The Suitability of BSP/CGM Model for HPC on Clouds

Alfredo Goldman, Daniel Cordeiro and Alessandro Kraemer
IME - USP

Cetraro, Italy, 28/06/2012

hp FAPESP

Great workshop

- High Quality Presentations
- Amazing location
  - even without the old elevator
- Great face to face contacts
  - Jogging with Ian Foster
  - Histories of Steve Wallach
  - Discussion about flash with Frank Baetke
  - Talk on teamwork with Natalie Bates
  - ....

Distributed Systems

- Two main conferences
- SBRC - Distributed Systems and Networks
  - 30th Edition
  - 1000 participants

- SBAC-PAD - Computer Architecture and HPC
  - 24th Edition
  - Papers in English
  - 2012 Edition in New York

24th International Symposium on Computer Architecture and High Performance Computing

SBAC-PAD'2012

October 24-26, 2012
New York City, USA

Columbia University

Back to the WIP

- Agenda
  - Motivation
  - Previous Experience
  - Some Related Works
  - Preliminary Experiments
  - Future Work

Motivation

- Paper from HP labs
- Evaluation of HPC Applications on Cloud
    - A. Gupta and D. Milojivic
    - Cloud would be suitable for *some* HPC apps

Main Points

- On the Cloud
  - poor network performance / OS noise
  - can be cost-effective
- Clouds are more cost-effective for:
  - Embarrassingly parallel/tree structured
  - Applications where comm. cost is hidden by computation

Other Applications ?

- Map Reduce
  - Widely spread with hadoop
  - Compared to BSP has limitations
    - (Pace - ICCS, 2012)
- How to deal with the Communication ?
  - Try to “minimize” them...

Previous Experience

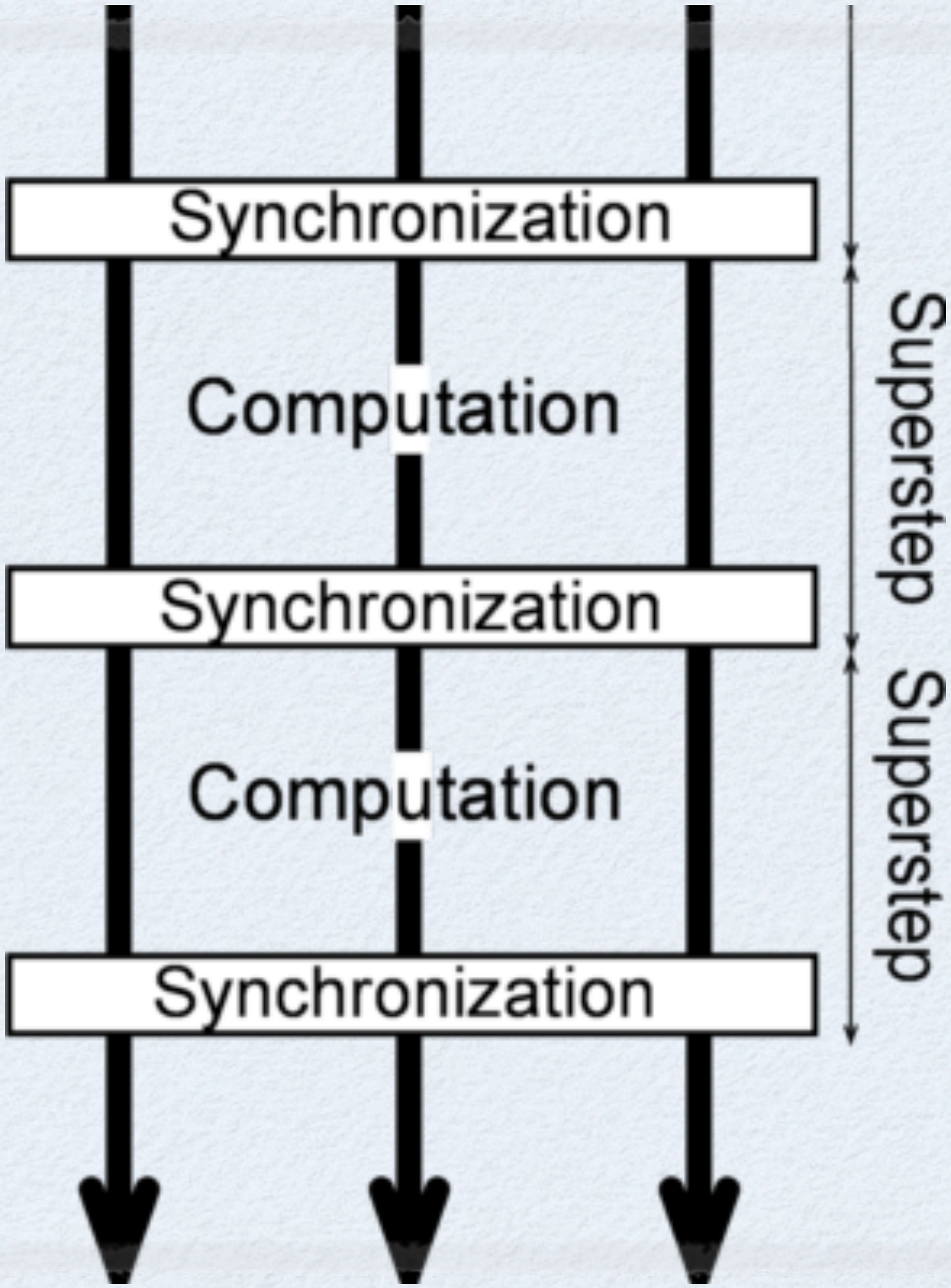
- Integrade
  - www.integrade.org.br
- Opportunistic Grid Middleware
- With support for Parallel Computing
  - Bag of Tasks
  - Either MPI and BSP

