12th LDBC TUC Meeting (July 5th, 2019)

Graphalytics team, including Ahmed Musaafir, Tim Hegeman, Alexandru Uta, Alexandru Iosup

AtLarge Massivizing Computer Systems research group, Vrije Universiteit Amsterdam, the Netherlands

Graphs, Many Graph-Processing Platforms

Which platforms perform well?
Why? How to improve?

Analyse large graphs
The Data Deluge: Large-scale Graphs

Graph Processing

LinkedIn

amazon.com

Spotify

Google

Steam
Predicting or recommending new relationships (friends-of-friends, product recommendations).

Navigation systems
The Data Deluge: Large-scale Graphs

Graph Processing

Analyse large graphs
Graph Processing Platforms

- Intel Graphmat
- Gemini
- IBM System G
- Gunrock
- nvGRAPH
- HyGraph
- JoyGraph
Which platforms perform well?
Graph Processing Platforms

- Oracle PGX
- Neo4j
- IBM System G
- Intel Graphmat
- Gemini
- Gunrock
- nvGRAPH
- Trinity
- JoyGraph
- HyGraph

Which platforms perform well?

Why? How can they be improved?
Two dimensions for understanding performance:

- **Breadth**: comparison across diverse platforms, algorithms, datasets.
  
  *Answers Q1: which platforms performs well?*

- **Depth**: performance analysis of individual jobs.
  
  *Answers Q2: why?*
Graphalytics ecosystem: set of complementary components for understanding graph processing performance.

- **Depth**
  - Grade10 [1]
  - Granula [2]

- **Breadth**
  - LDBC Graphalytics [3]
  - Global Competition [4]

---

[2] Ngai et al., Toward Fine-grained Performance Analysis of Large-scale Graph Processing Platforms. GRADES@SIGMOD/PODS 2017: 8:1-6
Graphalytics ecosystem: set of complementary components for understanding graph processing performance.

[2] Ngai et al., Toward Fine-grained Performance Analysis of Large-scale Graph Processing Platforms. GRADES@SIGMOD/PODS 2017: 8:1-6
Comparing Graph Processing Platforms

How to Compare the Performance of Graph Processing Platforms?

Typical approaches:

• Platform-centric comparative studies
  • Prove the superiority of a given system, limited set of metrics

• Benchmarks (Graph500, GreenGraph500, GraphBench, XGDBench, ...)
  • Issues with representativeness, systems covered, metrics, ...
Comparing Graph Processing Platforms

How to Compare the Performance of Graph Processing Platforms?

LDBC Graphalytics:

A comprehensive benchmark suite for graph processing across many platforms.
LDBC Graphalytics

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.
- Enables comparison of many platforms, community-driven and industrial.
Main finding:

Performance of graph processing is a non-trivial function of the PAD Triangle:

$$\text{(Platform, Algorithm, Dataset)} + \text{Hardware, if configurable separately from the Platform}$$
Software available at: [https://graphalytics.org](https://graphalytics.org)

- Benchmark core
- Platform drivers (11)
- Data sets (36); S, L, M, XL, 2XL
- Installer
- Documentation
The Graphalytics Ecosystem

Graphalytics ecosystem: set of complementary components for understanding graph processing performance.

Depth

- Grade10 [1]
- Granula [2]

Breadth

- LDBC Graphalytics [3]
- Global Competition [4]

[2] Ngai et al., Toward Fine-grained Performance Analysis of Large-scale Graph Processing Platforms. GRADES@SIGMOD/PODS 2017: 8:1-6
Graphalytics ecosystem: set of complementary components for understanding graph processing performance.

