	110	50
8	436	187	85
12	644	238	108
16	846	269	122
20	1042	286	130
24	1231	291	132
28	1415	289	131
32	1583	280	127
36	1764	268	122
40	1931	253	115
44	2092	236	107
48	2248	219	99
52	2398	201	92
56	2544	184	84
60	2684	168	76
64	2820	152	69

Note: Peak utilization = 55%
Average utilization = 25%

SUN UE10000 400 MHz Models

Assumption: 400 MHz uni approximately 67 mips

N-Way	SAP R/3 (Benchmark)	OLTP (Peak)	OLTP (Average)
4	265	131	59
8	522	222	101
12	771	283	129
16	1012	321	146
20	1246	340	155
24	1473	347	158
28	1693	344	156
32	1905	334	152
36	2111	319	145
40	2310	301	137
44	2503	281	128
48	2689	260	118
52	2869	240	109
56	3043	219	100
60	3211	199	91
64	3374	181	82

Note: Peak utilization = 55%
Average utilization = 25%

Sun UE10000 OLTP Capacity using Domains

250 MHz Models

Domains	OLTP Benchmark	OLTP Average
1 x 64-way	205	51
2 x 32-way	758	190
4 x 16-way	1456	364
8 x 8-way	2016	504

336 MHz Models

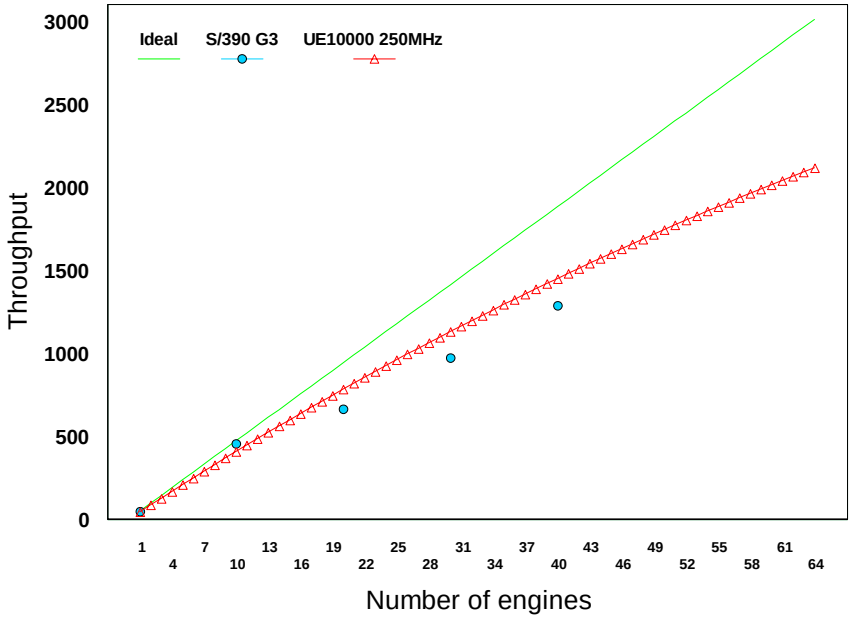
Domains	OLTP Benchmark	OLTP Average
1 x 64-way	276	69
2 x 32-way	1010	258
4 x 16-way	1960	484
8 x 8-way	2712	680

