CATEGORY: **DEVELOPER - ALGORITHMS - DA05**

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GPU TECHNOLOGY CONFERENCE

MDACCER: A local strategy for assessment of complex networks on GPUs

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Abstract

We propose a new method derived from DACCER *(Distributed Assessment of the Closeness Centrality Ranking)*[1]: the modified DACCER (MDACCER), for assessing traditional Closeness Centrality ranking.

MDACCER presents a relaxation that allows it to take advantage of massively parallel environment, like General Purpose Graphics Processing Units (GPGPUs).

DACCER assesses the node centrality by estabilishing a radius *h* for a limited neighborhood around each node. When *h=2,* it presents a good correlation level to Closeness Centrality at a lower cost besides being easier to be parallelized. Despite all the advantages, DACCER presents some diculties in GPGPUs programming model that increases computational cost at this particular environment [2].

In order to accomodate DACCER to that sort of environment, we proposed MDACCER. Experimental results demonstrate that MDACCER is as simple and efficient as DACCER to assess Closeness centrality ranking in complex networks and moreover does not have the same bottlenecks in GPGPUs computing, about memory usage and time complexity. We performed MDACCER for synthetically generated Barabási-Albert (BA) networks[3], and results indicate MADCCER correlates Closeness centrality ranking almost as well as DACCER does, at lower computational costs.

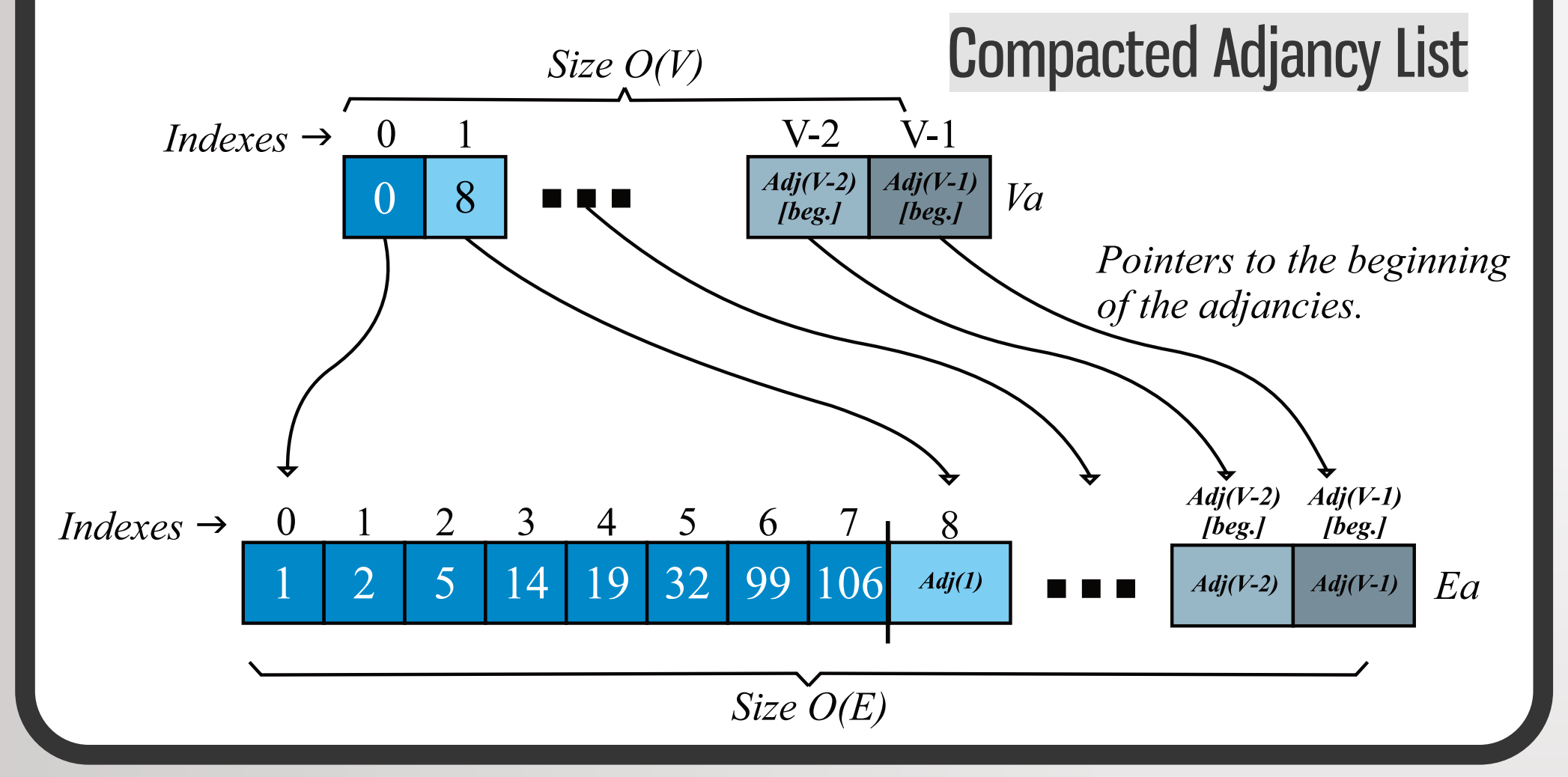
Implementation

We implemented MDACCER on CUDA 5.5 along with the *Thrust* parallel API [4] to implement the device/host arrays as well to perform some parallel primitives: reduce, exclusive-scan and sequence.