- Grade10 [1]
- Granula [2]
- LDBC Graphalytics [3]
- Global Competition [4]

[2] Ngai et al., Toward Fine-grained Performance Analysis of Large-scale Graph Processing Platforms. GRADES@SIGMOD/PODS 2017: 8:1-6
Graphalytics Global Competition

- Online archive for sharing results
  - [https://graphalytics.org/competition](https://graphalytics.org/competition)
  - Submissions are reviewed by the Graphalytics team

- Systematic and periodic comparison

- Different evaluation metrics
  - Edges and Vertices Per Second (EVPS)
  - Loading Time (TL)
  - Processing Time (PT)
  - Makespan (TM)

- Examples of recent competitions:
  - Google Cloud vs DAS-5
  - CPU vs GPU platforms
  - Various GPUs; GPU platform only competition

- Different scoring methods
Example 'CPU vs GPU platforms' competition

**Algorithm:** BFS  
**Metric:** Processing Time
Graphalytics Global Competition

Example 'CPU vs GPU platforms' competition

**Algorithm:** BFS

**Metric:** Processing Time

```
<table>
<thead>
<tr>
<th>System name</th>
<th>Datagen-8_6-Fb</th>
<th>Datagen-8_7-Zf</th>
</tr>
</thead>
<tbody>
<tr>
<td>nvGRAPH (GPU)</td>
<td>+3</td>
<td>+3</td>
</tr>
<tr>
<td>GraphMat (CPU)</td>
<td>+2</td>
<td>+1</td>
</tr>
<tr>
<td>Gunrock (GPU)</td>
<td>+1</td>
<td>+2</td>
</tr>
<tr>
<td>Giraph (CPU)</td>
<td>+0</td>
<td>+0</td>
</tr>
</tbody>
</table>
```

Processing Times:
- nvGRAPH (GPU): 0.09 s +3
- GraphMat (CPU): 0.20 s +2
- Gunrock (GPU): 0.80 s +1
- Giraph (CPU): 11.22 s +0
- Datagen-8_7-Zf: 0.45 s +3
- Datagen-8_7-Zf: 1.11 s +1
- Datagen-8_7-Zf: 0.58 s +2
- Datagen-8_7-Zf: 57.39 s +0
Example 'CPU vs GPU platforms' competition

**Algorithm:** BFS  
**Metric:** Processing Time

<table>
<thead>
<tr>
<th>System Name</th>
<th>Datagen-8_6-Fb</th>
<th>Datagen-8_7-Zf</th>
</tr>
</thead>
<tbody>
<tr>
<td>nvGRAPH (GPU)</td>
<td>+3 (0.09 s)</td>
<td>+3 (0.45 s)</td>
</tr>
<tr>
<td>GraphMat (CPU)</td>
<td>+2 (0.20 s)</td>
<td>+1 (1.11 s)</td>
</tr>
<tr>
<td>Gunrock (GPU)</td>
<td>+1 (0.80 s)</td>
<td>+2 (0.58 s)</td>
</tr>
<tr>
<td>Giraph (CPU)</td>
<td>+0 (11.22 s)</td>
<td>+0 (57.39 s)</td>
</tr>
</tbody>
</table>
Example 'CPU vs GPU platforms' competition

**Algorithm:** BFS  
**Metric:** Processing Time

<table>
<thead>
<tr>
<th>System name</th>
<th>Datagen-8_6-Fb</th>
<th>Datagen-8_7-Zf</th>
</tr>
</thead>
<tbody>
<tr>
<td>nvGRAPH (GPU)</td>
<td>+3</td>
<td>+3</td>
</tr>
<tr>
<td></td>
<td>0.09 (s) +3</td>
<td>0.45 (s) +3</td>
</tr>
<tr>
<td>GraphMat (CPU)</td>
<td>0.20 (s) +2</td>
<td>1.11 (s) +1</td>
</tr>
<tr>
<td>Gunrock (GPU)</td>
<td>+1</td>
<td>+2</td>
</tr>
<tr>
<td></td>
<td>0.80 (s) +1</td>
<td>0.58 (s) +2</td>
</tr>
<tr>
<td>Giraph (CPU)</td>
<td>+0</td>
<td>+0</td>
</tr>
<tr>
<td></td>
<td>11.22 (s) +0</td>
<td>57.39 (s) +0</td>
</tr>
</tbody>
</table>
Graphalytics Global Competition