Sun UE10000 OLTP Capacity using Domains

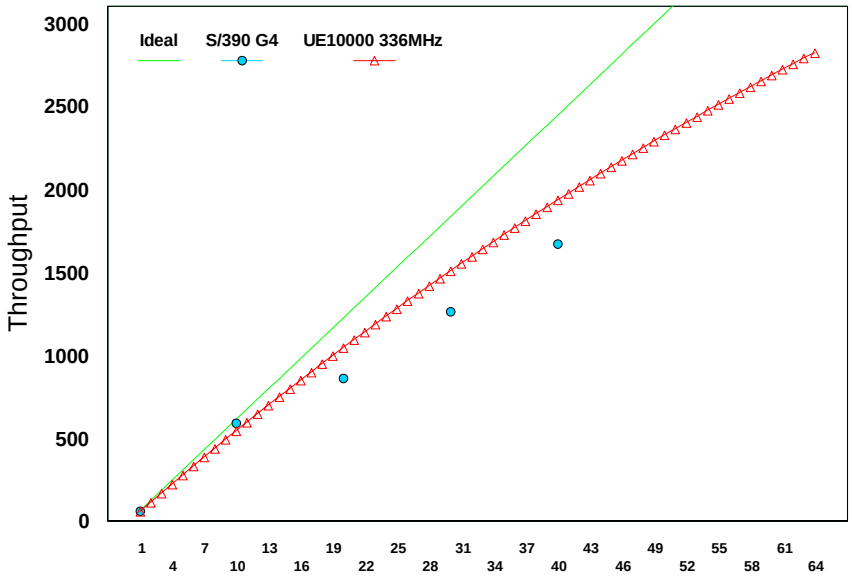
400 MHz Models

Domains	OLTP Benchmark	OLTP Average
1 x 64-way	329	82
2 x 32-way	1214	304
4 x 16-way	2332	584
8 x 8-way	3232	808

Server Performance - ERP Workloads (1)

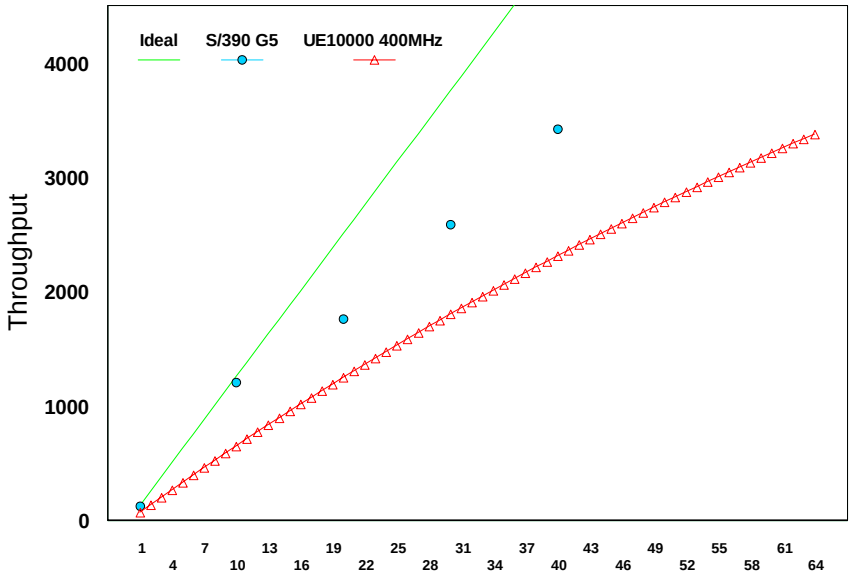


Server Performance - ERP Workloads (2)



