

Driving Innovation Through the Information Infrastructure

SPRING 2011



User Case Study: How Much Information? "Big Data" Research Findings for Enterprise and Consumer Information

James Short, Roger Bohn and Chaitan Baru UC San Diego, San Diego Supercomputer Center Thursday, April 7 11:15 - Noon



What is HMI?

- A research program at UCSD and SDSC
- Our goal: create a census of the World's information
 - How much is there?
 - Of what types?
 - How is it created and where does it go?
- Measuring data and information
 - Inexact science
 - Assumptions and methods key



Our Agenda This Morning

- Review HMI's Greatest Hits
 - Consumer Information Report
 - (new) Enterprise Server Report
- Including:
 - A new way to measure server activity that aggregates capacity over very different kinds of servers, using a common metric
 - New data on price/performance across different benchmarks and server classes
 - Review and discuss alternative views of server load types and load factors
 - Identify methods for defining and measuring data and information value
- Ongoing and Future Research



Consumers









facebook

Facebookで友達や家族と近況を知らせ合ったり、メッセージを交換したりして、楽しく交流しましょう。 Digital Scholarshipさんが書いたノート

brisbanetimes

Feeling bombarded with information? You're not imagining it BENNY EVANGELISTA OF THE SAN FRANCISCO CHRONICLE December 10, 2009





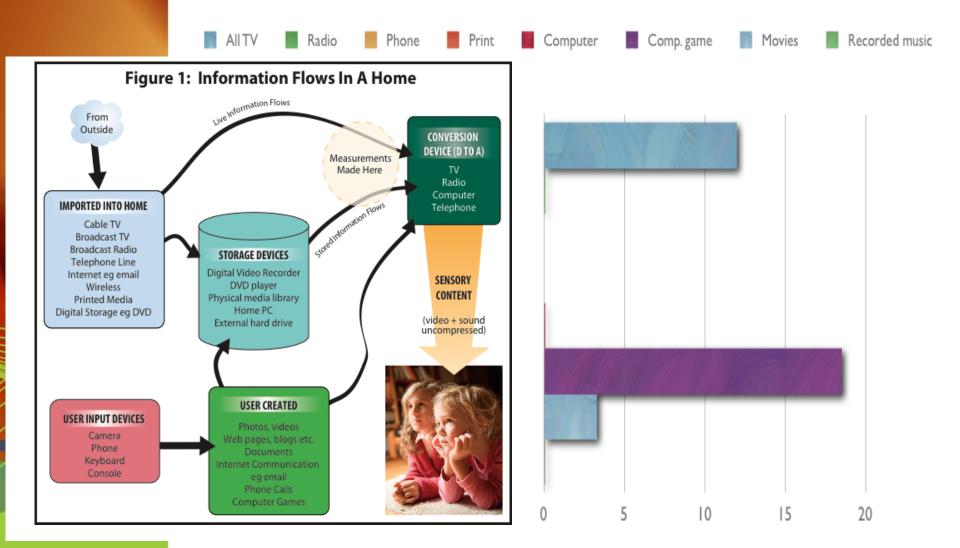
カリフォルニア大学サンディエゴ校(UCSD) 2008年に米国人がコンピュータ・テレビ・ラ ゲームなどにより一日に接した(消費した) Information? 2009 Report on American Co イト

3.6 ZETTABYTES HRS SF READING 1.13 HRS OTHER HIRS ON THE

U.S. DATA CONSUMPTION # ONE DAY

U.S. households consumed 3.6 zettabytes of information in 2008 Dec. 10, 2009 (1:23 pm) By: <u>Brian Osborne</u>

Information to American consumers: 2008 average day



COMPUTERWORLD



34 GB, 12 hours, 100000 words

	Info _c in GB/day	Infow in words/day	Hours per day
TV (incl. DVR, Internet, mobile)	12.0	44,342	4.9
Radio	0.1	8,315	2.2
Phone	0.01	5,269	0.7
Print	0.01	8,659	0.6
Computer	0.08	27,122	1.9
Computer games	18.5	2,459	0.9
Movies	3.3	198	0.03
Recorded music	0.08	1,112	0.45
Total	34.0	~100,000	~ 12





Slow Growth: 5% CAGR

	1960 to 1980	1980 to 2008
INFO _{Hours}	3.9%	2.6%
INFOwords	3.7%	3.0%
INFO _C (bytes)	2.9%	5.4%
US Population	1.1%	1.0%
GDP \$/capita	3.6%	2.9%

Source: HMI? 2009



Companies











Summary: How Many Bytes?