Example 'CPU vs GPU platforms' competition

**Algorithm**: BFS  
**Metric**: Processing Time

<table>
<thead>
<tr>
<th>System name</th>
<th>Datagen-8_6-Fb</th>
<th>Datagen-8_7-Zf</th>
</tr>
</thead>
<tbody>
<tr>
<td>nvGRAPH (GPU)</td>
<td>0.09 (s) +3</td>
<td>0.45 (s) +3</td>
</tr>
<tr>
<td>GraphMat (CPU)</td>
<td>0.20 (s) +2</td>
<td>1.11 (s) +1</td>
</tr>
<tr>
<td>Gunrock (GPU)</td>
<td>0.80 (s) +1</td>
<td>0.58 (s) +2</td>
</tr>
<tr>
<td>Giraph (CPU)</td>
<td>11.22 (s) +0</td>
<td>57.39 (s) +0</td>
</tr>
</tbody>
</table>
Example 'Various GPUs' competition

**Algorithm:** PR - BFS

**Metric:** Makespan - Processing Time

**Dataset scale:** Small - Large
Example 'Various GPUs' competition

Algorithm: PR - BFS
Metric: Makespan - Processing Time
Dataset scale: Small - Large
Graphalytics Global Competition

Example 'Various GPUs' competition

**Algorithm:** PR - BFS  
**Metric:** Makespan - Processing Time  
**Dataset scale:** Small - Large

<table>
<thead>
<tr>
<th>System name</th>
<th>Total score (TM)</th>
<th>Datagen-7.5-Fb</th>
<th>Datagen-7.6-Fb</th>
<th>Datagen-7.7-Zf</th>
<th>Data-League</th>
<th>Graph500-22</th>
<th>Datagen-7.9-Fb</th>
</tr>
</thead>
<tbody>
<tr>
<td>nvgraph @ TitanX</td>
<td>14</td>
<td>0.26 (s)</td>
<td>+2</td>
<td>+2</td>
<td>+2</td>
<td>+2</td>
<td>+2</td>
</tr>
<tr>
<td>nvgraph @ K20</td>
<td>6</td>
<td>1.29 (s)</td>
<td>+1</td>
<td>+1</td>
<td>+1</td>
<td>+1</td>
<td>+1</td>
</tr>
<tr>
<td>nvgraph @ K40</td>
<td>1</td>
<td>1.72 (s)</td>
<td>+0</td>
<td>+0</td>
<td>+0</td>
<td>+0</td>
<td>+0</td>
</tr>
</tbody>
</table>
Graphalytics Global Competition

Example 'Various GPUs' competition

**Algorithm:** PR - BFS  
**Metric:** Makespan - Processing Time  
**Dataset scale:** Small - Large

<table>
<thead>
<tr>
<th>System name</th>
<th>Total score (TM)</th>
<th>Datagen-7_5-Pb</th>
<th>Datagen-7_6-Pb</th>
<th>Datagen-7_7-2F</th>
<th>Data-League</th>
<th>Graph500-22</th>
<th>Datagen-7_8-Pb</th>
</tr>
</thead>
<tbody>
<tr>
<td>nvgraph @ TitanX</td>
<td>14</td>
<td>0.26 (s)</td>
<td>0.30 (s)</td>
<td>3.64 (s)</td>
<td>0.34 (s)</td>
<td>0.55 (s)</td>
<td>1.37 (s)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>+2</td>
<td>+2</td>
<td>+2</td>
<td>+2</td>
<td>+2</td>
<td>+2</td>
</tr>
<tr>
<td>nvgraph @ K20</td>
<td>6</td>
<td>1.29 (s)</td>
<td>1.31 (s)</td>
<td>6.45 (s)</td>
<td>1.10 (s)</td>
<td>1.34 (s)</td>
<td>2.50 (s)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>+1</td>
<td>+1</td>
<td>+1</td>
<td>+1</td>
<td>+1</td>
<td>+1</td>
</tr>
<tr>
<td>nvgraph @ K40</td>
<td>1</td>
<td>1.72 (s)</td>
<td>1.94 (s)</td>
<td>7.38 (s)</td>
<td>1.80 (s)</td>
<td>1.75 (s)</td>
<td>2.62 (s)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>+0</td>
<td>+0</td>
<td>+0</td>
<td>+0</td>
<td>+0</td>
<td>+0</td>
</tr>
</tbody>
</table>
### Graphalytics Global Competition