The most underlying structere of the application is the Compacted Adjacency List (CAL) [5]. There are three lists of that type: the one which stores the graph, the one which stores the adjacencies at the k-layer and the one which stores the adjacencies at the k-1 layer.

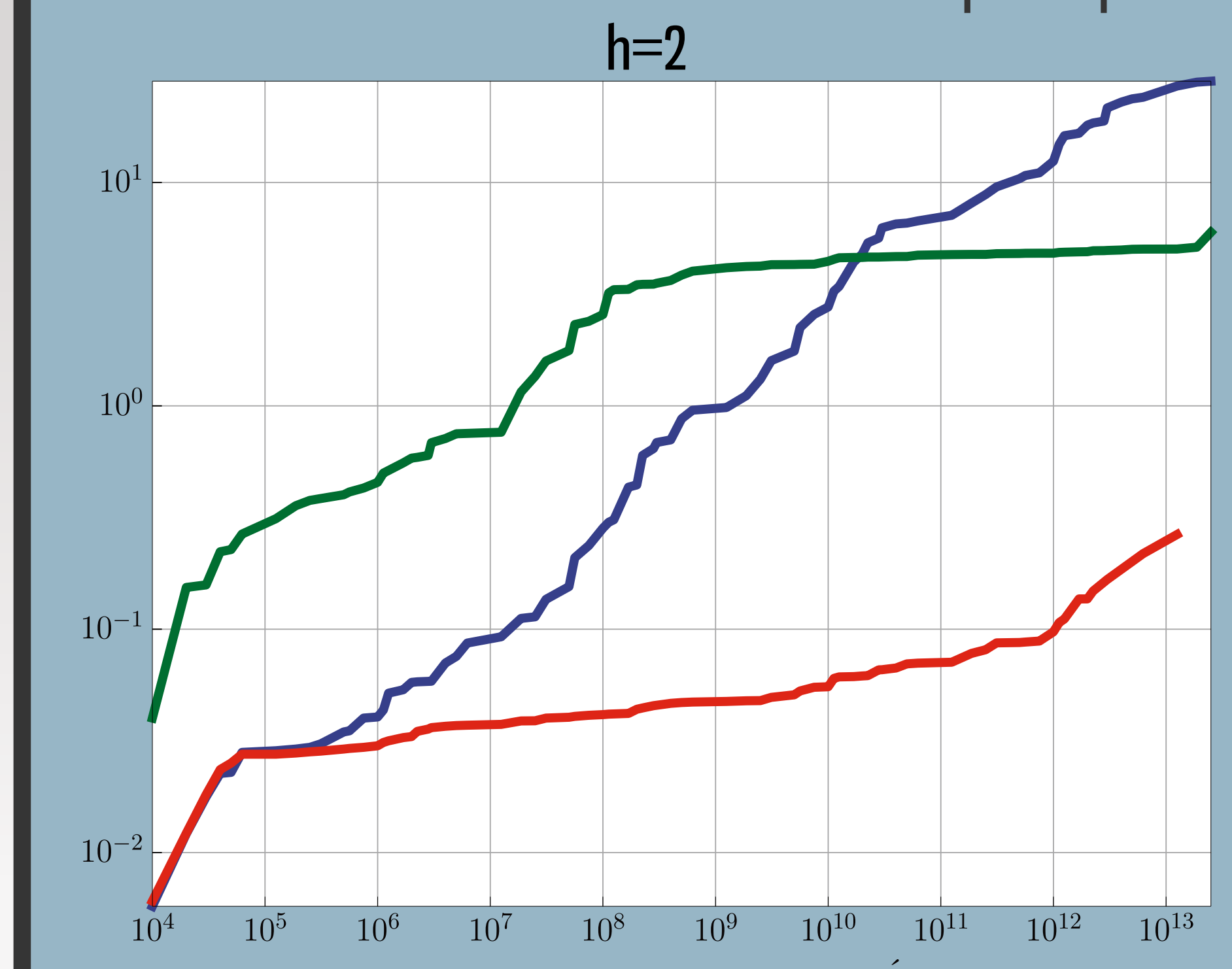
The algorithm starts with the reading of the graph and the radius. After that, it creates the CAL for the computation of the volume (centrality measure of the node). It iterates over the neighborhood of the vertices until it gets the input radius. At every iteration, It allocates a thread to each vertex to compute its correspondent volume. After, the volume computation, the algorithm output a ranking ordered of highest to lowest.