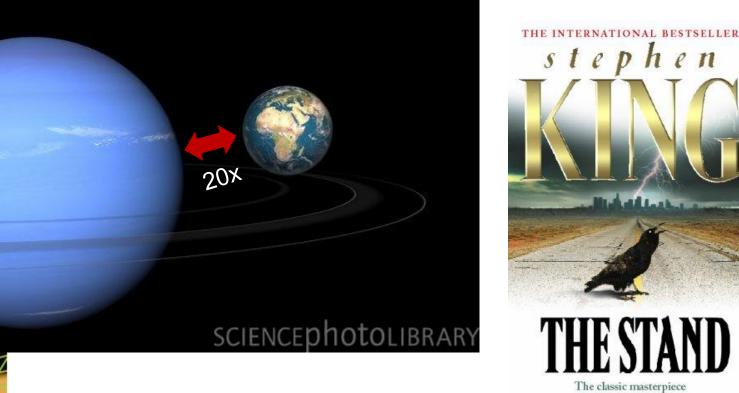
What is measured	World 2008 Total	Notes
Bytes processed plus delivered	9.57 zettabytes	
Bytes per worker per year per day	3.01 terabytes 12.0 gigabytes	3.18 billion workers in world labor force
Bytes per company per year	63.4 terabytes	151 million world businesses registered

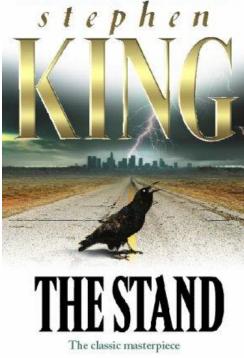
Table 3: World Server Information byServer Class 2008

	Entry-level	Midrange	High-end	Total
Total Bytes by Server Class (in zettabytes)	6.31	2.80	.451	9.57



How Much is 9.57 Zettabytes?





- 2.5 megabytes in Stephen King's Longest Novel
- Would need to stack novels from here to Neptune 20x to equal one year of server information



Enterprise Information Could Include:

Data delivered to workers - screen-based

Data stored on storage media (what about redundancy?)

Data used (inputs & outputs - to inform, to process something, to take action)

Data in embedded processors in office & industrial machines

Our model:

"Information" = **Data** processed plus delivered for use Measured as: **Bytes** processed plus delivered by servers Servers = **World** installed base in 2008



Measuring "Work"

WORK WORK WORK Performed by Servers We do not measure all workloads. But, our capacity measure accounts for all servers and we assume the workloads we do measure are representative of the whole

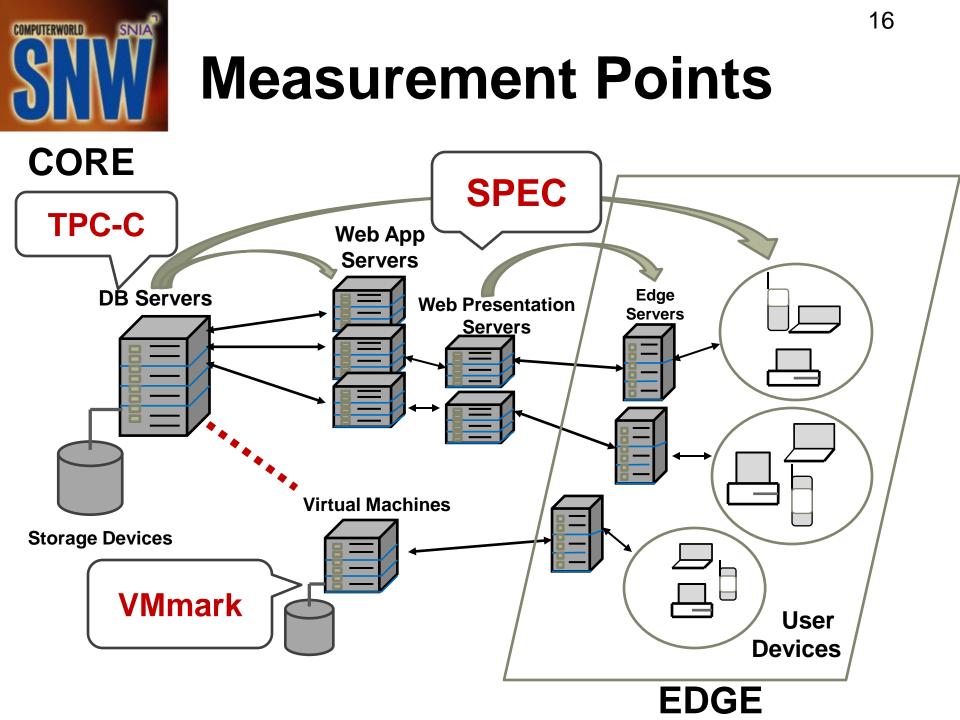
Measured

By

Assumptions:

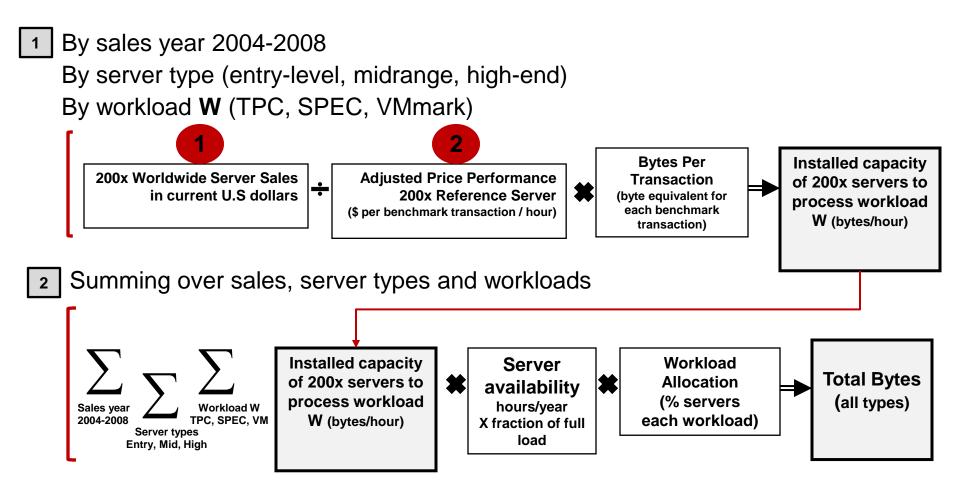
Simulated workloads represent actual workloads

Estimating max server processing capacity for multiple workloads yields meaningful upper limit Industry Standard Server Benchmarks Where Each Benchmark Simulates One or More Enterprise Workloads





Modeling Approach





World Server Sales 2004-2008

Annual World Server Sales 2004-2008

Current U.S. Dollars (in billions)

Server Class	2004	2005	2006	2007	2008	Total
Entry- level	\$24.4	\$27.3	\$28.5	\$30.8	\$29.3	\$140.5
Midrange	\$12.8	\$12.8	\$12.2	\$12.6	\$11.7	\$62.3
High-end	\$12.2	\$11.6	\$12.0	\$11.6	\$12.2	\$59.9
Total	\$49.5	\$51.8	\$52.8	\$55.1	\$53.3	\$262.7



2

COST ANALYSIS

- We used the detailed TPC-C pricing sheets to break down the costs of the System Under Test (SUT) into the cost of the Server Hardware and other components
- To accord with our server sales numbers, we recalculated price performance using only the costs of the server hardware (current dollars)
- Further cost performance (storage, network) analyses are possible and planned

