Large-Scale Hierarchical k-means for Heterogeneous Many-Core Supercomputers

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K-means is a well-known clustering algorithm, used widely in many AI and data mining applications, such as bioinformatics, image segmentation, information retrieval and remote sensing image analysis. Finding the optimal solution for a general *k-means* problem is known to be NP-hard. Currently high-end *k-means* problems are limited by the number of dimensions (d) and the number of centroids (k) they can consider.

The method and design they present targets the Sunway TaihuLight, one of the world's fastest supercomputers. The Sunway TaihuLight is a Chinese supercomputer which, as of November 2018, is ranked third in the TOP500 list, with a LINPACK benchmark rating of 93 petaflops. The Sunway TaihuLight uses a total of 40,960 Chinese-designed SW26010 manycore 64-bit RISC processors based on the Sunway architecture. Each processor chip contains 256 processing cores, and an additional four auxiliary cores for system management (also RISC cores, just more fully featured) for a total of 10,649,600 CPU cores across the entire system.

The key of their approach is a three-level data partition strategy based on hierarchical many-core hardware support. *Level 1* partitions clusters centroids k by the number of cores in a Core Group(CG), *level 2* partitions k by the dataflow n into multiple CGs and *level 3* partitions d by the number cores in a CG.

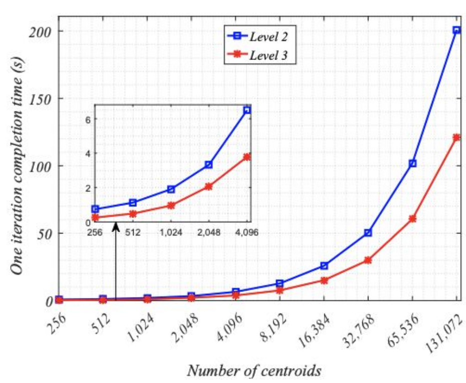

Figure 8: Comparison test: varying k with 4,096 dimensions and 1,265,723 data samples tested on 128 nodes

They report the results of three different partition strategies: Level 1 – a baseline single-level partition strategy, Level 2 – an implementation of a state-of-the-art two-level partition strategy used in recent supercomputer implementations , and Level 3 – our novel three-level partition strategy. Figure 8 shows how the one iteration completion time grows as the number of centroids, k increases. Since the number of d is fixed at 4096, the Level 3 approach actually always outperforms Level 2, with the gap increasing as k increases. Figure 9 shows how both Level 2 and Level 3 scale across an increasing number of computation nodes. Level 3 clearly outperforms Level 2 in all scenarios. The values of k and d are fixed, as described in the graph caption, at levels which Level 2 can operate. The performance gap narrows as more nodes are added, but remains significant. Clearly the exact performance numbers will vary with other values k and d, as can be inferred from other results, but the main conclusion we draw here is that Level 3 generally scales well.

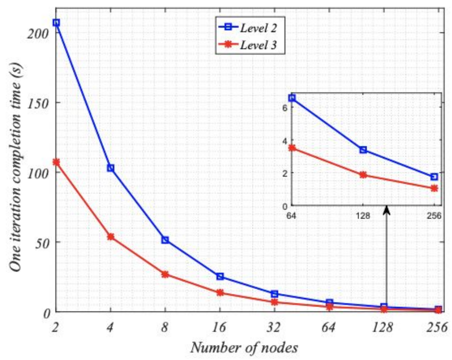

Figure 9: Comparison test: varying number of nodes used with a fixed 4,096 dimension, 2,000 centroids and 1,265,723 data samples

REFERENCES

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