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**Effective Data Rates on Fully Populated 3DPC Servers**  
**LRDIMM's dirty little secret – what you see is not what you get!**

**White Paper**  
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# Effective Data Rates on Fully Populated 3DPC Servers

## LRDIMM's dirty little secret – what you see is not what you get!

This paper compares the performance of Netlist's HyperCloud® HCDIMMs and Load Reduced DIMMs (LRDIMM) in a fully populated three DIMM Per Channel (3DPC) configuration to validate effective (actual) module data rates by measuring throughput (bandwidth) versus the data rate specified on the module label. Although individual modules may be labeled as 1066MT/s or 1333MT/s, at 3DPC, architectural limitations of the module and systems may limit the maximum data rate to a speed less than the label indicates. In the case of LRDIMMs, OEM benchmarking data confirms that the effective (actual) data rate is even less than specified for 3DPC such that a LRDIMM labeled at 1333MT/s, specified to operate at 3DPC 1066MT/s is actually providing throughput at a speed less than 800MT/s (the "Effective Data Rate").

### Architectural Differences between HCDIMM and LRDIMM

Although the memory industry adopted LRDIMM to duplicate the functions of HCDIMM, the LRDIMM's architectural limitations inhibit it from meeting HCDIMM performance. The LRDIMM single buffer architecture results in asymmetrical data paths which increase skew and latency leading to lower performance. LRDIMM also lacks HyperCloud Rank Multiplication technology and appears as four physical ranks per module to the host memory controller while HCDIMM presents four physical ranks as two virtual ranks. The combination of superior architecture and technology enable HCDIMMs to significantly outperform LRDIMM on fully populated 3DPC servers and provide effective data rates as labeled and specified at system operation.

