Graphalytics: A Benchmark for Large-Scale Graph Analysis on Parallel and Distributed Platforms

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Several slides developed jointly with Yong Guo.

Co-authored by LDBC team:

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Founded 10th century
Pop: 850,000
Amsterdam

Founded 1880
Pop: 23,500
Delft

Founded 1842
Pop: 19,500
Munich, Germany

Founded 13th century
Pop: 100,000

Pop: 16.5 M
## GraphsComp in Academic Publications

Title Keywords in Computer Systems Conferences (CCGRID, CLOUD, Cluster, HPDC, ICPP, IPDPS, NSDI, OSDI, SC, SIGMETRICS, SoCC, SOSP) and Journals (CCPE, FGCS, JPDC, TPDS) and Journals (CCPE, FGCS, JPDC, TPDS)

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**Warning:** Linear regressions may be deceiving.
Graphs Are at the Core of Our Society: The LinkedIn Example

The State of LinkedIn

A very good resource for matchmaking workforce and prospective employers

Vital for your company’s life, as your Head of HR would tell you

Vital for the prospective employees

Tens of “specialized LinkedIns”: medical, mil, edu, science, ...

150,000,000
registered members
(Q1 '12)

Sources: Vincenzo Cosenza, The State of LinkedIn, http://vincos.it/the-state-of-linkedin/
LinkedIn’s Service Analysis

By processing the graph: opinion mining, hub detection, etc. Always new questions about whole dataset.

Sources: Vincenzo Cosenza, The State of LinkedIn, http://vincos.it/the-state-of-linkedin/
LinkedIn’s Service Analysis

Periodic and/or continuous full-graph analysis

Sources: Vincenzo Cosenza, The State of LinkedIn, http://vincos.it/the-state-of-linkedin/
Graph Processing Platforms

Which platforms perform well?

What to tune?

What to re-design?
Graph Processing Platforms

Intel Graphmat

IBM System G

Benchmark!
What Is the Performance of Graph Processing Platforms?

- **Graph500**
  - Single application (BFS), Single class of synthetic datasets. @ISC16: future diversification.

- Few existing platform-centric comparative studies
  - Prove the superiority of a given system, limited set of metrics

- **GreenGraph500, GraphBench, XGDBench**
  - Issues with representativeness, systems covered, metrics, ...
What Is the Performance of Graph Processing Platforms?

Graphalytics = comprehensive benchmarking suite for graph processing across many platforms

http://ldbcouncil.org/ldbc-graphalytics
http://graphalytics.org/
Graphalytics, in a nutshell

- An LDBC benchmark
- Advanced benchmarking harness
- Many classes of algorithms used in practice
- Diverse real and synthetic datasets
- Diverse set of experiments representative for practice
- Renewal process to keep the workload relevant
- Extended toolset for manual choke-point analysis
- Enables comparison of many platforms, community-driven and industrial

[Losup et al., VLDB’16] [Guo et al., CCGRID’15] [Guo et al., IPDPS’14]
Graphalytics Software: 4 Types of Benchmarks

1. **Test benchmark / fire drill**

2. **Standard benchmark**
   - cost-efficiency*, performance

3. **Full benchmark**
   - scalability, robustness

4. **Custom benchmark**
   - analysis, based on our tools Granula and Grade10

BENCHMARK +
GLOBAL COMPETITION
=
A public, curated DB of rated graph-processing platforms

* Cost-efficiency based on metrics used for all LDBC benchmarks.
Ongoing Activity in the Graphalytics Team  (2016-2017)

1. **Benchmark + Global Competition**
   - Details follow in next presentation by Tech Lead Wing Lung Ngai

2. **Granula**: process for modeling, modeling, archiving, and sharing performance results for graph-processing platforms
   - Presented in Walldorf, February 2017

3. **Grade10**: automated bottleneck detection and performance-issue identification

Granula: Performance Modeling, Visualization, Analysis

Computation imbalance!

Giraph - BFS on LDBC-1000, 5 nodes
Analytical modeling is **time-consuming**. Profiling (aggregating) and full tracing are **data-intensive**. All are **expertise-driven**.

Grade10 analyses Granula and resource utilization data for you.

Possible performance bottlenecks:

- 20% slowdown due to imbalance in ‘Computation’ phase
- HW resource bottlenecks of ‘GlobalSuperstep’: CPU 60%, network 30%, none 10%
Grade10: Performance Bottleneck Identification

Analytical modeling is time-consuming. Profiling (aggregating) and full tracing are data-intensive. All are expertise-driven. Grade10 analyses Granula and resource utilization data for you.

Possible performance bottlenecks:

- 20% slowdown due to imbalance in 'Computation' phase
- HW resource bottlenecks of 'GlobalSuperstep': CPU 60%, network 30%, none 10%

Goal: Help users understand the performance of graph-processing systems through automated analysis of performance data
Grade 10: Automated Bottleneck Detection and Performance Issue Identification

- Execution model
  + Event logging
  
- Monitoring (sampling)

- Resource attribution

- Bottleneck detection

- Top bottlenecks:
  - 
  
- Perf.-issue identification
Preliminary Result: Analysing a Giraph Job

CPU usage < 32 cores (100%), so no bottleneck... yet
Preliminary Result: Analysing a Giraph Job

![Graph showing CPU usage over time](image)

**WorkerSuperstep**
- **PreCompute**
- **Compute**
- **PostCompute**
Preliminary Result: Analysing a Giraph Job

Max CPU usage = 1

Blocks on:
- Message queue full
- Garbage collect
Preliminary Result: Analysing a Giraph Job

Max CPU usage = 1

Blocks on:
- Message queue full
- Garbage collect

WorkerSuperstep

Compute

Max CPU usage = 1

ComputeThread[1-22]

PostCompute
Preliminary Result: Analysing a Giraph Job

WorkerSuperstep

CPU Usage (ComputeThread1)

CPU Bottleneck (CT1)

Message Queue Bottleneck (CT1)

Garbage Collect Bottleneck (CT1)

Compute

PostCompute

ComputeThread[1-22]

PU usage = 1

Blocks on:
- Message queue full
- Garbage collect
Grade10 : Help users understand the performance of graph-processing systems through automated analysis of performance data

Average time bottlenecked for Compute/ComputeThread:
- None: 0 ms (always bottlenecked)
- Message queue full: 1768 ms
- Garbage collect: 781 ms
- CPU: 748 ms

... So focus on reducing:
- Communication bottlenecks
- GC overheads (good luck!)
Graphalytics, in the future

An LDBC benchmark*
Advanced benchmarking harness
Diverse real and synthetic datasets
Many classes of algorithms
Granula, Grade10 for bottleneck analysis
Modern software engineering practices
Supports many platforms
Enables comparison of community-driven and industrial systems
Public, curated DB of rated systems

https://github.com/ldbc/ldbc_graphalytics
1. Grade10: (upcoming)