BSP

- Bulk Synchronous Parallel
- Valiant'90
- Model that links software and hardware
    - Given the machine parameters it is easy to estimate the execution time

BSP Main Points

- Execution performed in **super-steps**
  - Computation and synchronization phases
- Two communication mechanisms:
  - Direct Remote Memory Access (DRMA)
  - Bulk Synchronous Message Passing (BSPM)
- Several existing implementations
  - BSPLib, Green BSPLib, PUB, BSP-G


Synchronization
Computation
Synchronization
Computation
Synchronization
Superstep
Superstep

SCHEMATICS

InteGrade - Checkpointing

- Essential in opportunistic environments
- Checkpoints are stored periodically
- Using BSP
  - Checkpointing on InteGrade is portable and transparent to the programmer

CGM

- Coarse Grained Model
- Theoretical model proposed by Dehne '93
- n data size, p processors with memory O(n/p)
  - n/p >> p
- At each step processors exchange O(n/p) data
- Goal: minimize the number of steps

CGM Algorithms

- Randomized List Ranking
  - O(p log n) with high probability
- All-Substrings longest common subsequence
  - O(log p)
- Euler Tour
- Efficient ways to do the h-relation
- more than 10 thousand results on Google Scholar

Back to BSP

- Interest on large graphs
- Pregel (2010)
  - suitable for large-scale graph computing
  - Vertex centric approach
  - designed to be
    - efficient, scalable and fault-tolerant

PREGEL (1/2)

- Each process/ core is assigned to one vertex
- Loop, for each vertex
  - Receive data from the previous step
  - Change state
  - Send data to other vertices
  - May vote to halt

PREGEL (2/2)

- Was applied in clusters with thousands of commodity computers
- Applications:
  - Page Rank
  - Shortest Path
  - Bipartite-Matching

Apache Hama

- Apache Hama is a pure BSP computing framework on top of HDFS
- For massive scientific computations such as matrix, graph and network algorithms
- Computation Engines:
    - Map Reduce - for matrix computations
    - BSP, Dryad - for graph computations

Several others

- Apache Giraph
- GPS: Graph Processing System
  - API for global comm., load balancing & distribution
- Golden ORB
- Phoebus
- Bagel

