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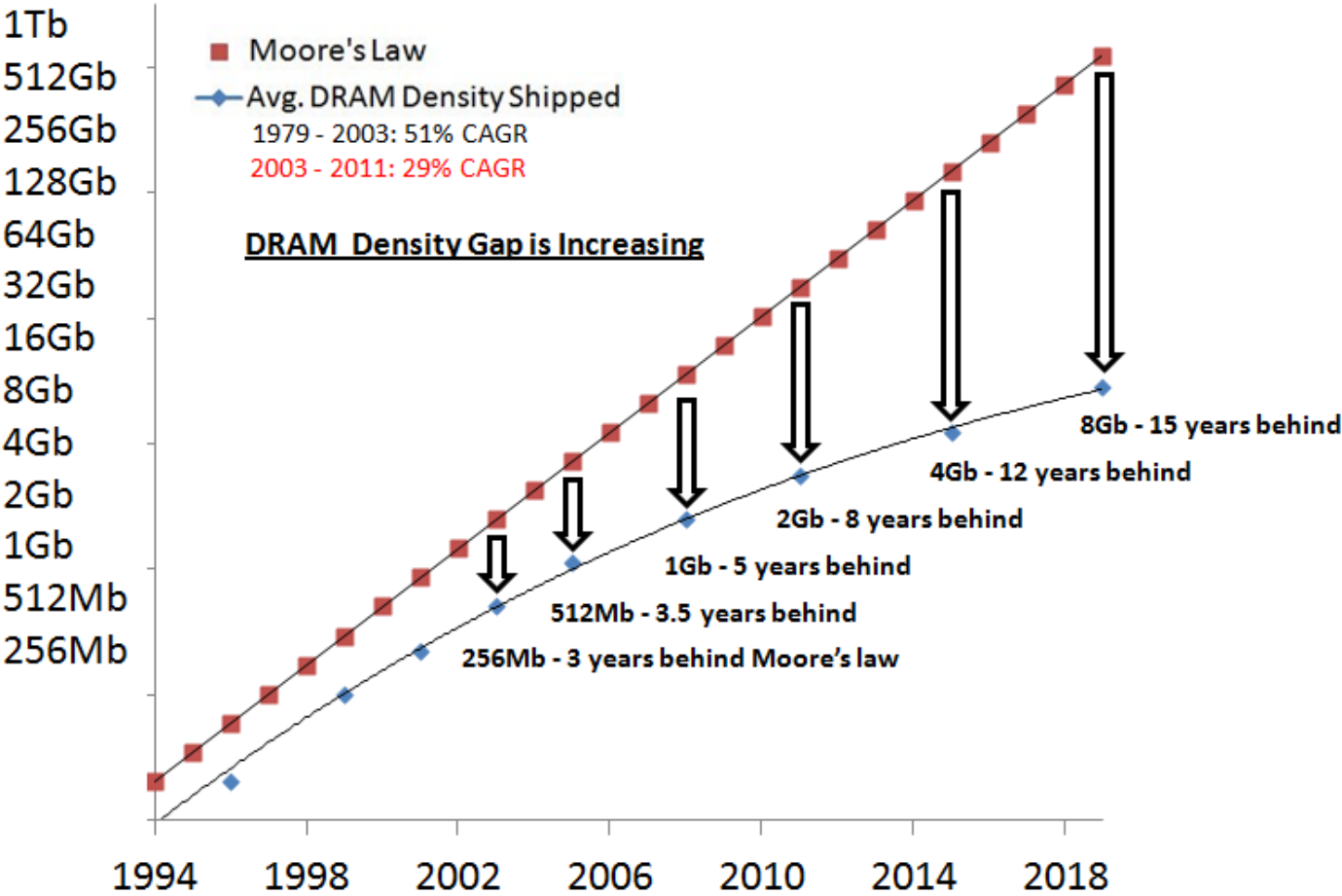
HyperCloud HCDIMM: Scaling the High Density Memory Cliff

July 24, 2012 at 5:00 AM

While microprocessors have continued to double in performance every 18 months as predicted by Moore's Law, DRAM has not and has resulted in a High Density Memory Cliff for server applications. If DRAM technology had advanced according to Moore's Law (Figure 1), the industry would have 64 or 128 GigaByte (GB) Dual In-line Memory Modules (DIMM) using 64 Gigabit (Gb) DRAM. Instead, the largest DRAM density in production is 4Gb and will remain so for some number of years due to many challenges in producing a next generation 8Gb monolithic device.

In order to meet high density server requirements, the number of DRAM components used per DIMM and the number of DIMMs used per server has increased. The combination of additional components and DIMMs has resulted in a cliff between DRAM, DIMM and server performance for which only HyperCloud HCDIMMs are able to overcome. HyperCloud rank multiplication enables more DRAM capacity and load reduction reduces the loading to the memory interface allowing HCDIMMs to run at faster speeds at maximum capacity.