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1/363, 341, 341, 341, 341, 341, 341, 341, 34	1/363,3617,347,533,147,154 3/1-302.5 1 3/29,00 3/29,00 Subtool Set,302.00 Subtool Stables,302.00	SAS Cable, 1M, MD1000	310-7082	1	\$30.00	6	\$180.00		1	\$799.00	
220 Rack, US1 340-4090 1 \$239.99 1 \$239.99 1 \$239.99 1 \$239.99 3 \$30.93 Server Software 0 2 \$2,498.00 1 \$2,498.00 3 \$3.93 \$30 Oracle Database 11g Standard Edition One,Per Processor 2 \$2,498.00 1 \$2,498.00 \$10 \$2,498.00 \$10	220 Rack, US1 340-4696 1 \$239.39 1 \$229.39 1 \$229.39 Server Software 1 Subton \$46,676.97 \$9,888.00 3 \$3.93 Oracle Database 11g Standard Edition One,Per Processor 2 \$2,498.00 1 \$2,498.00 3 \$3.93 Unimited Users, 3 years 2 \$2,498.00 1 \$2,498.00 16% discount (\$8,967.52) Windows Server 2003 Standard x64 Server 420-7118 1 \$799.00 1 \$799.00 16% discount (\$8,967.52) Microsoft Problem Resolution Services 3 \$245.00 1 \$245.00 1 \$245.00 Total \$51,429.38 Oracle Premium Support, 3 years 2 \$1,099.00 3 \$3,297.00 \$3,542.00 Total \$551,429.38 Oracle Premium Support, 3 years 2 \$1,099.00 3 \$3,297.00 \$3,542.00 Total \$551,429.38 Oracle Premium Support, 3 years 2 \$1,099.00 3 \$3,297.00 \$3,542.00 Total \$551,429.38 Oracle Premium Support, 3 years 2 \$1,099.00 Subtota	73GB,3GBPS,SAS,3.5IN,15K	341-3023	1	\$299.00	98	\$29,302.00		1	\$250.00	
Server Software 3 \$3.93 Oracle Database 11g Standard Edition One,Per Processor 2 \$2,498.00 1 \$2,498.00 \$3.93 \$3.93 Unlimited Users, 3 years 2 \$2,498.00 1 \$2,498.00 1 \$3.93 \$3.03 Windows Server 2003 Standard x64 Server 420-7118 1 \$799.00 1 \$799.00 16% discount (\$8,967.52) Microsoft Problem Resolution Services 3 \$245.00 1 \$245.00 1 \$245.00 Total \$51,429.38 \$14,480 Oracle Premium Support, 3 years 2 \$1,099.00 3 \$3,297.00 \$3,542.00 Total \$51,429.38 \$14,480 Vial hardware items from Dell(1) are discounted 16% based on total dollar volume of this configuration. Three-Year Cost of Ownership: \$65,910 USD Price Source: 1=Dell, 2=Oracle,3=Microsoft,4=Kairon TPC-C Throughput: 97,083.53 tpmC/USD as a complex quote. Audited by Lorna Livingtree, Performance Metrics Inc. Price/Performance: \$0.68 tpmC/USD	Server Software 3 33.93 Oracle Database 11g Standard Edition One,Per Processor Unlimited Users, 3 years 2 \$2,498.00 1 \$2,498.00 \$3.93 Windows Server 2003 Standard x64 Server 420-7118 1 \$799.00 1 \$799.00 16% discount (\$8,967.52) Microsoft Problem Resolution Services 3 \$245.00 1 \$245.00 Total \$51,429.38 Oracle Premium Support, 3 years 2 \$1,099.00 3 \$3,297.00 \$3,542.00 Total \$51,429.38 Vindows Cerver 2003 Standard x64 Server 2 \$1,099.00 3 \$3,297.00 \$3,297.00 \$51,429.38 Oracle Premium Support, 3 years 2 \$1,099.00 3 \$3,297.00 \$3,542.00 Total \$51,429.38 Vindows Eterse from Dell(1) are discounted 16% based on total dollar volume of this configuration. Three-Year Cost of Ownership: \$65,910 \$65,910 \$65,910 \$65,910 \$65,910 \$65,910 \$65,910 \$665,910 \$665,910 \$665,910 \$665,910 \$665,910 \$665,910 \$665,910 \$665,910 \$665,910 \$665,910 \$665,910 \$665,910 \$665,910	42U Rack,CUST	340-4896	1	\$239.99	1	\$239.99	1	Subtotal	\$1,049.00	\$0.0
Server Software Concile Database 11g Standard Edition One,Per Processor 2 \$2,498.00 1 \$2,498.00 Subtotal \$3.93 \$6.90 Unlimited Users, 3 years 2 \$2,498.00 1 \$2,498.00 1 \$2,498.00 1 \$3.93 \$6.000 Windows Server 2003 Standard x64 Server 420-7118 1 \$799.00 1 \$799.00 1 \$799.00 1 \$6.000 16% discount (\$8,967.52) 1 1 \$51,429.38 \$14,480 1 \$799.00 3 \$3,297.00 \$3,3297.00 \$3,297.00 \$3,542.00 1 1 \$51,429.38 \$14,480 1 \$100 \$3,297.00 \$3,542.00 1 1 \$100 1 1 \$100 1	Server Software Concile Database 11g Standard Edition One, Per Processor 2 \$2,498.00 1 \$2,498.00 Subtotal \$3.93 Unlimited Users, 3 years 2 \$2,498.00 1 \$2799.00 1 \$799.00 16% discount (\$8,967.52) Windows Server 2003 Standard x64 Server 420-7118 1 \$799.00 1 \$799.00 1 \$799.00 16% discount (\$8,967.52) 16% discount (\$8,967.52) 16% discount \$51,429.38 1 \$51,429.38 1 \$51,429.38 1 \$51,429.38 1 \$51,429.38 1 \$51,429.38 1 \$51,429.38 1 \$51,429.38 1 \$51,429.38 1 1 \$51,429.38 1 \$51,429.38 1 \$51,429.38 1 1 \$51,429.38 1 1 \$51,429.38 1 1 \$51,429.38 1 1 \$51,429.38 1 1 \$51,429.38 1 1 \$51,429.38 1 1 \$51,429.38 1 1 \$51,429.38 1 1 \$51,429.38 1 1 1 1 1 1 1 1 <t< td=""><td></td><td></td><td></td><td></td><td>Subtotal</td><td>\$46,676.97</td><td>\$9,888.00</td><td></td><td></td><td></td></t<>					Subtotal	\$46,676.97	\$9,888.00			