Example ‘Various GPUs’ competition

**Algorithm:** PR - BFS  
**Metric:** Makespan - Processing Time  
**Dataset scale:** Small - Large

<table>
<thead>
<tr>
<th>System name</th>
<th>Total score (TM)</th>
<th>DataGen-T_5-Fb</th>
<th>DataGen-T_6-Fb</th>
<th>DataGen-T_7-CF</th>
<th>Data-Legue</th>
<th>Graph500-22</th>
<th>DataGen-T_8-Fb</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>0.26 (s)</td>
<td>0.30 (s)</td>
<td>3.64 (s)</td>
<td>0.34 (s)</td>
<td>0.55 (s)</td>
<td>1.37 (s)</td>
</tr>
<tr>
<td>nvgap @ TitanX</td>
<td>14</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>nvgap @ K20</td>
<td>6</td>
<td>1.29 (s)</td>
<td>1.31 (s)</td>
<td>6.45 (s)</td>
<td>1.10 (s)</td>
<td>1.34 (s)</td>
<td>2.50 (s)</td>
</tr>
<tr>
<td>nvgap @ K40</td>
<td>1</td>
<td>1.72 (s)</td>
<td>1.94 (s)</td>
<td>7.18 (s)</td>
<td>1.80 (s)</td>
<td>1.75 (s)</td>
<td>2.62 (s)</td>
</tr>
</tbody>
</table>
Graphalytics Global Competition

Example 'Various GPUs' competition

**Algorithm:** PR - BFS  
**Metric:** Makespan - Processing Time  
**Dataset scale:** Small - Large

<table>
<thead>
<tr>
<th>System Name</th>
<th>Total Score (TM)</th>
<th>Datagen-7_5-Fb</th>
<th>Datagen-7_5-Fb</th>
<th>Datagen-7_7-Zf</th>
<th>Dota-League</th>
<th>Graph500-22</th>
<th>Datagen-7_9-Fb</th>
</tr>
</thead>
<tbody>
<tr>
<td>nvgraph @ TitanX</td>
<td>14</td>
<td>0.26 (s)</td>
<td>0.30 (s)</td>
<td>3.64 (s)</td>
<td>0.34 (s)</td>
<td>0.55 (s)</td>
<td>1.37 (s)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>+2</td>
<td>+2</td>
<td>+2</td>
<td>+2</td>
<td>+2</td>
<td>+2</td>
</tr>
<tr>
<td>nvgraph @ K20</td>
<td>6</td>
<td>1.29 (s)</td>
<td>1.31 (s)</td>
<td>6.45 (s)</td>
<td>1.10 (s)</td>
<td>1.34 (s)</td>
<td>2.50 (s)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>+1</td>
<td>+1</td>
<td>+1</td>
<td>+1</td>
<td>+1</td>
<td>+1</td>
</tr>
<tr>
<td>nvgraph @ K40</td>
<td>1</td>
<td>1.72 (s)</td>
<td>1.94 (s)</td>
<td>7.18 (s)</td>
<td>1.80 (s)</td>
<td>1.75 (s)</td>
<td>2.62 (s)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>+0</td>
<td>+0</td>
<td>+0</td>
<td>+0</td>
<td>+0</td>
<td>+0</td>
</tr>
</tbody>
</table>
Example ‘Various GPUs’ competition

**Algorithm:** PR - BFS

**Metric:** Makespan - Processing Time

**Dataset scale:** Small - Large
Example 'Various GPUs' competition

**Algorithm:** PR - BFS  
**Metric:** Makespan - Processing Time  
**Dataset scale:** Small - Large
Example 'Various GPUs' competition