Figure 1 – Moore’s Law and DRAM Density Progression



Source: De Dios and Associates

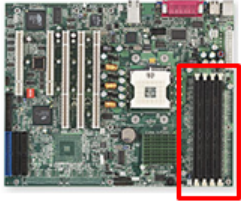
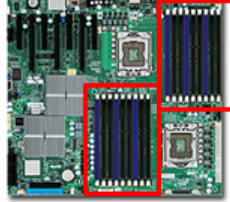
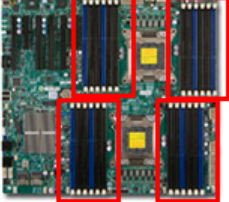
In the late 1980’s and early 1990’s, DIMMs were assembled using eight or nine “x”Gb DRAM components to create an equivalent “x”GB DIMM. The ninth DRAM is used for Error Correction Code and is utilized on all high density server DIMMs. As DRAM became unable to scale to Moore’s Law, the industry adopted DIMMs with 18 DRAM components, 36 components and today, 72 components in order to scale DIMM densities to meet server requirements (Figure 2).

Figure 2 – Memory Module Configurations

Front			
			
Back			
			
9 DRAM	18 DRAM	36 DRAM	72 DRAM (Stacked)

Even as an increasingly higher number of DRAM components are being utilized for each DIMM, server manufacturers still cannot not meet the memory requirements of CPUs that are continuing to follow Moore's Law and are being produced with an increased number of CPU cores. To meet the higher density requirements, server manufacturers dramatically increased the number of DIMM sockets (Figure 3) but this response has created a crisis which only HyperCloud addresses.

Figure 3 – Server DIMM sockets

Pentium DDR	Pentium III Xeon DDR	Xeon DDR2 FBDIMM	Westmere DDR3	Sandy Bridge DDR3
				
4 DIMM Sockets	8 DIMM Sockets	8 DIMM Sockets	18 DIMM Sockets	24 DIMM Sockets

With the increased load created by additional components and DIMMs and with speeds increasing at the same time, the motherboard memory system bus becomes overloaded and cannot operate at the speeds for which CPUs and DRAM components have been designed (Figure 4). Tens of billions of dollars invested annually by the industry is effectively for naught as the overall server performance is degraded to less than optimal speed.

Figure 4 – DRAM vs. DIMM performance

	Pentium DDR	Pentium III Xeon DDR	Xeon DDR2 FBDIMM	Westmere DDR3	Sandy Bridge DDR3
# of DRAM at Maximum Density	18	36	72	72	72
Maximum DRAM Speed	266	400	800	1333	1600
# of DIMMs	4	8	8	18	24
# of DRAM Components Supported	72	288	576	1,296	1,728
Maximum DIMM Speed Fully Populated	266	400	800	1066	1066
Maximum HCDIMM Speed Fully Populated				1333	1333*

*1600 available Q1'13

HyperCloud HCDIMMs overcome the limitations of the server memory subsystem by effectively creating a next generation 8Gb DRAM density using two smaller 4Gb components and reducing the load presented to the system. 8Gb components will not be commercially available until the introduction of DDR4 in 2014 or 2015 and when they are available, HyperCloud will be available as 64GB DIMMs that appear to utilize 16Gb DRAM which would actually be two 8Gb components. Figure 5 is comparison of 32GB DIMM options currently available on dual processor server platforms.

Figure 5 – 32GB DIMM Comparison

	1 DIMM Per Channel 256GB	2 DIMM Per Channel 512GB	3 DIMM Per Channel 768GB
32GB 4R RDIMM	1066	800	Not Supported
32GB 4R LRDIMM	1333	1333	1066*
32GB 2R HCDIMM	1333	1333	1333

* Advertised speed. Actual throughput results ~ 41% less (see below).

As you can see, 32GB RDIMM is 4R and limited to 512GB at 800MT/s speed. While LRDIMM, an industry alternative, can achieve 768GB, it has severe architectural and system limitations resulting in significant loaded latency delays and lower performance (Figure 6). The results listed below are at equal Data Rates for comparison purposes. With 24 HCDIMM operating at a 1333 Data Rate, the throughput result is similar to the 68.1GB/s result of only populating 16 HCDIMMS. With LRDIMM, depending on application, it's possible that overall server performance will decline even as memory and the dollars spent on it increases.

Figure 6 – HCDIMM vs. LRDIMM Performance*

Sample Memory Configurations (2CPU)	Total Memory (GB)	Number of DIMMs	DIMM Size	DIMM Ranks	DIMM Type (UDIMM, RDIMM, LRDIMM)	Data Rate	DIMMs per Channel	Unloaded Latency (ns)	Loaded Latency (ns)	Throughput (GB/s)
16 x 32GB 4R 1333 L	512	16	32GB	4R	LRDIMM	1333	2	66.8	138.9	68.1
24 x 32GB 4R 1333 L	768	24	32GB	4R	LRDIMM	1066	3	70.9	235	40.4
16 x 32GB 2R 1333 H *	512	16	32GB	2R	HCDIMM	1333	2	66.8	138.9	68.1
24 x 32GB 2R 1333 H *	768	24	32GB	2R	HCDIMM	1066	3	67.5	161.9	63.9

Source: HP, <http://h20000.www2.hp.com/bc/docs/support/SupportManual/c03293145/c03293145.pdf>, Appendix A

*HCDIMM data to be published at later date

HyperCloud HCDIMMs are the only solution to achieve maximum memory at maximum speed on cost effective dual processor servers and scales the cliff created by the inability of DRAM to adhere to Moore's Law.

Tags: *HCDIMM LRDIMM Moore's Law Scaling Memory Cliff*

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