PPoPP 2020

POSTER: Optimizing GPU Programs By Partial Evaluation

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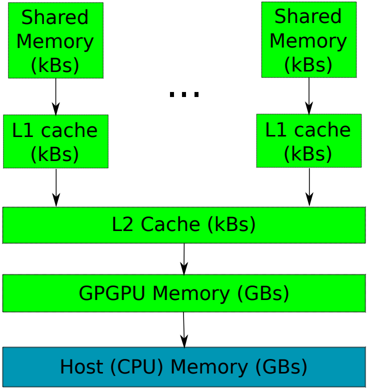
GPGPU Architecture



Navigation through a graph

- Global memory
  - ☺ Big

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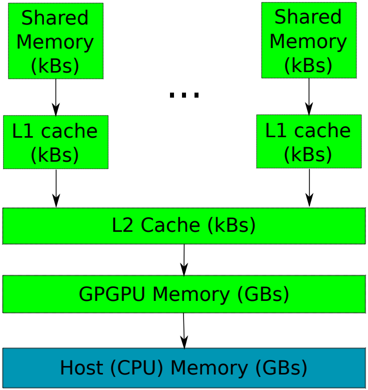

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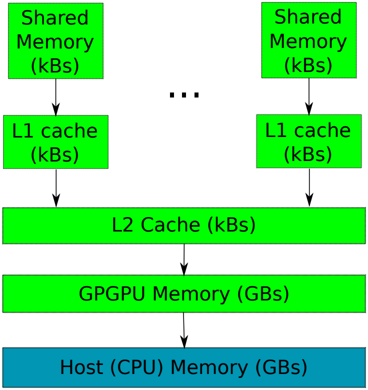

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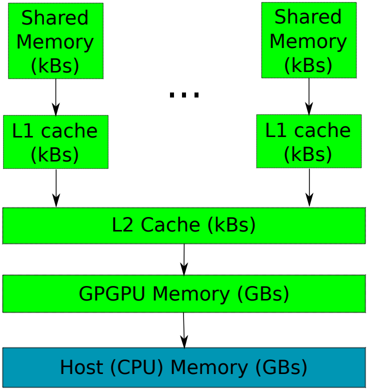

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- Constant memory
  - ☺ Fast
    - ☹ Only for appropriate access pattern
  - ☹ Small
  - ☹ Static allocation
- **Memory traffic is a bottleneck**

Data Processing

- Substring matching
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__global__ void estimateSimilarity
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- Substring matching $\Rightarrow$ Data curving (digital forensics)
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How can we use this fact to optimize our procedure?

Partial Evaluation

!!! Framework

[Scipy] Sparse matrices multiplication by using **Scipy** in **Python**

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[M4RI] Dense matrices multiplication by using **m4ri** library which implements the Method of Four Russians in **C**

Evaluation: Data Curving

[GPU4R] Our own implementation of the Method of Four Russians in **CUDA C**

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[GPU_N] Our own implementation of the naïve boolean matrix multiplication in **CUDA C**

[GPU_Py] Our own implementation of naïve boolean matrix multiplication in **Python** by using **numba** compiler

Evaluation: !!!

[CuSprs]

- Rustam Azimov, 2018, "Context-free Path Querying by Matrix Multiplication"
- Implementation is based on NVIDIA cuSPARSE library (**CUDA C, GPGPU**)

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[CYK]
- X. Zhang et al, 2016, "Context-free path queries on RDF graphs"
- CYK-based algorithm implemented in **Java** (CPU)

Limitations

[RDF]

- The set of the real-world RDF files (ontologies)
- Queries:
  $G_4 : s \to SCOR\ s\ SCO \mid TR\ s\ T \mid SCOR\ SCO \mid TR\ T$
  $G_5 : s \to SCOR\ s\ SCO \mid SCO$

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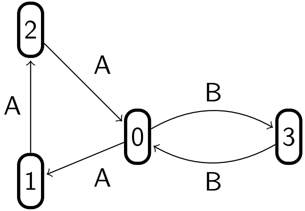
[Worst]

- The input graph is two cycles of coprime lengths with one shared vertex



- Query: $G_1 : s \to A\ s\ B \mid A\ B$

Dataset

[Full]

- The input graph is sparse, but the result is a full graph
- Queries:
  $G_2 : s \to s\ s \mid A$
  $G_3 : s \to s\ s\ s \mid A$

Dataset

[Full]

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- Queries:
  $G_2 : s \to s\ s \mid A$
  $G_3 : s \to s\ s\ s \mid A$

[Sparse]

- Sparse graphs are generated by GTgraph
- Query: $G_1 : s \to A\ s\ B \mid A\ B$

Conclusion

- OS: Ubuntu 18.04
- CPU: Intel core i7 8700k 3,7GHz
- RAM: DDR4 32 Gb
- GPGPU: NVIDIA GeForce 1080Ti (11Gb RAM)

Future Research

- Investigate implemented algorithms to explain nontrivial behaviors
- Create open extensible platform for CFPQ algorithms comparison
- Evaluate other CFPQ algorithms
  - Sparse matrices
  - Destributed matrix multiplication
  - LL- and LR-based algorithms
- Add new data and queries to the dataset
  - Bigger RDFs
  - Static code analysis

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- Sergey Gorbatyuk: sergeygorbatyuk171@gmail.com

- Dataset and algorithm implementations: https://github.com/SokolovYaroslav/CFPQ-on-GPGPU

Thanks!