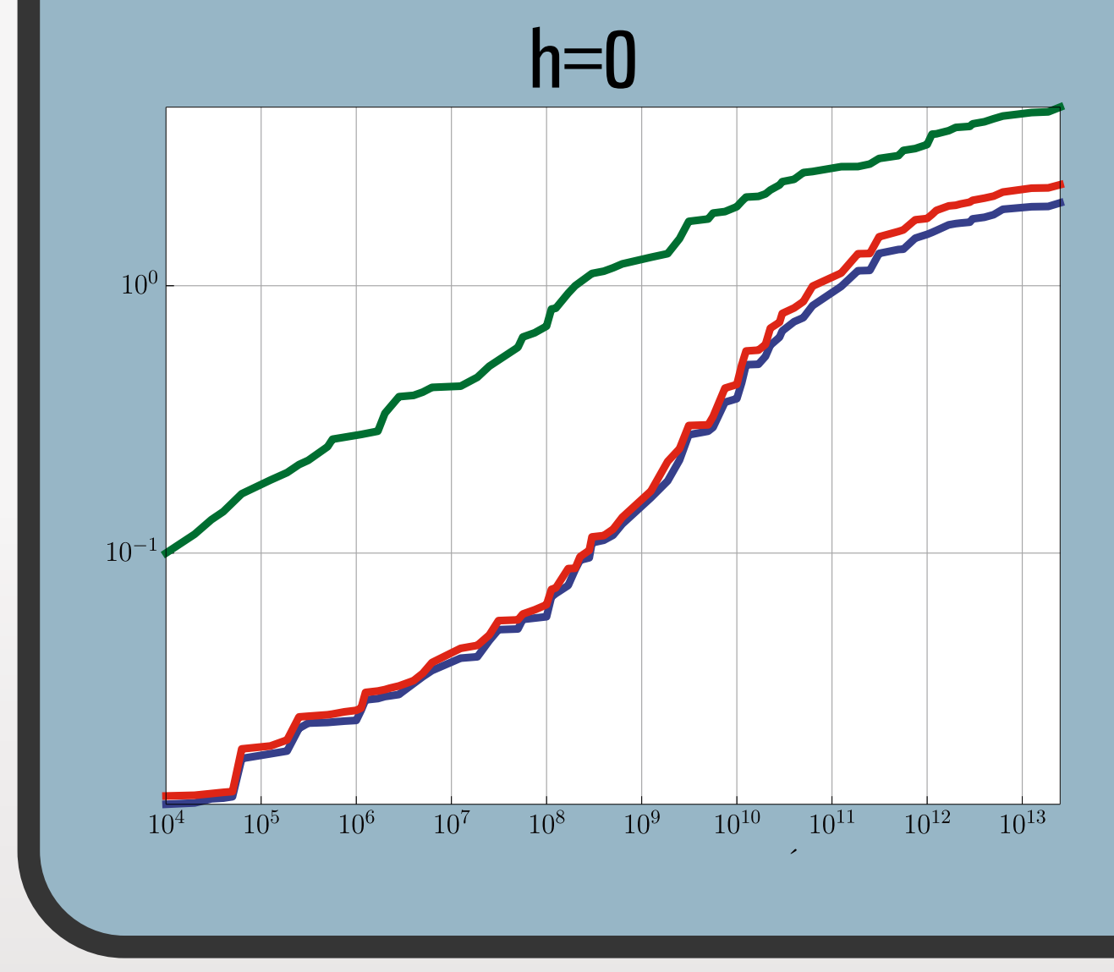
Compacted Adjancy List

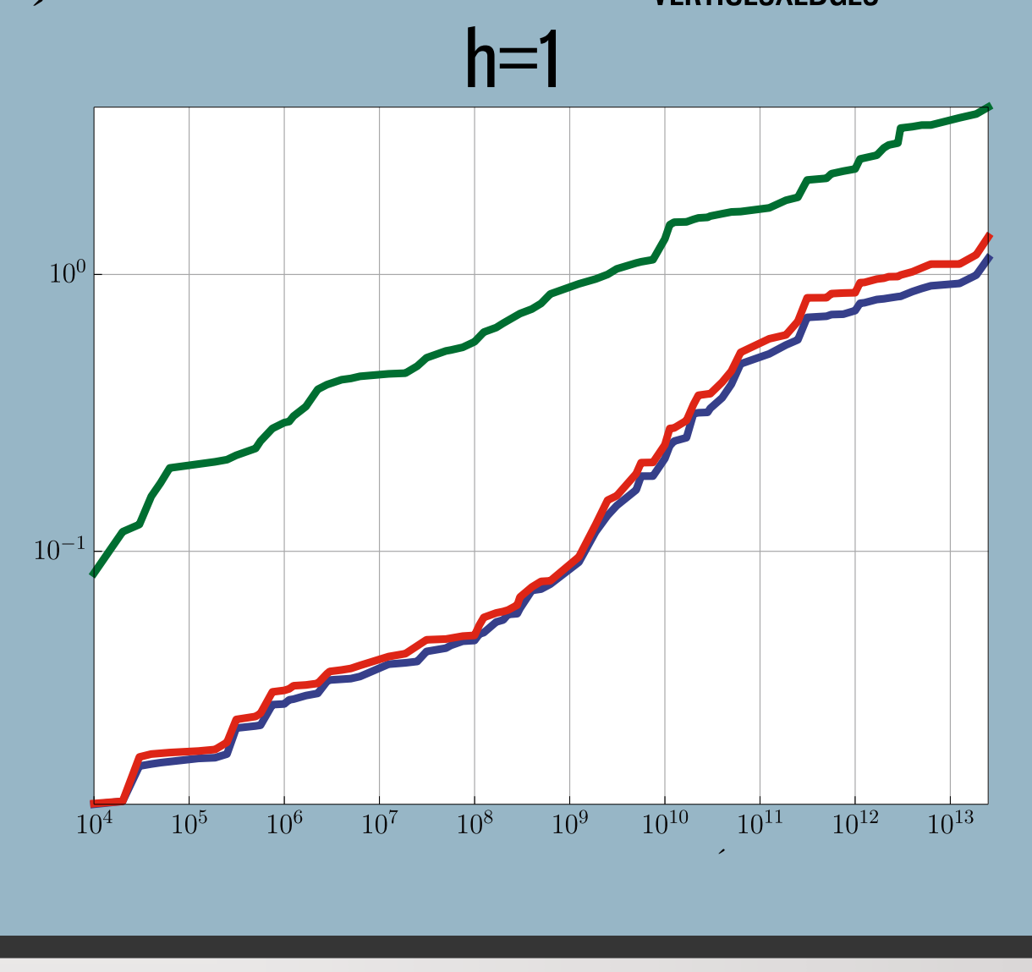


Results

speedup - the higher the better







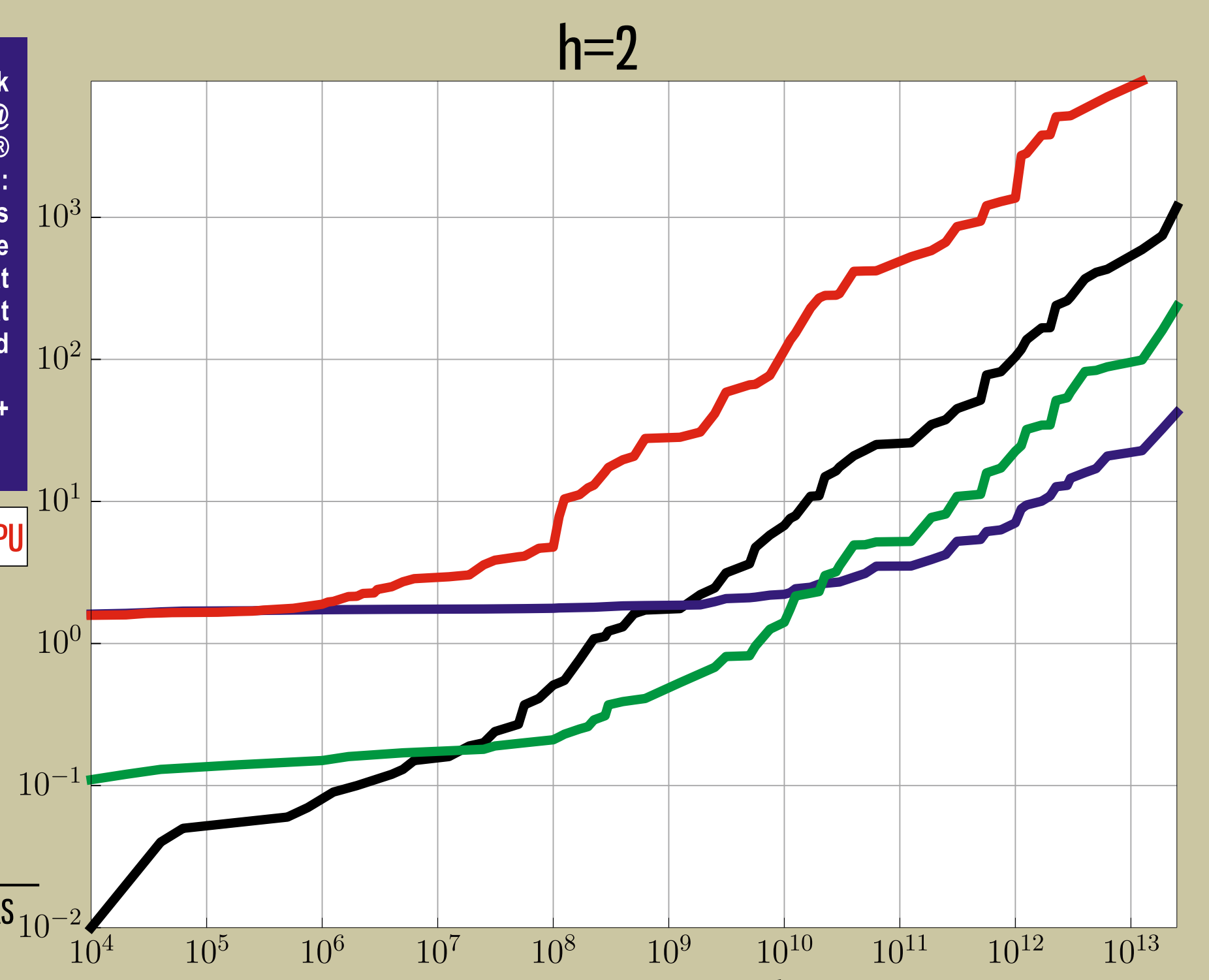
The experiment was carried out on a Linux cluster with an infini-band network channel and 4 nodes. Each node has 2 Intel® Xeon® CPU E5-2660 0 @ 2.20GHZ (8 cores per processor), 64GB DDR3 DIMMs memory and a Nvidia® Tesla k20 GPU. There were three types of applications for the experiments: serial, MPI/OpenMP and hybrid between CPU and GPU. The serial one was compiled with gcc version 4.4.7. The MPI/OpenMP one was compiled with the following products: 1) Portland Group Compiler Collection (pgcc) 14.2 that supports OpenMP 3.0 and OpenACC 2.0 standards; 2) MVAPICH 2.2.0, that fully supports MPI 2.0 standard and executed with 32 processes. The hybrid one was compiled with NVCC (Nvidia Compiler Driver) version 5.5.0.
The charts are related to the elapsed times of the applications, i.e., read + computation + write.