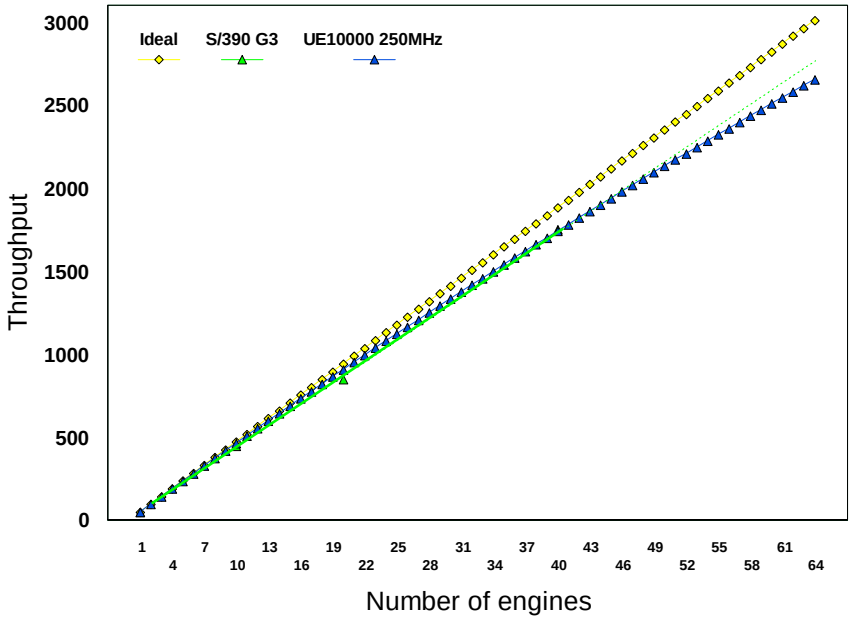
IBM Technical Support

Server Performance - ERP Workloads (3)