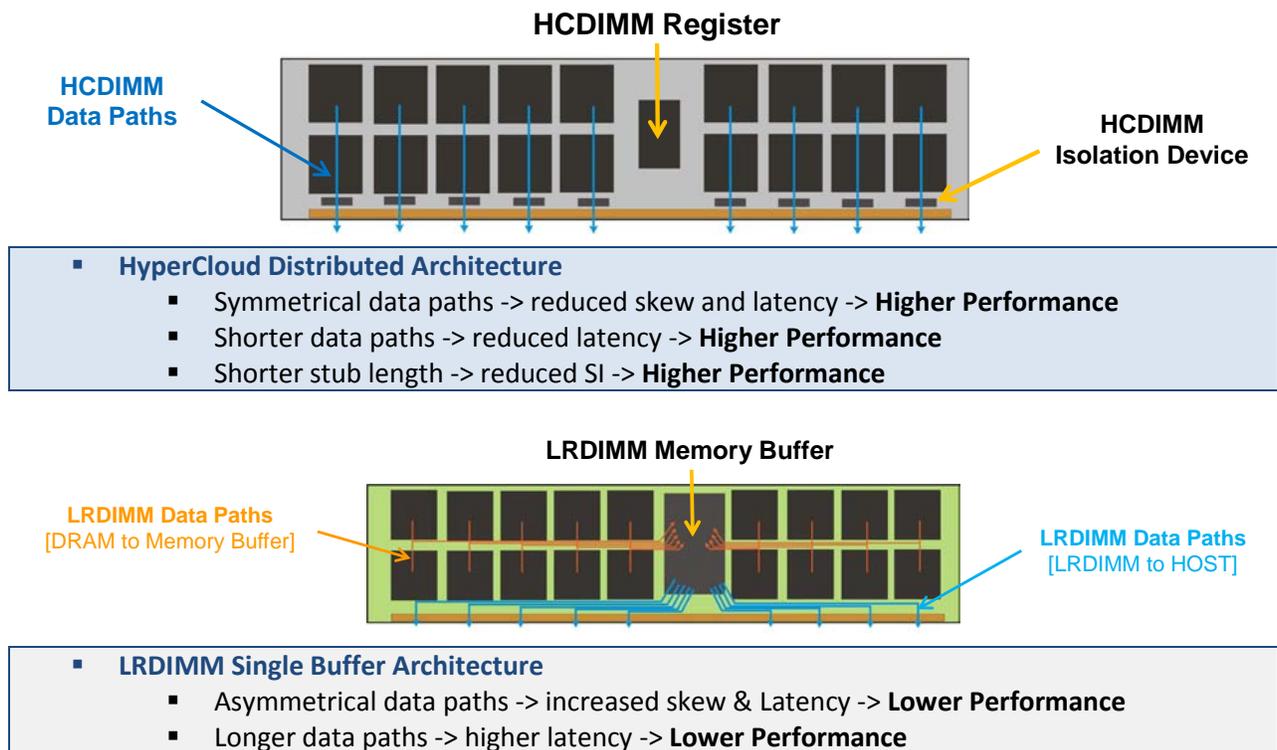


Fig. 1 Architectural Differences between LRDIMM and HCDIMM

## HCDIMM vs. LRDIMM Performance Comparison

An Intel® Xeon® Processor E5-2600 server platform with dual Intel E5-2690 processors and 768GB memory configurations (4 memory channels per processor, 3 DIMMs Per Channel, 24 DIMMs total) featuring 32GB HCDIMM and LRDIMM modules were used in OEM performance evaluations under identical conditions. The purpose of the comparison is to focus exclusively on the memory bus interface between the CPU and memory with all other parameters remaining equal.

RDIMM support at 768GB is not possible because 32GB RDIMMs are only available as 4R modules and are not supported in 3DPC configurations. 8Gb DRAM components are required to manufacture 32GB 2R RDIMMs, but are not commercially available and likely unavailable until the adoption of DDR4 technology. HCDIMM was tested at 1333MT/s while LRDIMM was tested at the supported Intel Plan of Record (POR) 3DPC configuration of 1066MT/s.

The parameter that this paper focuses on is throughput, measured in Gigabytes per second (GB/s), which is the actual amount of data available to the system at any given time and therefore, the true performance measurement of how quickly applications can complete. Theoretically, the throughput can be easily calculated from module data rate and system configuration. As an example, a typical Intel Xeon Processor E5-2600 server platform contains two processors with four memory channels each. With memory modules labeled as 1333MT/s, the theoretical system data rate is:

$$1333 \text{ MT/s} * 8 \text{ channels} * 64\text{bit/DIMM} * 1\text{Byte}/8\text{bit} = 85.3\text{GB/s}$$

In reality, the maximum throughput is smaller due to the fact that the memory is accessed by multiple thread or processes at the same time. The theoretical maximum throughput is one in which only one memory access is being executed by a single processor while no other accesses are occurring. This state, also referred to as “unloaded latency”, is never possible in a real system with real applications since multiple processes and memory accesses are occurring simultaneously. With multiple processes and memory access, latencies increase and this “loaded latency” condition can significantly impact the overall throughput. Regardless of module labeling or system specification, the throughput value can be used to determine the effective data rate of HCDIMM and LRDIMM.

### OEM Benchmark Throughput Data

Sample Memory Configuration (2CPU) Module Label	3DPC Data Rate	Throughput (GB/s)
24 x 32GB 2R 1333 HCDIMM	1333	69
24 x 32GB 4R 1333 LRDIMM	1066	40

Fig 2 OEM Benchmark Throughput Data

Figure 3 summarizes the throughput values for 32GB LRDIMM at 1066MT/s and 32GB HCDIMM at 1333MT/s.

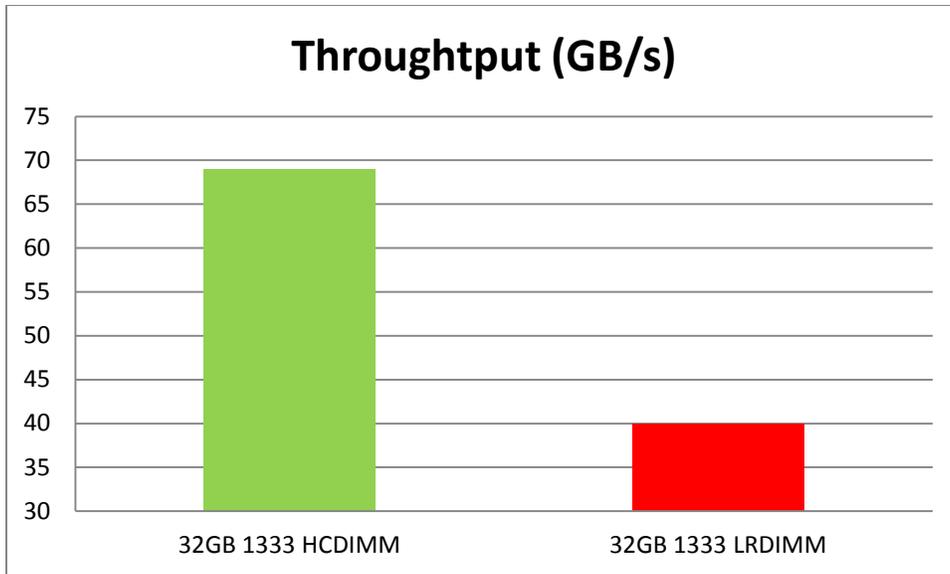


Fig 3 Throughput comparison

The data confirms that 32GB HCDIMM provides 71% more throughput than 32GB LRDIMM which applies directly to improved application performance.