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Windows Server 2003 Standard x64 Server 420-7118 1 \$799.00 1 \$799.00 16% discount (\$8,967.52) Microsoft Problem Resolution Services 3 \$245.00 1 \$245.00 1 \$245.00 Total \$51,429.38 \$14,480 Oracle Premium Support, 3 years 2 \$1,099.00 3 \$3,297.00 \$3,527.00 \$3,5240.00 \$3,297.00 \$3,542.00 \$65,910 USD Vall hardware items from Dell(1) are discounted 16% based on total dollar volume of this configuration. Three-Year Cost of Ownership: \$65,910 USD Price Source: 1=Dell, 2=Oracle,3=Microsoft,4=Kalron TPC-C Throughput: 97,083.53 tpmC Pricing may be verified by calling 1-800-BUY-DELL and referencing quote # 432979497 1 1 1 Audited by Lorna Livingtree, Performance Metrics Inc. Price/Performance: \$0.68 tpmC/USD	Windows Server 2003 Standard x64 Server 420-7118 1 \$799.00 1 \$799.00 16% discount (\$8,967.52) Microsoft Problem Resolution Services 3 \$245.00 1 \$245.00 Total \$51,429.38 Oracle Premium Support, 3 years 2 \$1,099.00 3 \$3,297.00 \$3,542.00 Total \$51,429.38 Vall hardware items from Dell(1) are discounted 16% based on total dollar volume of this configuration. Three-Year Cost of Ownership: \$65,910 Price Source: 1=Dell, 2=Oracle,3=Microsoft,4=Kalron TPC-C Throughput: 97,083.53 1 Pricing may be verified by calling 1-800-BUY-DELL and referencing quote # 432979497 Three-Vear Cost of the stated components. Individually negotieted - Audited by Lorna Livingtree, Performance Metrics Inc. Prices used in TPC benchmarks reflect the actual prices a customer would pay for a one-time purchase of the stated components. Individually negotieted -	Oracle Database 11g Standard Edition One,Per Processor		2	\$2,498.00	1	\$2,498.00		Subtotal	\$3.93	\$0.0
Windows Server 2003 Standard x64 Server 420-7118 1 \$799.00 1 \$799.00 1 \$799.00 Microsoft Problem Resolution Services 3 \$245.00 1 \$245.00 Total \$51,429.38 \$14,480 Oracle Premium Support, 3 years 2 \$1,099.00 3 \$3,297.00 \$3,542.00 Total \$51,429.38 \$14,480 *All hardware items from Dell(1) are discounted 16% based on total dollar volume of this configuration. Three-Year Cost of Ownership: \$665,910 USD *All hardware items from Dell(1) are discounted 16% based on total dollar volume of this configuration. Three-Year Cost of Ownership: \$665,910 USD Price Source: 1=Dell, 2=Oracle,3=Microsoft,4=Kalron TPC-C Throughput: 97,083.53 tpmC Pricing may be verified by calling 1-800-BUY-DELL and referencing quote # 432979497 as a complex quote. Price/Performance: \$0.68 tpmC/USD Audited by Lorna Livingtree, Performance Metrics Inc. Viring reg. Price/Performance: \$0.68 tpmC/USD	Windows Server 2003 Standard x64 Server 420-7118 1 \$799.00 1 \$799.00 Microsoft Problem Resolution Services 3 \$245.00 1 \$245.00 Total \$51,429.38 Oracle Premium Support, 3 years 2 \$1,099.00 3 \$3,297.00 \$3,542.00 Total \$51,429.38 *All hardware items from Dell(1) are discounted 16% based on total dollar volume of this configuration. *All hardware items from Dell(1) are discounted 16% based on total dollar volume of this configuration. Three-Year Cost of Ownership: \$65,910 Price Source: 1=Dell, 2=Oracle, 3=Microsoft, 4=Kalron TPC-C Throughput: 97,083.53 the price generative of the stated components. Individually regorised Audited by Lorna Livingtree, Performance Metrics Inc. Prices used in TPC benchmarks reflect the actual prices a customer would pay for a one-time purchase of the stated components. Individually regorised Prices used in TPC benchmarks reflect the actual prices a customer would pay for a one-time purchase of the stated components. Individually regorised	Unlimited Users, 3 years									
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Oracle Premium Support, 3 years 2 \$1,099.00 3 \$3,297.00 \$3,297.00 Subtoal S3,297.00 \$3,297.00 \$3,542.00 \$3,550 \$1,500.00 \$3,550 \$1,500.00 \$3,550 \$1,500.00 \$3,550 \$1,500.00 \$1,5	Oracle Premium Support, 3 years 2 \$1,099.00 3 \$3,297.00 \$3,297.00 *All hardware items from Dell(1) are discounted 16% based on total dollar volume of this configuration. *All hardware items from Dell(1) are discounted 16% based on total dollar volume of this configuration. Three-Year Cost of Ownership: \$65,910 Price Source: 1=Dell, 2=Oracle,3=Microsoft,4=Kalron TPC-C Throughput: 97,083.53 1 Pricing may be verified by calling 1-800-BUY-DELL and referencing quote # 432979497 as a complex quote. Price/Performance: \$0.68 tpr Audited by Lorna Livingtree, Performance Metrics Inc. Prices used in TPC benchmarks reflect the actual prices a customer would pay for a one-time purchase of the stated components. Individually regoristed Prices/Performance \$0.68 tpr	Microsoft Problem Resolution Services		3	\$245.00	1		\$245.00			