**Algorithm:** PR - BFS  
**Metric:** Makespan - Processing Time  
**Dataset scale:** Small - Large
Graphalytics Global Competition

Example 'Various GPUs' competition

**Algorithm:** PR - BFS

**Metric:** Makespan - Processing Time

**Dataset scale:** Small - Large

<table>
<thead>
<tr>
<th>System name</th>
<th>Total score (TM)</th>
<th>Datagen-6_5-Fb</th>
<th>Datagen-6_6-Fb</th>
<th>Datagen-6_7-Zf</th>
<th>Graph500-25</th>
<th>Datagen-8_8-Zf</th>
<th>Datagen-8_9-Fb</th>
</tr>
</thead>
<tbody>
<tr>
<td>nvgraph @ TitanX</td>
<td>8</td>
<td>8.11 (s)</td>
<td>12.24 (s)</td>
<td>237.48 (s)</td>
<td>9.29 (s)</td>
<td>250.67 (s)</td>
<td>-</td>
</tr>
<tr>
<td></td>
<td></td>
<td>+2</td>
<td>+1</td>
<td>+2</td>
<td>+1</td>
<td>+2</td>
<td>+0</td>
</tr>
<tr>
<td>nvgraph @ K40</td>
<td>7</td>
<td>9.47 (s)</td>
<td>11.45 (s)</td>
<td>305.96 (s)</td>
<td>7.78 (s)</td>
<td>307.90 (s)</td>
<td>-</td>
</tr>
<tr>
<td></td>
<td></td>
<td>+1</td>
<td>+2</td>
<td>+1</td>
<td>+2</td>
<td>+1</td>
<td>+0</td>
</tr>
<tr>
<td>nvgraph @ K20</td>
<td>0</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>+0</td>
<td>+0</td>
<td>+0</td>
<td>+0</td>
<td>+0</td>
<td>+0</td>
</tr>
</tbody>
</table>
Example 'Various GPUs' competition

**Algorithm:** PR - BFS  
**Metric:** Makespan - Processing Time  
**Dataset scale:** Small - Large

<table>
<thead>
<tr>
<th>System name</th>
<th>Total score (TM)</th>
<th>Datagen-8_5-Fb</th>
<th>Datagen-8_6-Fb</th>
<th>Datagen-8_7-Zf</th>
<th>Graph500-25</th>
<th>Datagen-8_8-Zf</th>
<th>Datagen-8_9-Fb</th>
</tr>
</thead>
<tbody>
<tr>
<td>nvgraph @ TitanX</td>
<td>8</td>
<td>8.11 (s)</td>
<td>12.24 (s)</td>
<td>237.48 (s)</td>
<td>9.29 (s)</td>
<td>250.67 (s)</td>
<td>+2</td>
</tr>
<tr>
<td>nvgraph @ K40</td>
<td>7</td>
<td>9.47 (s)</td>
<td>11.45 (s)</td>
<td>305.96 (s)</td>
<td>7.78 (s)</td>
<td>307.90 (s)</td>
<td>+1</td>
</tr>
<tr>
<td>nvgraph @ K20</td>
<td>0</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Example 'Various GPUs' competition

**Algorithm:** PR - BFS  
**Metric:** Makespan - Processing Time  
**Dataset scale:** Small - Large
Example 'Various GPUs' competition

