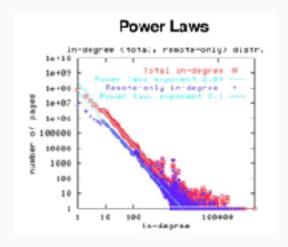
Tigr: Transforming Irregular Graphs for GPU-Friendly Graph Processing

Sadet, Qiu, Zhao (2018)

Presented by Edward Fan

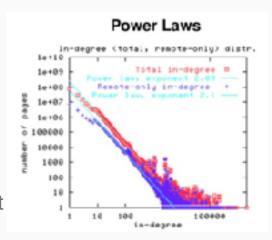
Real-world graphs are irregular

- Power-law or not, large imbalances in vertex degree are common
- Lots of frameworks that we've seen have worked around this
 - Partitioning the graph by edges
 - Splitting work into sub-tasks
 - Duplicating vertices across nodes



Real-world graphs are irregular

- For GPUs, the issue is even more important
- Threads are organized in warps
 - A warp is SIMD-like- a group of threads execute the same instructions in parallel over different data
 - There is implicit synchronization- all threads must complete before execution can continue
 - If vertices are assigned to threads,
 this can lead to a major bottleneck



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Physical	29	28 65	A9 x 10 ⁵	91.12%	45	6.6 × 10°	70.11%
Virtaa.	94	17.64	7.6×10^{5}	92,53%	1.9	2.2×10^6	95.51%

Tigr: vertex transformations

- Basic idea: split a high degree node into multiple nodes
- Many possible connections, but tradeoffs between propagation time, edge count, and vertex count
- Solution: uniform-degree tree transformation (UDT)

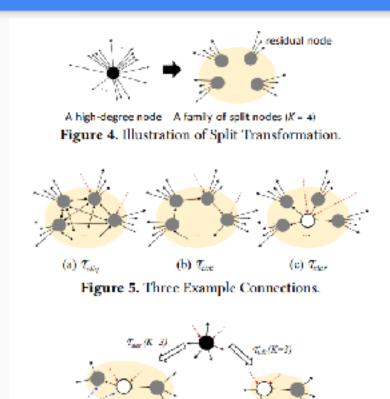


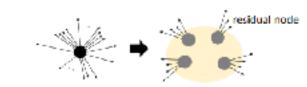
Figure 6. Comparison between $\mathcal{T}_{\text{star}}$ and \mathcal{T}_{ndt} .

no residual nodes

two residual nodes

Correctness of split nodes

- Many algorithms still work correctly on the split nodes
- Can assign internal edges zero weight (or equivalent)
 - Just need to treat split vertex as if it were a single vertex
- Total in/out-degree does not change, so PageRank still works
 - Sum the split nodes



A high-degree node A family of split nodes (K = 4)Figure 4. Illustration of Split Transformation.

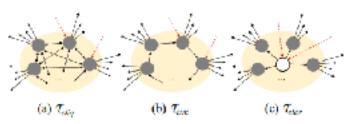


Figure 5. Three Example Connections.

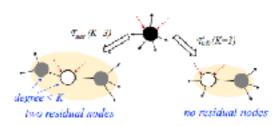


Figure 6. Comparison between T_{star} and T_{ndt} .

Virtual transformation

- Benefits of vertex splitting, without having to synchronize!
- Slightly modified CSR serves this purpose well

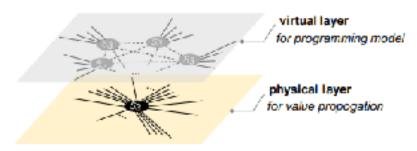


Figure 9. Illustration of Virtual Split Transformation.

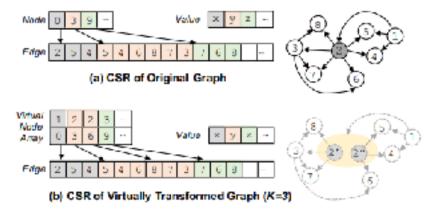
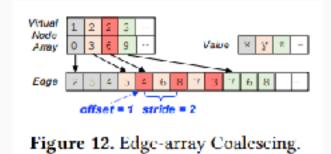


Figure 10. Integrating Virtual Node Array into CSR Format.

Virtualization details

- Use atomic operations to resolve concurrent writes
 - For push execution: no correctness difference (as every vertex needs to be able to accept concurrent pushes)
 - For pull execution: writes must be associative, as neighbors are processed in parallel
- Clever trick for GPU coalescing
 - A normal split would result in strided accesses
 - Solution: stride the split!
 - Leads to sequential access



Performance

- On single GPU, beats CuSha and Gunrock most of the time
- Caveat: custom code vs framework limitations

Table 4. Performance Comparison.

execution time: ms; the bes: performance is belded

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Questions?

Thanks!