*All hardware items from Dell(1) are discounted 16% based on total dollar volume of this Three-Year Cost of Ownership: \$65,910 USD configuration. Price Source: 1=Dell, 2=Oracle, 3=Microsoft, 4=Kalron TPC-C Throughput: 97,083.53 tpmC Pricing may be verified by calling 1-800-BUY-DELL and referencing quote # 432979497 Price/Performance: \$0.68 tpmC/USD Audited by Lorna Livingtree, Performance Metrics Inc. V V V V	*All hardware items from Dell(1) are discounted 16% based on total dollar volume of this Three-Year Cost of Ownership: \$65,910 configuration. Price Source: 1=Dell, 2=Oracle,3=Microsoft,4=Kalron TPC-C Throughput: 97,083.53 1 Pricing may be verified by calling 1-800-BUY-DELL and referencing quote # 432979497 Price/Performance: \$0.68 tpr Audited by Lorna Livingtree, Performance Metrics Inc. Prices used in TPC benchmarks reflect the actual prices a customer would pay for a one-time purchase of the stated components. Individually regenerated Prices/Performance Individually regenerated	Oracle Premium Support, 3 years		2	\$1,099.00	3		\$3,297.00	Total	\$51,429.38	\$14,480.0
configuration. TPC-C Throughput: 97,083.53 tpmC Price Source: 1=Dell, 2=Oracle,3=Microsoft,4=Kalron TPC-C Throughput: 97,083.53 tpmC Pricing may be verified by calling 1-800-BUY-DELL and referencing quote # 432979497 Price/Performance: \$0.68 tpmC/USD as a complex quote. Price/Performance: \$0.68 tpmC/USD Audited by Lorna Livingtree, Performance Metrics Inc. Image: Complex quote in the second se	configuration. Price Source: 1=Dell, 2=Oracle,3=Microsoft,4=Kalron TPC-C Throughput: 97,083.53 1 Pricing may be verified by calling 1-800-BUY-DELL and referencing quote # 432979497 Price/Performance: \$0.68 tprice/Performance: Audited by Lorna Livingtree, Performance Metrics Inc. Prices used in TPC benchmarks reflect the actual prices a customer would pay for a one-time purchase of the stated components. Individually negotiated and the stated components. Individually negotiated and the stated components. Individually negotiated and the stated components.					Subtotal	\$3,297.00	\$3,542.00			
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Price Source: 1=Dell, 2=Oracle,3=Microsoft,4=Kalron TPC-C Throughput: 97,083.53 tpmC Pricing may be verified by calling 1-800-BUY-DELL and referencing quote # 432979497 Price/Performance: \$0.68 tpmC/USD as a complex quote. Price/Performance: \$0.68 tpmC/USD Audited by Lorna Livingtree, Performance Metrics Inc. Image: Complex quote in the second sec	Price Source: 1=Dell, 2=Oracle,3=Microsoft,4=Kalron TPC-C Throughput: 97,083.53 1 Pricing may be verified by calling 1-800-BUY-DELL and referencing quote # 432979497 Price/Performance: \$0.68 tpr as a complex quote. Price/Performance: \$0.68 tpr Audited by Lorna Livingtree, Performance Metrics Inc. Prices used in TPC benchmarks reflect the actual prices a customer would pay for a one-time purchase of the stated components. Individually negotiated Pricestated			items from Dell(1)	are discounted 16% bas	ed on total dollar vo	olume of this	Inree-rear Cost	or Ownership:	\$65,910	USD
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Audited by Lorna Livingtree, Performance Metrics Inc.	Audited by Lorna Livingtree, Performance Metrics Inc. Prices used in TPC benchmarks reflect the actual prices a customer would pay for a one-time purchase of the stated components. Individually negotieted				1-800-BUY-DELL and re	eterencing quote #	432979497	Price	Performance	\$0.68	tomC/IISD
	Prices used in TPC benchmarks reflect the actual prices a customer would pay for a one-time purchase of the stated components. Individually negotiated			-	Destance Matrice	1		Flice	Performance.	30.00	upinic/030
	for the listed components. For complete details, see the pricing sections of the TPC benchmark specifications. If you find that the stated prices are not availa										