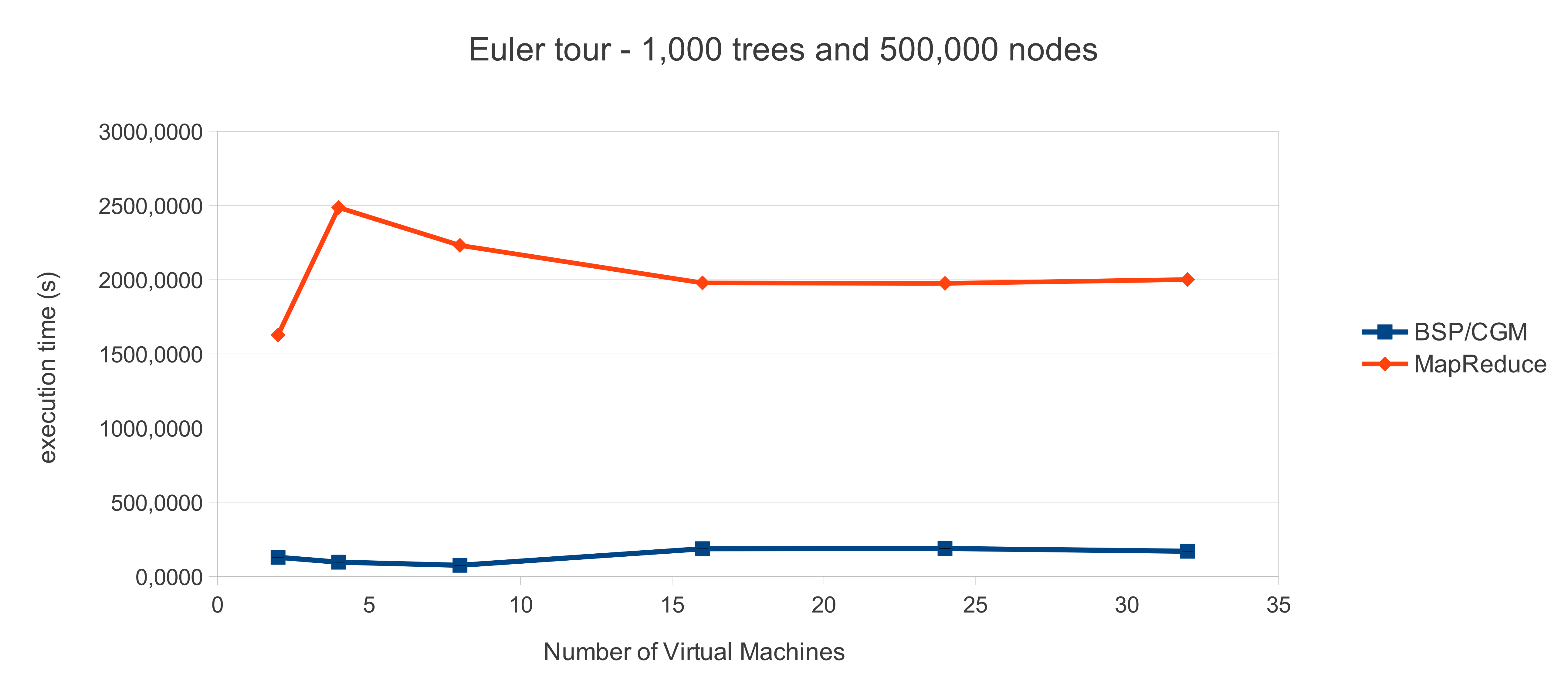
Preliminary Results

- We have conducted some experiments with two classical graph problems:
    - Connected Components and Eulerian Path.
- With one twist: the MapReduce algorithm only tests if it exists a Eulerian Path and find a single connected component while the BSP computes the path and find all connected components.