### Effective Data Rate Based on Throughput

In order to compute the Effective Data Rate, we establish a Throughput per Single Data Rate reference value since the modules have different data rates by dividing the throughput value by the specified 3DPC data rate (Column D = B/C). Using HCDIMM's measured throughput, a reference value of 51.76MB/s is calculated based on the maximum value achieved by HCDIMM and multiplied by the specified data rate to arrive at the Effective Data Rate (Column E = D \* B).

A	B	C	D	E
DIMM Description	Specified Data Rate	Throughput (GB/s)	Throughput per Single Data Rate (MB/s)	Effective Data Rate at 51.76MB/s Throughput*
32GB 1333 HCDIMM	1333	69	51.76	1333
32GB 1333 LRDIMM	1066	40	37.52	773

Figure 4 Effective Data Rate based on HCDIMM Throughput per Single Data Rate of 51.76MB/s

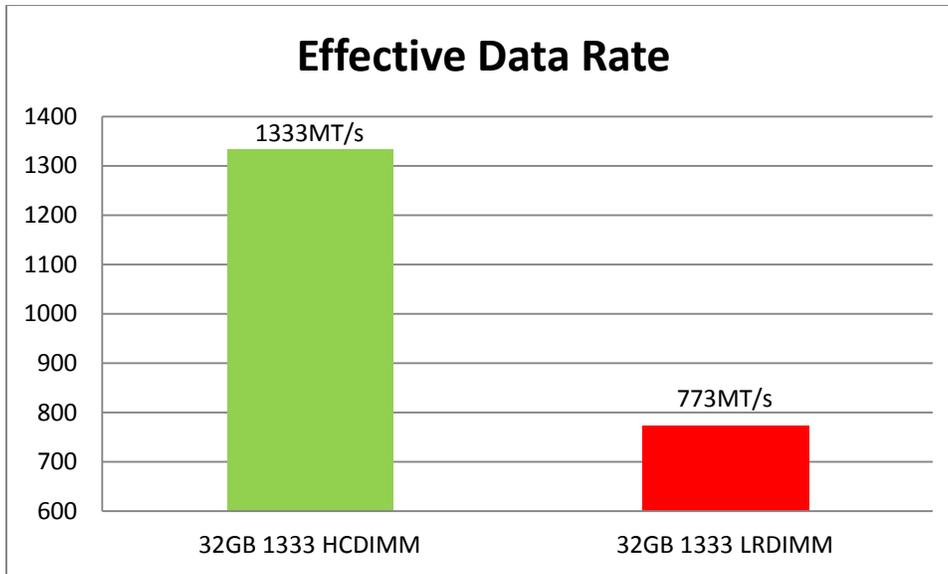


Fig 5 Effective Data Rate based on normalized throughput

If HCDIMM's Effective Data Rate is computed based on LRDIMM results of 37.52MB/s Throughput per Single Data Rate at 1066MT/s, HCDIMM's 1333 Effective Data Rate would be labeled at 1839MT/s.

A	B	C	D	E
DIMM Description	Specified Data Rate	Throughput (GB/s)	Throughput per Single Data Rate (MB/s)	Effective Data Rate at 37.52MB/s Throughput*
32GB 1333 HCDIMM	1333	69	51.76	1839
32GB 1333 LRDIMM	1066	40	37.52	1066

Figure 6 Effective Data Rate based on LRDIMM Throughput per Single Data Rate of 37.52MB/s

## Summary

OEM benchmark data confirms that throughput value, which is the true measure of application performance, is 71% higher for 32GB HCDIMM than 32GB LRDIMM in fully populated 3DPC server platforms. Based on normalized throughput values, effective data rates for HCDIMMs are actually more than two speed grades faster than LRDIMMs and show that LRDIMMs are not performing as specified. Only HyperCloud HCDIMMs provide maximum memory at maximum performance which allows customers to maximize their IT investments.