**Algorithm:** PR - BFS

**Metric:** Makespan - Processing Time

**Dataset scale:** Small - Large
Example ‘Various GPUs’ competition

**Algorithm:** PR - BFS

**Metric:** Makespan - Processing Time

**Dataset scale:** Small - Large
**Graphalytics Global Competition**

Example 'Various GPUs' competition

**Algorithm:** PR - BFS  
**Metric:** Makespan - Processing Time  
**Dataset scale:** Small - Large

<table>
<thead>
<tr>
<th>System name</th>
<th>Total score (TP)</th>
<th>Datagen-7_5-Fb</th>
<th>Datagen-7_6-Fb</th>
<th>Datagen-7_7-Zf</th>
<th>Dota-League</th>
<th>Datagen-7_8-Zf</th>
<th>Graph500-22</th>
<th>Datagen-7_9-Fb</th>
</tr>
</thead>
<tbody>
<tr>
<td>nvgraph @ K40</td>
<td>10</td>
<td>0.31 (s)</td>
<td>0.40 (s)</td>
<td>1.28 (s)</td>
<td>0.18 (s)</td>
<td>2.00 (s)</td>
<td>0.04 (s)</td>
<td>0.95 (s)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>+1</td>
<td>+1</td>
<td>+2</td>
<td>+1</td>
<td>+2</td>
<td>+2</td>
<td>+1</td>
</tr>
<tr>
<td>nvgraph @ TitanX</td>
<td>8</td>
<td>0.10 (s)</td>
<td>0.12 (s)</td>
<td>3.37 (s)</td>
<td>0.09 (s)</td>
<td>5.68 (s)</td>
<td>0.21 (s)</td>
<td>0.46 (s)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>+2</td>
<td>+2</td>
<td>+0</td>
<td>+2</td>
<td>+0</td>
<td>+0</td>
<td>+2</td>
</tr>
<tr>
<td>nvgraph @ K20</td>
<td>3</td>
<td>0.38 (s)</td>
<td>0.48 (s)</td>
<td>1.50 (s)</td>
<td>0.23 (s)</td>
<td>2.33 (s)</td>
<td>0.05 (s)</td>
<td>1.10 (s)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>+0</td>
<td>+0</td>
<td>+1</td>
<td>+0</td>
<td>+1</td>
<td>+1</td>
<td>+0</td>
</tr>
</tbody>
</table>
Graphalytics Global Competition

Example ‘Various GPUs’ competition

**Algorithm:** PR - BFS

**Metric:** Makespan - Processing Time

**Dataset scale:** Small - Large

<table>
<thead>
<tr>
<th>System name</th>
<th>Total score (TP)</th>
<th>Datagen-7.5-Fb</th>
<th>Datagen-7.6-Fb</th>
<th>Datagen-7.7-Zf</th>
<th>Dota-League</th>
<th>Datagen-7.8-Zf</th>
<th>Graph500-22</th>
<th>Datagen-7.9-Fb</th>
</tr>
</thead>
<tbody>
<tr>
<td>nvgraph @ K40</td>
<td>10</td>
<td>0.31 (s)</td>
<td>0.40 (s)</td>
<td>1.28 (s)</td>
<td>0.18 (s)</td>
<td>2.00 (s)</td>
<td>0.04 (s)</td>
<td>0.95 (s)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>+1</td>
<td>+1</td>
<td>+2</td>
<td>+1</td>
<td>+2</td>
<td>+2</td>
<td>+1</td>
</tr>
<tr>
<td>nvgraph @ TitanX</td>
<td>8</td>
<td>0.10 (s)</td>
<td>0.12 (s)</td>
<td>3.37 (s)</td>
<td>0.09 (s)</td>
<td>5.68 (s)</td>
<td>0.21 (s)</td>
<td>0.46 (s)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>+2</td>
<td>+2</td>
<td>+0</td>
<td>+2</td>
<td>+0</td>
<td>+0</td>
<td>+2</td>
</tr>
<tr>
<td>nvgraph @ K20</td>
<td>3</td>
<td>0.38 (s)</td>
<td>0.48 (s)</td>
<td>1.50 (s)</td>
<td>0.23 (s)</td>
<td>2.33 (s)</td>
<td>0.05 (s)</td>
<td>1.10 (s)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>+0</td>
<td>+0</td>
<td>+1</td>
<td>+0</td>
<td>+1</td>
<td>+1</td>
<td>+0</td>
</tr>
</tbody>
</table>
Graphalytics Global Competition

