Longest Flow Paths, Shortest Compute Times

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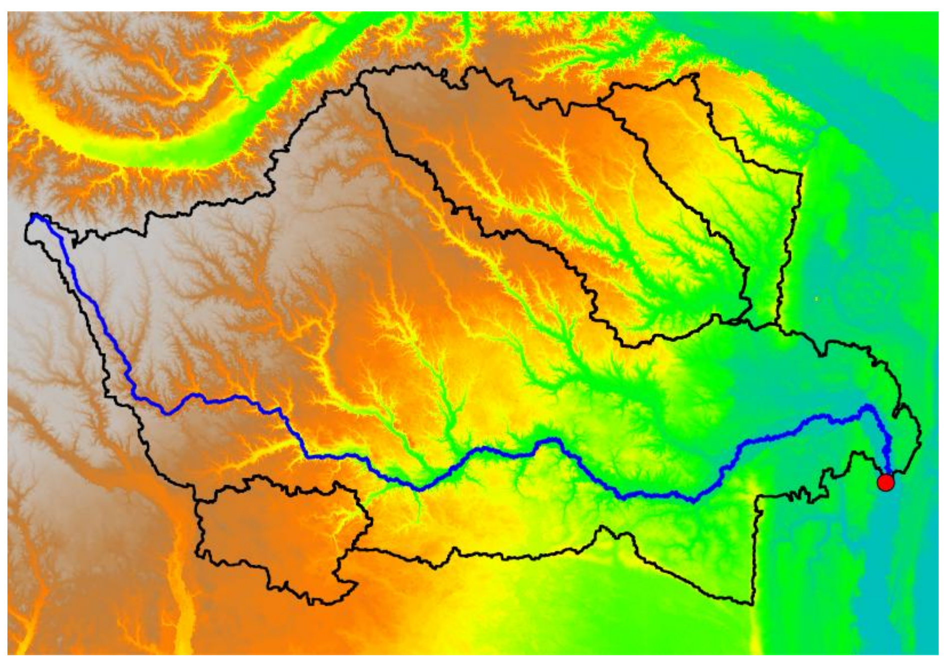
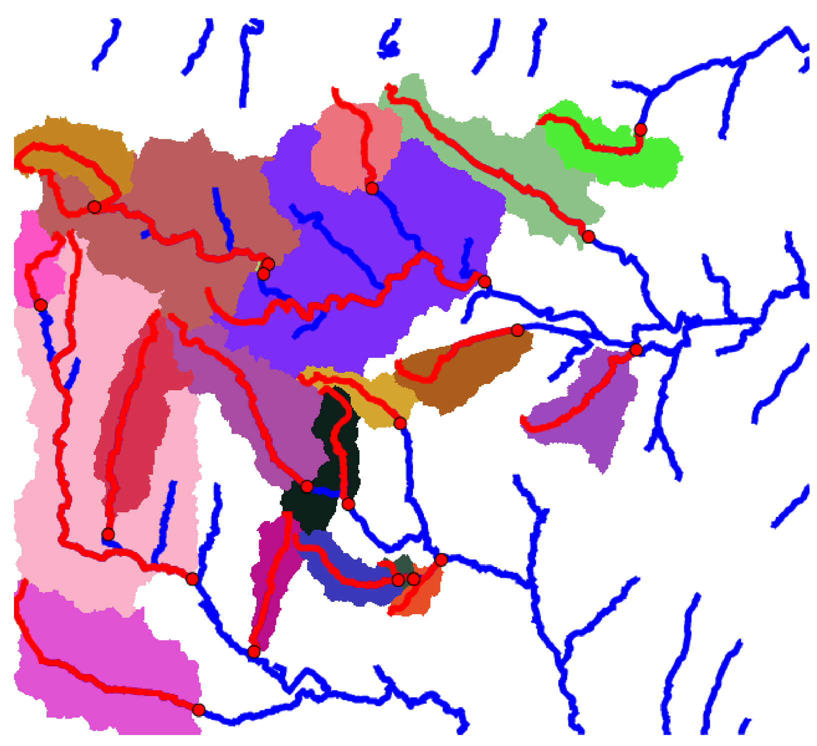
https://github.com/HuidaeCho/melfp

Longest Flow Path

A flow path (FP) is the hydrologic path or watercourse from one point to another in the watershed. The longest flow path (LFP) represents the flow path from a headwater point (typically on the watershed divide) to the outlet that is longer than all other flow paths in the watershed.