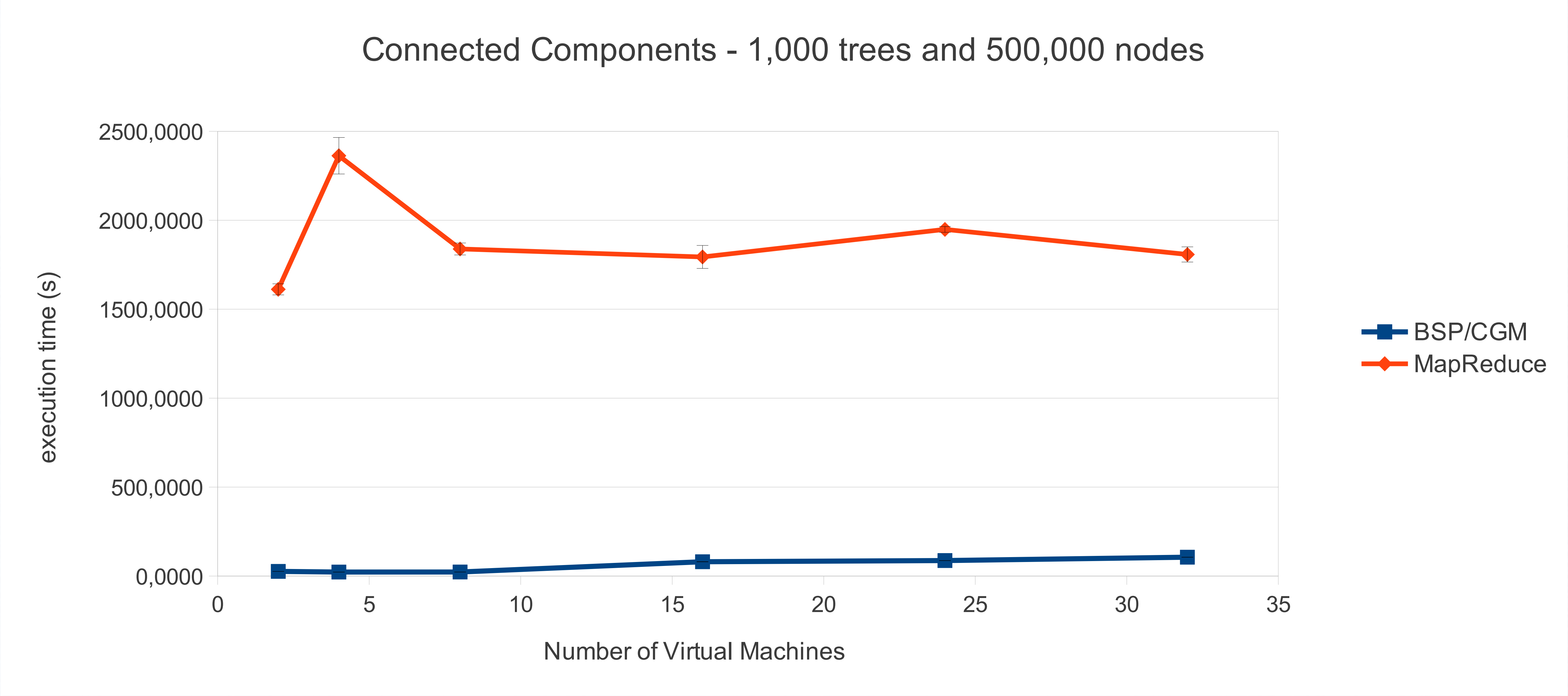
Experimental Environment

- Private cloud
  - 11 Intel Core Duo 2.66 GHz, 2GBytes, interconnected by a FastEthernet network
  - The PCs are shared by 33 Virtual Machines
- Software used:
- For BSP/CGM: mpich2, cgmlib 0.9.5 and NFS.
- For MapReduce: sun java 5, hadoop 1.0.1 and HDFS.