Example 'Various GPUs' competition

**Algorithm:** PR - BFS

**Metric:** Makespan - Processing Time

**Dataset scale:** Small - Large
Example ‘Various GPUs’ competition

**Algorithm:** PR - BFS

**Metric:** Makespan - Processing Time

**Dataset scale:** Small - Large
Graphalytics Global Competition

Example 'Various GPUs' competition
**Algorithm:** PR - BFS  
**Metric:** Makespan - Processing Time  
**Dataset scale:** Small - Large

<table>
<thead>
<tr>
<th>System name</th>
<th>Total score (TP)</th>
<th>Dataset-8_5-Fb</th>
<th>Dataset-8_6-Fb</th>
<th>Dataset-8_7-Zf</th>
<th>Graph500-25</th>
<th>Dataset-8_8-Zf</th>
<th>Dataset-8_9-Fb</th>
</tr>
</thead>
<tbody>
<tr>
<td>nvgraph @ TitanX</td>
<td>10</td>
<td>2.93 (s)</td>
<td>3.89 (s)</td>
<td>209.50 (s)</td>
<td>0.40 (s)</td>
<td>162.36 (s)</td>
<td>-</td>
</tr>
<tr>
<td></td>
<td></td>
<td>+2</td>
<td>+2</td>
<td>+2</td>
<td>+2</td>
<td>+2</td>
<td>+0</td>
</tr>
<tr>
<td>nvgraph @ K40</td>
<td>5</td>
<td>4.02 (s)</td>
<td>5.13 (s)</td>
<td>278.62 (s)</td>
<td>0.54 (s)</td>
<td>218.09 (s)</td>
<td>-</td>
</tr>
<tr>
<td></td>
<td></td>
<td>+1</td>
<td>+1</td>
<td>+1</td>
<td>+1</td>
<td>+1</td>
<td>+0</td>
</tr>
<tr>
<td>nvgraph @ K20</td>
<td>0</td>
<td>+0</td>
<td>+0</td>
<td>+0</td>
<td>+0</td>
<td>+0</td>
<td>+0</td>
</tr>
</tbody>
</table>

43
**Example ‘Various GPUs’ competition**

**Algorithm:** PR - BFS  
**Metric:** Makespan - Processing Time  
**Dataset scale:** Small - Large

<table>
<thead>
<tr>
<th>System name</th>
<th>Total score (TP)</th>
<th>Datagen-8_5-Fb</th>
<th>Datagen-8_6-Fb</th>
<th>Datagen-8_7-Zf</th>
<th>Graph500-25</th>
<th>Datagen-8_8-Zf</th>
<th>Datagen-8_9-Fb</th>
</tr>
</thead>
<tbody>
<tr>
<td>nvgraph @ TitanX</td>
<td>+2</td>
<td>+2</td>
<td>+2</td>
<td>+2</td>
<td>+2</td>
<td>+2</td>
<td>+0</td>
</tr>
<tr>
<td>nvgraph @ K40</td>
<td>+1</td>
<td>+1</td>
<td>+1</td>
<td>+1</td>
<td>+1</td>
<td>+1</td>
<td>+0</td>
</tr>
<tr>
<td>nvgraph @ K20</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>+0</td>
<td>+0</td>
<td>+0</td>
</tr>
</tbody>
</table>
### Graphalytics Global Competition

**Example ‘Various GPUs’ competition**  
**Algorithm:** PR - BFS  
**Metric:** Makespan - Processing Time  
**Dataset scale:** Small - Large