World Server Capacities

	Defense			Total	Server	Adhuatad	
ENTRY-LEVEL SERVERS	Reference Year	tpmC	Price/tpmC	System Cost	Hardware (SH) Cost	Adjusted SH_Price/tpmC	Core Capacity tpmC
Dell PowerEdge 2900	2008	97,083	\$0.68	\$65,910	\$7,256	\$0.07	3.92E+11
Dell PowerEdge 2900	2007	69,564	\$0.91	\$63,080	\$11,658	\$0.17	1.84E+11
Dell PowerEdge 2900	2006	65,833	\$0.98	\$64,512	\$9,839	\$0.15	1.912+11
Dell PowerEdge 2800	2005	38,622	\$0.99	\$38,028	\$10,771	\$0.28	9.81E+10
Dell PowerEdge 2850	2004	26,410	\$1.53	\$40,170	\$7,993	\$0.30	8.08E+10
Estimated	2003	•	•	· •		\$0.33	7.34E+10
	_			Total	Server		
MIDRANGE SERVERS	Reference Year	tpmC	Price/tpmC	Total System Cost	Server Hardware (SH) Cost	Adjusted SH Price/tomC	Core Capacity
	Reference Year 2008	tpmC 402,234	Price/tpmC \$1.26	System Cost	Hardware (SH) Cost	Adjusted SH_Price/tpmC \$0.11	Core Capacity tpmC 1.08E+11
HP ProLiant DL585 G5	Year	tpmC 402,234 407,079		System	Hardware (SH)	SH_Price/tpmC	tpmC
MIDRANGE SERVERS HP ProLiant DL585 G5 HP ProLiant DL580 G5 HP ProLiant ML370 G5	Year 2008	402,234	\$1.26	System Cost \$502,836	Hardware (SH) Cost \$43,634	SH_Price/tpmC \$0.11	tpmC 1.08E+11
HP ProLiant DL585 G5 HP ProLiant DL580 G5	Year 2008 2007	402,234 407,079	\$1.26 \$1.71	System Cost \$502,836 \$694,335	Hardware (SH) Cost \$43,634 \$70,560	SH_Price/tpmC \$0.11 \$0.17	tpmC 1.08E+11 7.33E+10
HP ProLiant DL585 G5 HP ProLiant DL580 G5 HP ProLiant ML370 G5	Year 2008 2007 2006	402,234 407,079 240,737	\$1.26 \$1.71 \$1.85	System Cost \$502,836 \$694,335 \$443,443	Hardware (SH) Cost \$43,634 \$70,560 \$83,504	SH_Price/tpmC \$0.11 \$0.17 \$0.35	tpmC 1.08E+11 7.33E+10 3.53E+10

		Server								
	Reference				Hardware (SH)	Adjusted	Core Capacity			
HIGH-END SERVERS	Year	tpmC	Price/tpmC	Total Price	Cost	SH_Price/tpmC	tpmC			
IBM System x3950 M2	2008	841,809	\$3.46	\$2,911,484	\$1,020,576	\$1.21	1.01E+10			
IBM System p 570	2007	404,462	\$3.50	\$1,417,121	\$625,499	\$1.55	7.50E+09			
IBM System p5 570	2006	203,440	\$3.93	\$799,990	\$514,449	\$2.53	4.76E+09			
IBM eServer p5 570	2005	194,391	\$5.62	\$1,092,119	\$527,839	\$2.72	4.29E+09			
IBM eServer p5 570	2004	371,044	\$5.26	\$1,951,215	\$1,035,538	\$2.79	4.39E+09			
Estimated	2003					\$3.35	3.66E+09			



New Way To Measure Capacity

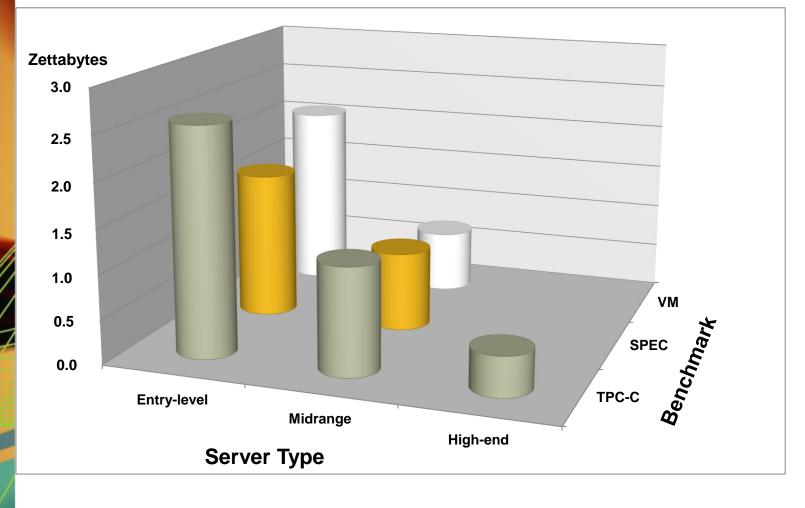
- Aggregate capacity over very different kinds of servers
- Assume companies spend dollars for server capacity efficiently
- Measure capital cost per unit of benchmarked performance
- Then we translate different benchmarks into a common unit: bytes

23 **COMPUTERWORLD World Server Summary** Information 451 exabytes Server Type 2.8 zettabytes Entry-level Midrange 6.31 zettabytes High-end

IDC/EMC 2010 Total Digital Universe: 1.2 zettabytes in 2010 35 zettabytes by 2020 Lyman/Varian 2003: 18 exabytes of new information produced annually



Class Server Contribution to Total



Total = 9.57 zettabytes = 9.57×10^{21} bytes



Discussion and Implications

- Results expressed in capacity per dollar (not capacity per server)
- Data Intensive Computing Platforms
 - Large memory systems
 - Shared nothing platforms
 - Database machines
- Ongoing and Future Research
 - Center for Large Scale Data Systems Research (CLDS)



Center for Large-Scale Data Systems (CLDS): What?