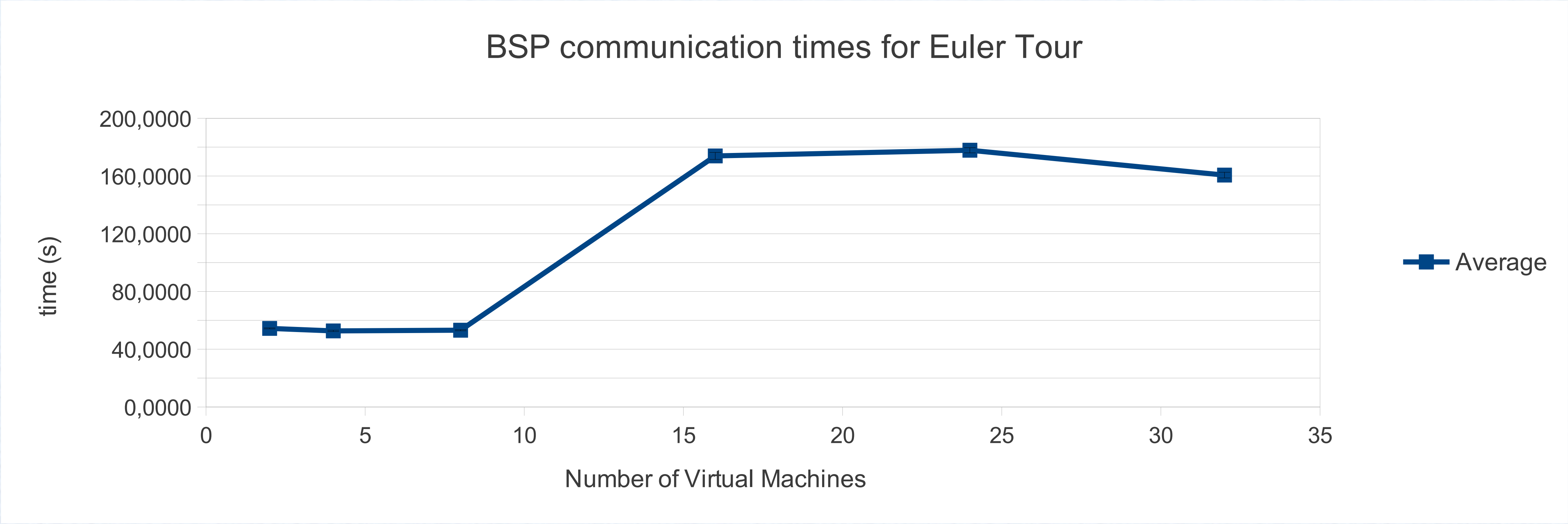
Euler Tour

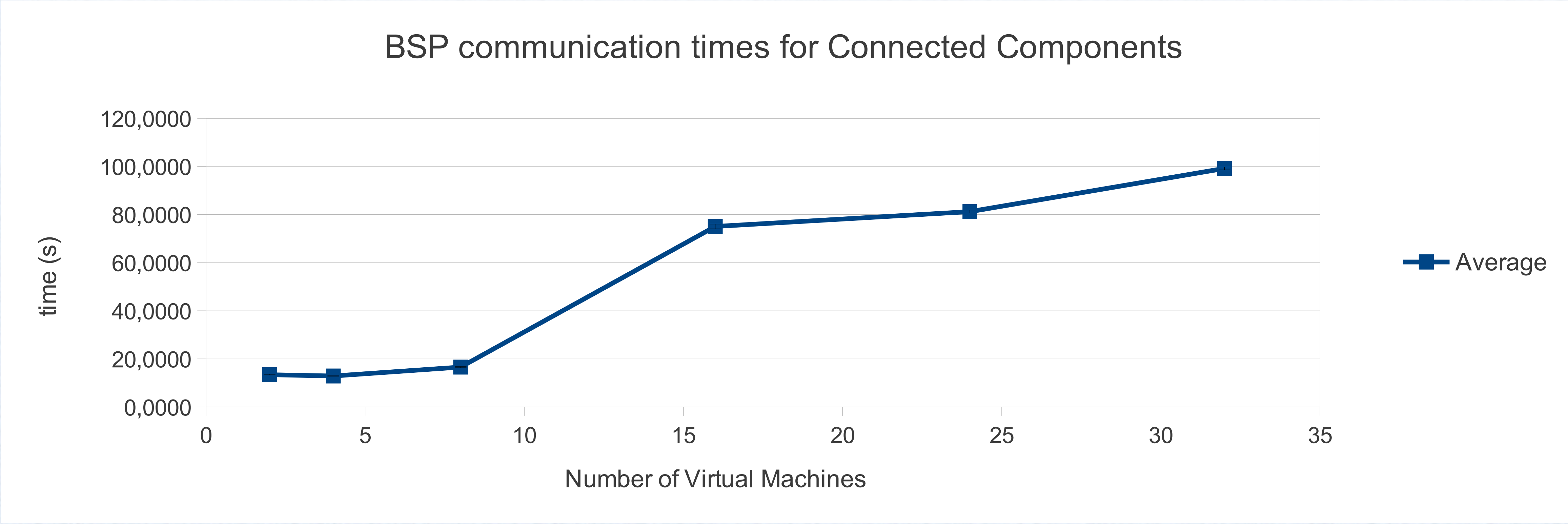

Euler tour - 1,000 trees and 500,000 nodes
3000,0000
2500,0000
2000,0000
1500,0000
1000,0000
500,0000
0,0000
execution time (s)
0
5
10
15
20
25
30
35
Number of Virtual Machines
BSP/CGM
MapReduce

Connected Components



Communication times for BSP





Future Directions

- Explore Scalability
- Apply Locality to place the BSP processes
- Use partial synchronization