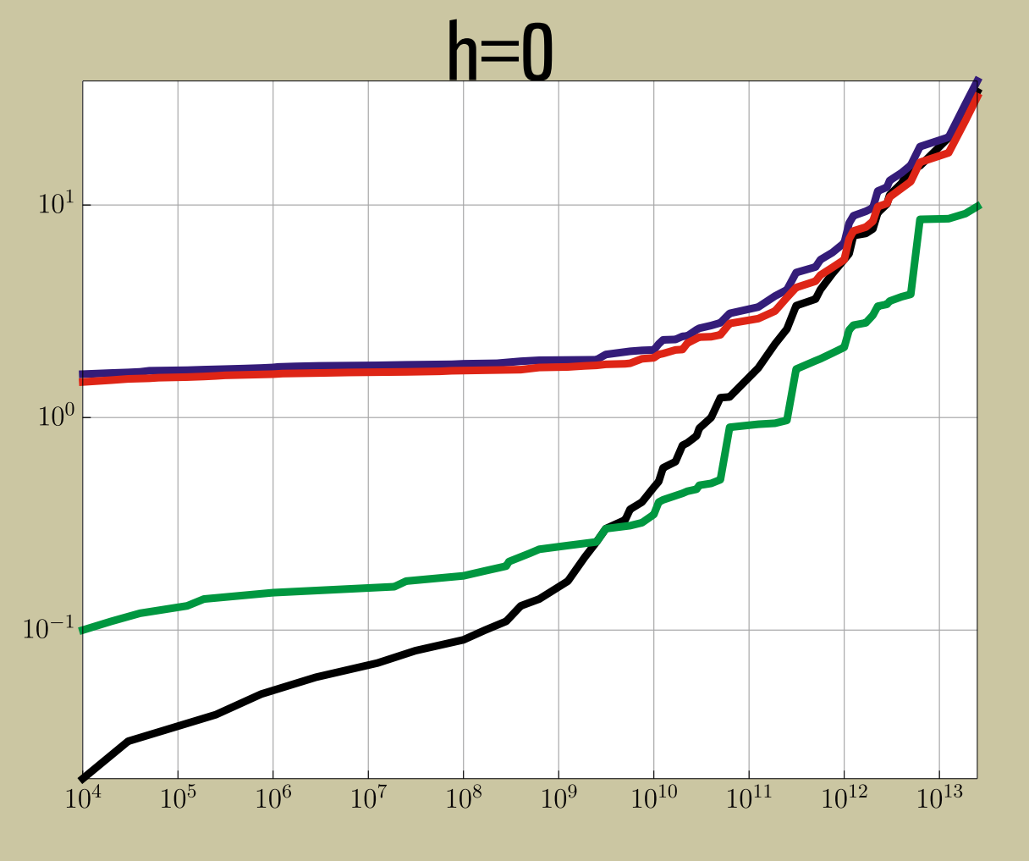
— Daccer Serial — Daccer Multicore — Mdaccer GPU — Daccer GPU