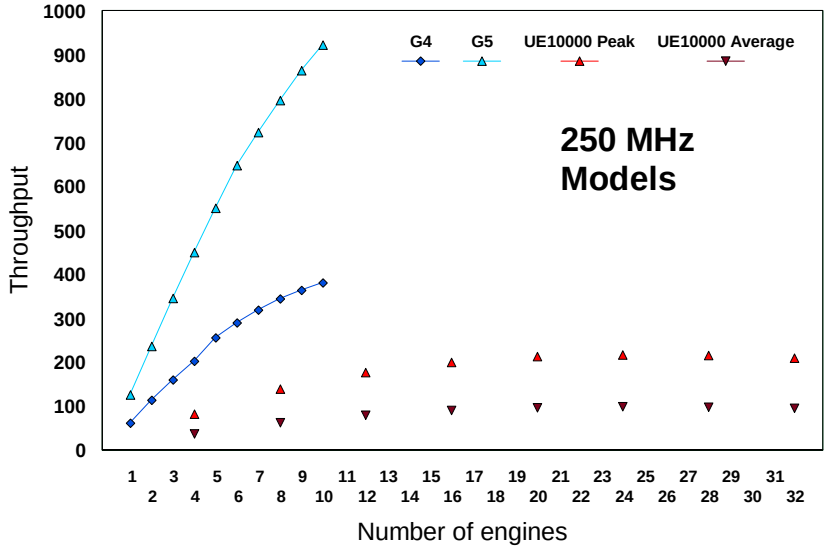


IBM Technical Support

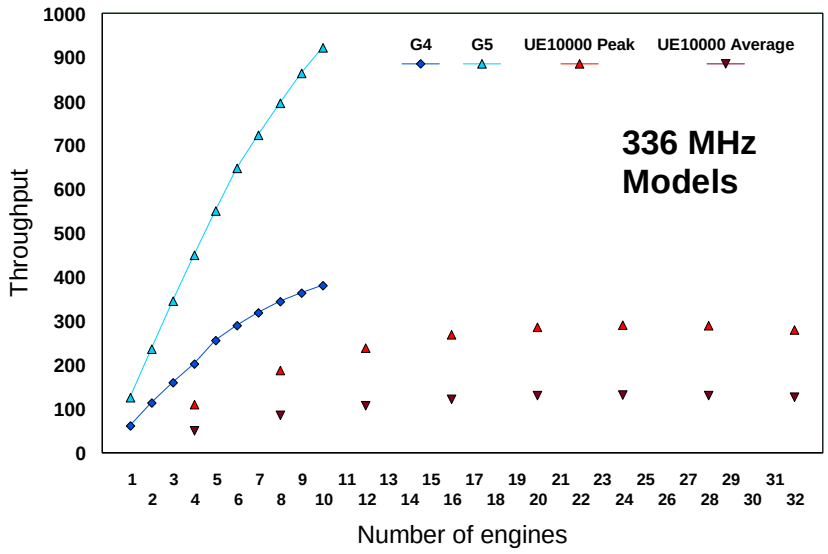
Server Performance - BI Workloads



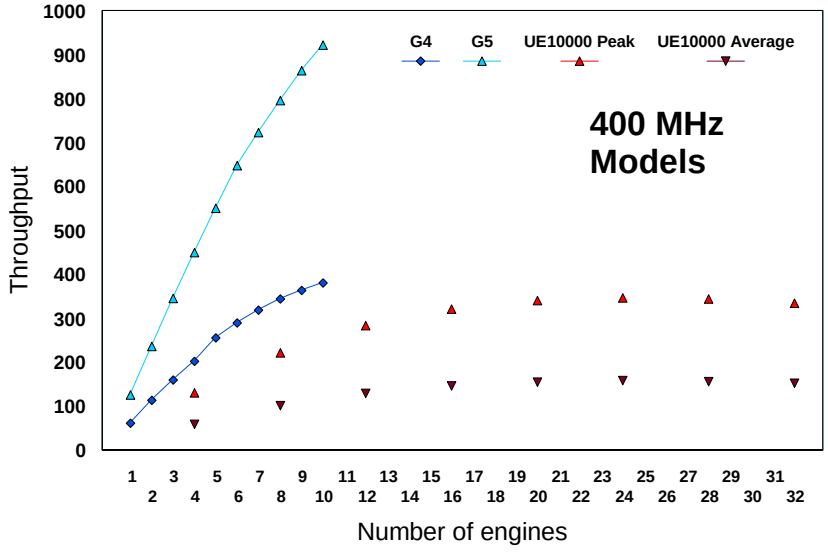
UE10000 Performance - OLTP Workloads



UE10000 Performance - OLTP Workloads



UE10000 Performance - OLTP Workloads

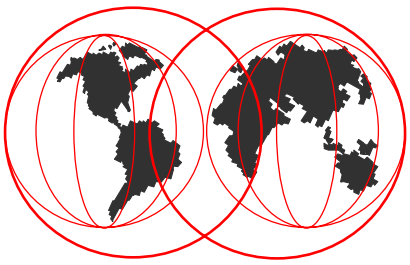


Examples of Domain Capacity
400 MHz models

1	16-way	
	OLTP	**146**
	ERP	**557**
2	8-way | 8-way	
	OLTP / ERP	**202**
	OLTP / OLTP	**388**
	12-way | 4-way	
	OLTP / ERP	**275**
	ERP etc / OLTP	**483**
3	8-way | 4-way | 4-way	
	OLTP / ERP	**393**
	ERP / OLTP	**405**
	ERP / OLTP	
4	4-way | 4-way | 4-way | 4-way	
	4 x OLTP	**236**
	2 x OLTP / 2 x ERP	**410**

Assumptions:
OLTP at 25% utilization
ERP at 55% utilization

Summary



Large SMPs

- Current large SMPs have:
  - Large number of engines (16-64)
  - Have fast engines (similar level of technology to S/390)
  - Have very large raw performance ratings.
- VERY few single traditional workloads could fill such capacity
  - Good for Business Intelligence
  - Good for SAP R/3
- Economics therefore demand mixed workloads
- Mixed workloads only feasible with:
  - Good workload management
  - Logical partitioning
  - Physical partitioning

Mixed Workload Management

- OS/390:
  - Recognized strength
  - Mixed workload management according to business priorities
  - Manage resources effectively up to 90%+ average utilization
- UNIX:
  - Limited ability to manage mixed workloads
  - Some tools available to assign engine affinity to workload components
    - Problem of 'White Space' management
  - Typically only run less than 30% average utilization
  - Typically only run at 50-60% peak utilization

Logical Partitioning

- OS/390:
  - Recognized strength
  - Partition weights dynamically changeable
  - Partition resources dynamically changeable
  - Can partition CPU, Memory, and I/O
  - Shared or dedicated resources
- UNIX:
  - Only Sun UE10000 has physical partitioning capability
    - Dedicated resources only
    - Partitioning in units of 4-engine boards
    - No need for partition weights etc.
  - DG and Compaq (Digital) have software partitioning

SMP Ratios by Workload Type (N = 1-16)