- A center dedicated to the study of technical, management, and economic issues related to large-scale data systems
 - Investigate / study architectures and software systems for cloud storage systems
 - Analyze / develop relevant benchmarks and cost analysis
 - Build upon early work by the HMI? project
 - Create forums for exchange of ideas
 - Among different industry segments, e.g. applications versus infrastructure
 - Among entities dealing with different types of data, e.g. enterprise warehouses, data streams, scientific data, healthcare



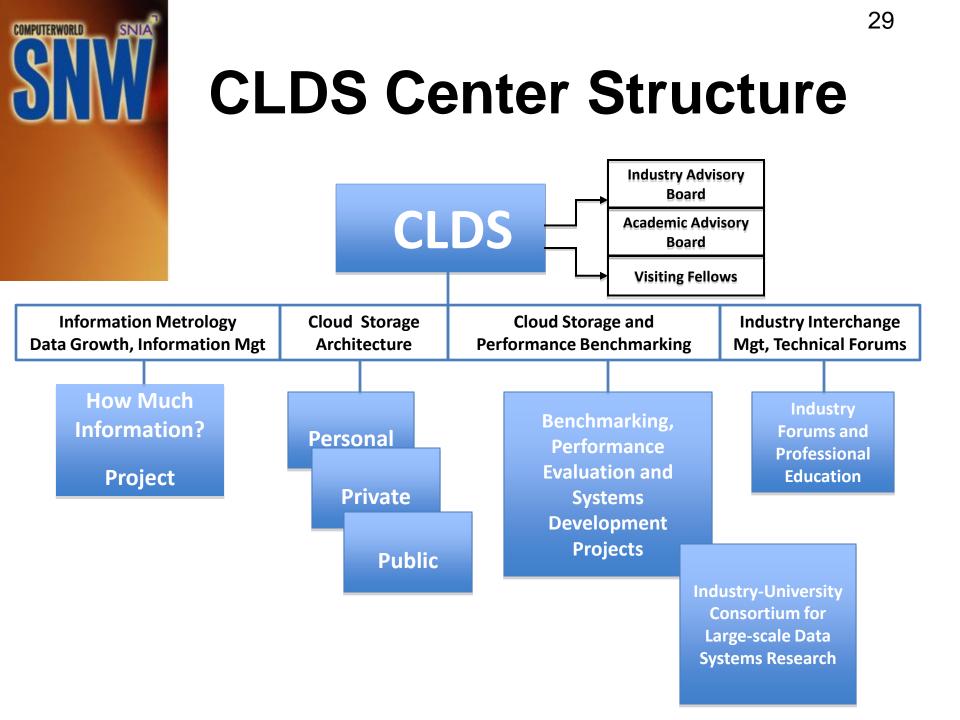
CLDS Rationale: Why?

- Dealing with the *data deluge*
- Addressing the *fourth paradigm*: data-intensive science and decision making
- Understanding the paradigm shift occurring with *cloud computing*, specifically for largescale data
- Need for a research and industry forum that can step back, assess situation, visualize current and future trends, provide insights and offer solutions



CLDS Structure: How?

- Participate in projects on
 - Information Metrology, Data Growth, and Information Management
 - Build upon on-going How Much Information? project
 - Cloud Storage Architecture
 - Cloud Storage Performance Benchmarking
 - Build upon on-going cloud-related research at SDSC
- Obtain insights into application requirements
 - For different application domains
- Participate in industry forums and professional education
 - Serve on Industry Advisory Board, Fellows Program
 - Help design and develop professional ed programs



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Example CLDS Projects

- HMI?: How Much Information?
 - HMI Consumer, HMI Enterprise reports
 - HMI enterprise server study adding storage and network
 - HMI company projects
 - Data Mobility and Information Value
 - CIO Interview Project: Managing the Challenges and Opportunities in "Big Data"
 - Pilot Projects on Managing and Exploiting Information Value
- Cloud Storage Architecture, Benchmarking & Performance
 - Management and technical systems research on personal, private, and public cloud storage architectures
 - Cloud storage systems evaluation and performance benchmarking, including development and testing of new benchmarks
 - Cloud storage capacity and performance evaluation by industry vertical and by enterprise workload



For More Information

- Chaitanya Baru [baru@sdsc.edu]
- Jim Short [jshort@ucsd.edu]

Director, Industry Relations, SDSC

• Ron Hawkins [rhawkins@sdsc.edu]