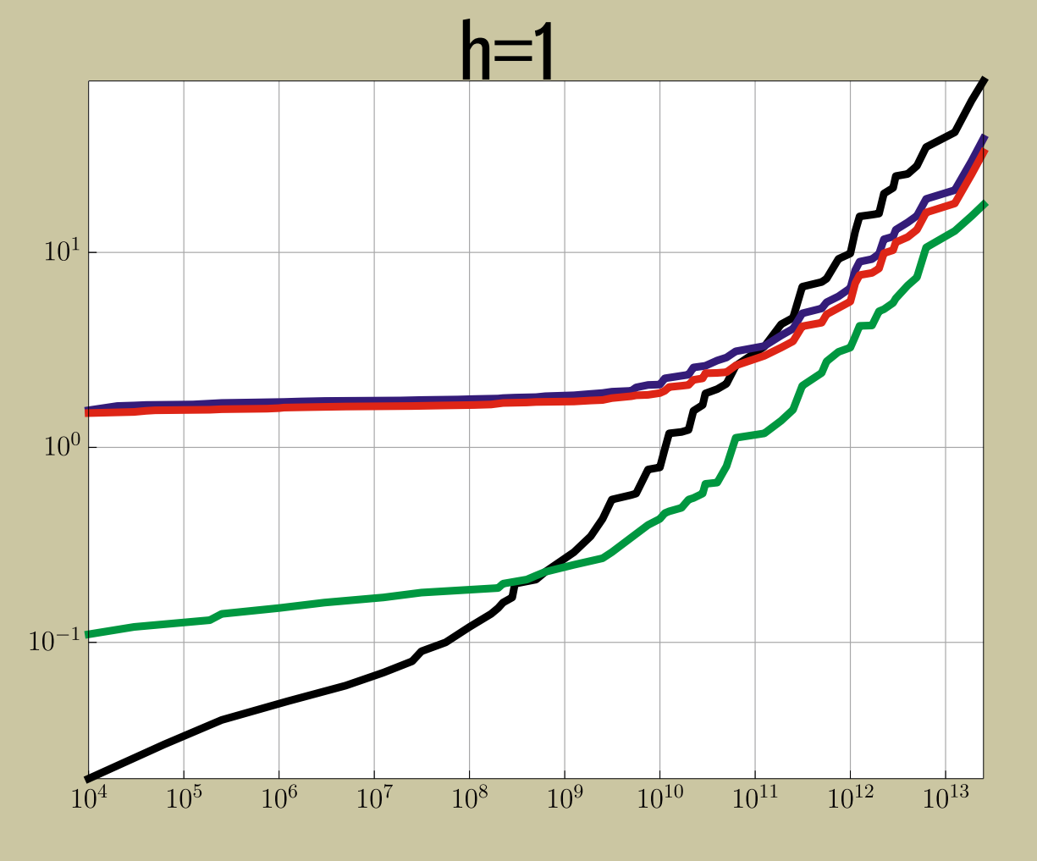
Chart Axes: SPEEDUP AGAINST DACCER SERIAL; COMPLEXITY B.A. NETWORKS VERTICESXEDGES

Chart Axes: TIME IN SECONDS; COMPLEXITY B.A. NETWORKS VERTICESXEDGES

time - the lower the better







Centrality of Complex Networks

A complex network is defined as a graph whose topological features are non-trivial, i.e., there are conectivity patterns (spatial and temporal) between its elements which are neither purely regular nor purely random. Nowadays, Complex networks include most social, biological and technological networks [5].

The study of dynamics of such networks can be accomplished through models, one of which is the Barabási-Albert one [3].

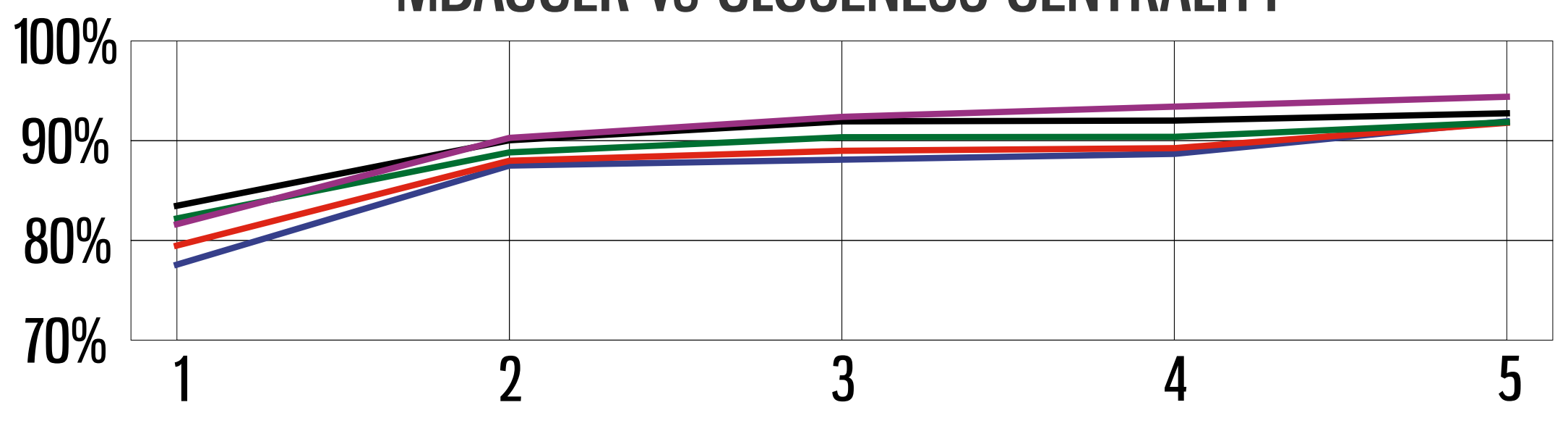
One of the characteristics assessed in the Network Theory is the centrality of the nodes. In broad terms, it tells the relative importance of them in the network. In this study, many approaches have been used as the *Closeness Centrality* and *Betweenness Centrality* [7].