N	OLTP	Web Serving	Domino	Commercial batch	SAP R/3	BI	Eng/Sci
1	1.00	1.00	1.00	1.00	1.00	1.00	1.00
2	1.92	1.92	1.96	1.96	1.99	2.00	2.00
3	2.77	2.77	2.89	2.87	2.98	2.99	3.00
4	3.54	3.54	3.78	3.74	3.95	3.98	4.00
5	4.25	4.25	4.63	4.57	4.92	4.96	5.00
6	4.90	4.90	5.45	5.36	5.89	5.94	5.99
7	5.49	5.49	6.24	6.11	6.84	6.92	6.99
8	6.03	6.03	7.00	6.83	7.79	7.89	7.99
9	6.51	6.51	7.73	7.51	8.73	8.86	8.99
10	6.95	6.95	8.42	8.16	9.66	9.83	9.98
11	7.34	7.34	9.09	8.77	10.59	10.79	10.98
12	7.69	7.69	9.73	9.36	11.51	11.75	11.97
13	7.96	7.96	10.11	9.86	12.42	12.71	12.97
14	8.20	8.20	10.56	10.33	13.32	13.66	13.96
15	8.39	8.39	10.98	10.76	14.22	14.61	14.95
16	8.55	8.55	11.36	11.17	15.11	15.55	15.94

SMP Ratios by Workload Type (N = 17-32)

	OLTP	Web Serving	Domino	Commercial batch	SAP R/3	BI	Eng/Sci
17	8.68	8.68	11.71	11.54	15.99	16.49	16.93
18	8.78	8.78	12.03	11.89	16.87	17.43	17.92
19	8.86	8.86	12.32	12.20	17.74	18.36	18.91
20	8.91	8.91	12.59	12.49	18.60	19.29	19.90
21	8.94	8.94	12.82	12.76	19.46	20.22	20.89
22	8.95	8.95	13.03	13.00	20.31	21.14	21.87
23	8.94	8.94	13.22	13.22	21.15	22.06	22.86
24	8.91	8.91	13.38	13.42	21.99	22.97	23.85
25	8.87	8.87	13.52	13.60	22.82	23.88	24.83
26	8.81	8.81	13.65	13.76	23.64	24.79	25.82
27	8.75	8.75	13.75	13.90	24.45	25.70	26.80
28	8.67	8.67	13.83	14.02	25.26	26.60	27.78
29	8.58	8.58	13.90	14.12	26.07	27.50	28.76
30	8.48	8.48	13.95	14.21	26.86	28.39	29.75
31	8.37	8.37	13.99	14.28	27.65	29.28	30.73
32	8.26	8.26	14.01	14.34	28.44	30.17	31.71

SMP Ratios by Workload Type (N = 34-64)

N	OLTP	Web Serving	Domino	Commercial batch	SAP R/3	BI	Eng/Sci
34					29.99	31.93	33.67
36					31.51	33.68	35.62
38					33.01	35.42	37.57
40					34.48	37.14	39.52
42					35.93	38.85	41.47
44					37.36	40.54	43.41
46					38.76	42.23	45.36
48					40.14	43.90	47.29
50					41.49	45.55	49.23
52					42.82	47.19	51.16
54					44.13	48.82	53.09
56					45.42	50.44	55.02
58					46.69	52.04	56.95
60					47.93	53.63	58.87
62					49.15	55.21	60.79
64					50.25	56.77	62.71

Sources of SMP Ratios

Workload	Source
Eng/Sci	Almost ideal
BI	Sun E10000 DB2 claim
SAP R/3	IBM 9672 SD benchmark
Commercial batch	LSPR workloads
Domino	S/390 experience
OLTP	TPC-C/LSPR
Web Serving	SPECWeb96

Resetting the Bar

- Ensure you understand the workload profile
- UNIX systems typically run at 20-30% average utilization
- UNIX Systems typically peak at 60-60% utilization
- Most UNIX systems either need separate servers or partitioning to run multiple applications
- A single S/390 has higher availability than a UNIX cluster
- Parallel Sysplex provides near-linear scalability for both traditional and the new workloads

End of Presentation