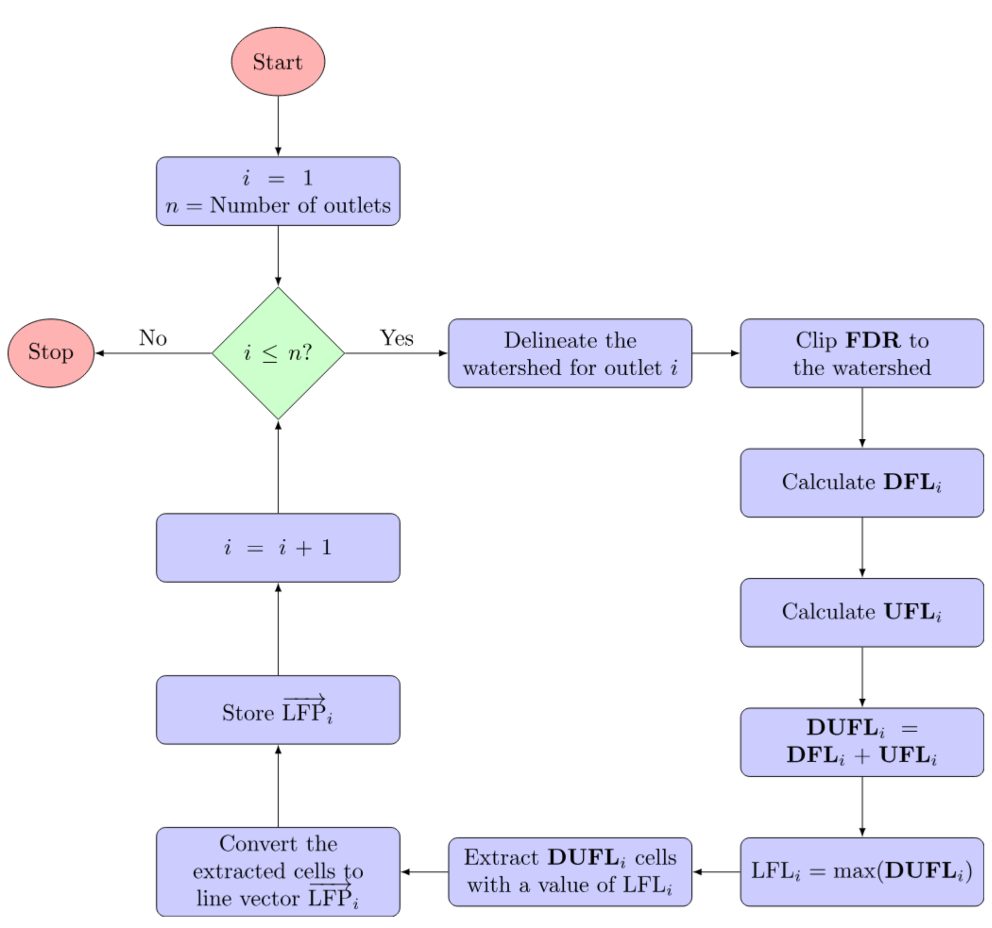
$$\overrightarrow{\mathrm{LFP}}_i \in \begin{cases} \left\{\overrightarrow{\mathrm{LFP}}_j + \vec{P}_{ji} \,\middle|\, \left|\overrightarrow{\mathrm{LFP}}_j + \vec{P}_{ji}\right| \geq \left|\overrightarrow{\mathrm{LFP}}_k + \vec{P}_{ki}\right| \forall j,k \in \mathbf{UP}_i, j \neq k\right\} & \text{if } \mathbf{UP}_i \neq \emptyset \\ \{\vec{0}\} & \text{otherwise} \end{cases}$$