Those approaches, called global ones, need to have a full knowledge of the net, which makes them computationally expensive. Beside that, it is very difficult to parallelize them .Those two factors have been leading researchers to look into local and parallelizable methodologies, i.e., the ones that do not need to have complete knowledge of the net as the DACCER one.

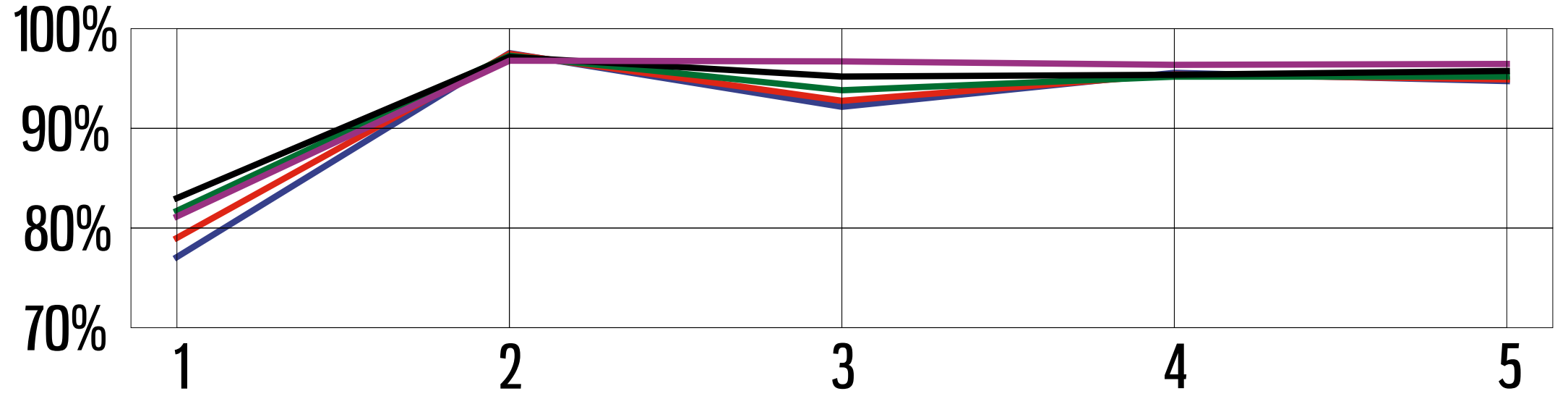
Correlation Degree for h=2

value given by Rank-Biased Overlap [8]