<table>
<thead>
<tr>
<th>System name</th>
<th>Total score (TP)</th>
<th>Dataset-8_5-Fb</th>
<th>Dataset-8_6-Fb</th>
<th>Dataset-8_7-Zf</th>
<th>Graph500-25</th>
<th>Dataset-8_8-Zf</th>
<th>Dataset-8_9-Fb</th>
</tr>
</thead>
<tbody>
<tr>
<td>nvgraph @ TitanX</td>
<td>10</td>
<td>2.93 (s)</td>
<td>3.89 (s)</td>
<td>209.50 (s)</td>
<td>0.40 (s)</td>
<td>162.36 (s)</td>
<td>-</td>
</tr>
<tr>
<td></td>
<td></td>
<td>+2</td>
<td>+2</td>
<td>+2</td>
<td>+2</td>
<td>+2</td>
<td>+0</td>
</tr>
<tr>
<td>nvgraph @ K40</td>
<td>5</td>
<td>4.02 (s)</td>
<td>5.13 (s)</td>
<td>278.62 (s)</td>
<td>0.54 (s)</td>
<td>218.09 (s)</td>
<td>-</td>
</tr>
<tr>
<td></td>
<td></td>
<td>+1</td>
<td>+1</td>
<td>+1</td>
<td>+1</td>
<td>+1</td>
<td>+0</td>
</tr>
<tr>
<td>nvgraph @ K20</td>
<td>0</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
</tbody>
</table>
Example 'Various GPUs' competition

**Algorithm:** PR - BFS

**Metric:** Makespan - Processing Time

**Dataset scale:** Small - Large
Graphalytics Global Competition

Example 'Various GPUs' competition

**Algorithm:** PR - **BFS**

**Metric:** Makespan - **Processing Time**

**Dataset scale:** Small - **Large**
Graphalytics Global Competition

Example ‘Various GPUs’ competition

**Algorithm:** PR - **BFS**

**Metric:** Makespan - Processing Time

**Dataset scale:** Small - **Large**
Example 'Various GPUs' competition

**Algorithm:** PR - **BFS**

**Metric:** Makespan - **Processing Time**

**Dataset scale:** Small - **Large**

<table>
<thead>
<tr>
<th>System name</th>
<th>Total score (TP)</th>
<th>Datagen-8.5-Fb</th>
<th>Datagen-8.5-Fb</th>
<th>Datagen-8.7-Zf</th>
<th>Graph500-25</th>
<th>Datagen-8.8-Zf</th>
<th>Datagen-8.9-Fb</th>
</tr>
</thead>
<tbody>
<tr>
<td>nvgraph @ TitanX</td>
<td>12</td>
<td>0.07 (s)</td>
<td>0.09 (s)</td>
<td>0.45 (s)</td>
<td>0.16 (s)</td>
<td>0.60 (s)</td>
<td>0.20 (s)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>+2</td>
<td>+2</td>
<td>+2</td>
<td>+2</td>
<td>+2</td>
<td>+2</td>
</tr>
<tr>
<td>nvgraph @ K40</td>
<td>6</td>
<td>0.22 (s)</td>
<td>0.31 (s)</td>
<td>0.72 (s)</td>
<td>0.41 (s)</td>
<td>0.92 (s)</td>
<td>0.56 (s)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>-1</td>
<td>+1</td>
<td>+1</td>
<td>+1</td>
<td>+1</td>
<td>+1</td>
</tr>
<tr>
<td>nvgraph @ K20</td>
<td>0</td>
<td>0.28 (s)</td>
<td>0.37 (s)</td>
<td>-</td>
<td>0.51 (s)</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td></td>
<td></td>
<td>+0</td>
<td>+0</td>
<td>+0</td>
<td>+0</td>
<td>+0</td>
<td>+0</td>
</tr>
</tbody>
</table>
Graphalytics Global Competition

Full results & competition reports available:
https://graphalytics.org/competition
Graphalytics 1.0 (Trusted benchmark)

Graphalytics 2.0 (Trusted benchmark)
- Larger data sets
- Scalability experiments
- Visualization algorithms

Graphalytics 2.0 + Custom Benchmarking
- Own algorithms
- Fault tolerance
- Energy/power usage
- Elasticity
- Queries (+ analytics)
- Workflows
- Scaling graphs, performance variability, etc.
Take home message

- The **Graphalytics ecosystem** provides *breadth* and *depth* in understanding graph processing performance.
- View & submit benchmark results @ **Graphalytics Global Competition**

**graphalytics.org**

[2] Ngai et al., Toward Fine-grained Performance Analysis of Large-scale Graph Processing Platforms. GRACES@SIGMOD/PODS 2017: 8:1-6