MDACCER vs CLOSENESS CENTRALITY



DACCER vs CLOSENESS CENTRALITY



MDACCER vs DACCER

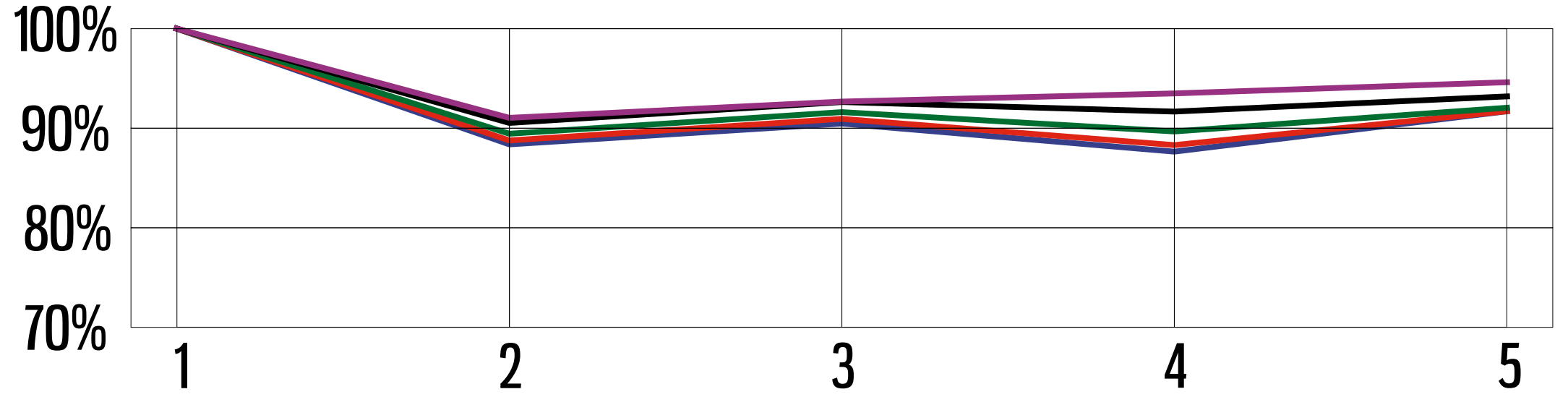
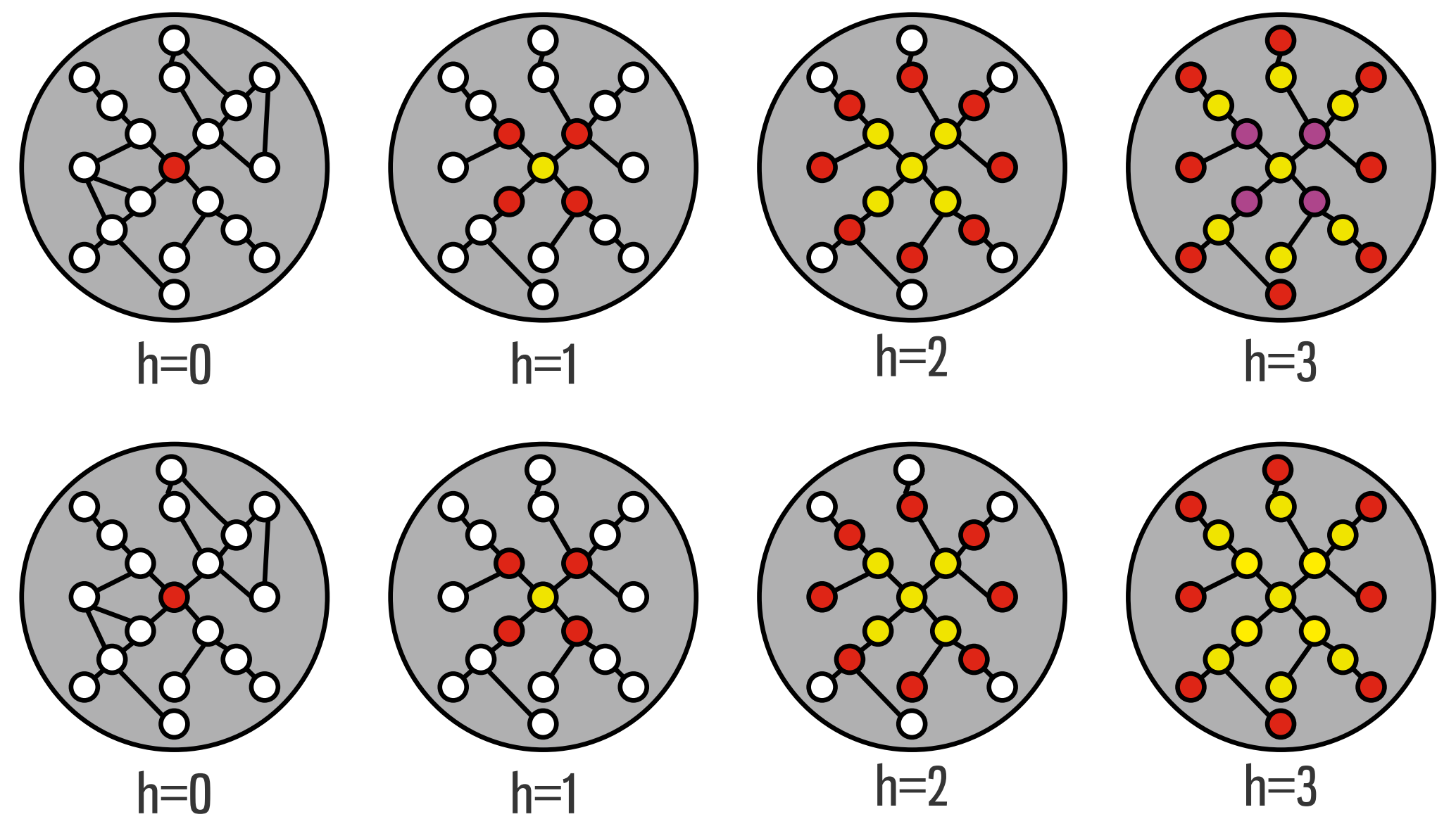


Chart Axes: CORRELATION; AVERAGE DEGREE B.A. NETWORKS

Depth of Evaluation
— 10%
— 25%
— 50%
— 75%
— 99%

For each average degree we generated a hundred B.A. networks with 1.000 nodes each.

Differences between MDACCER and DACCER



MDACCER

🟥	Being computed	🟨	Already computed
○	Not computed yet	●	Being recomputed

DACCER

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Acknowledgements

1- The authors are thankful to the SINAPAD network (http://www.lncc.br/sinapad) for providing the HPC resources to the experiments described herein.
2- Authors are thankful to Nvidia for all support.
3 - Partially supported by the "Conselho Nacional de Desenvolvimento Científico e Tecnológico" (CNPq) Brazilian agency.