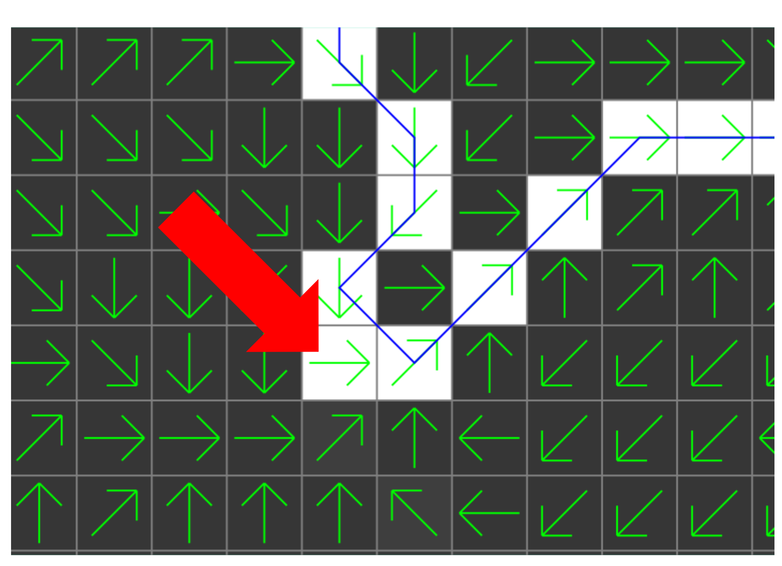


Smith's Method

Smith's (1995) (original? LFP) method uses a raster-based approach. LFL=max(DFL+UFL) and the typical workflow for multiple outlets involves a lot of raster operations!

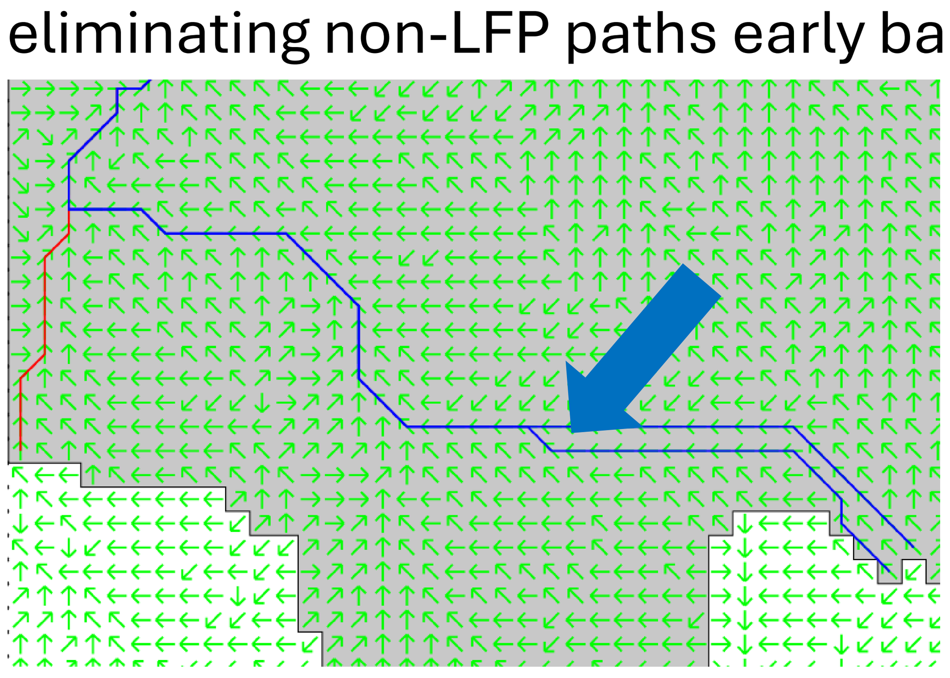


Vectorized results are not always guaranteed to be hydrologically correct!



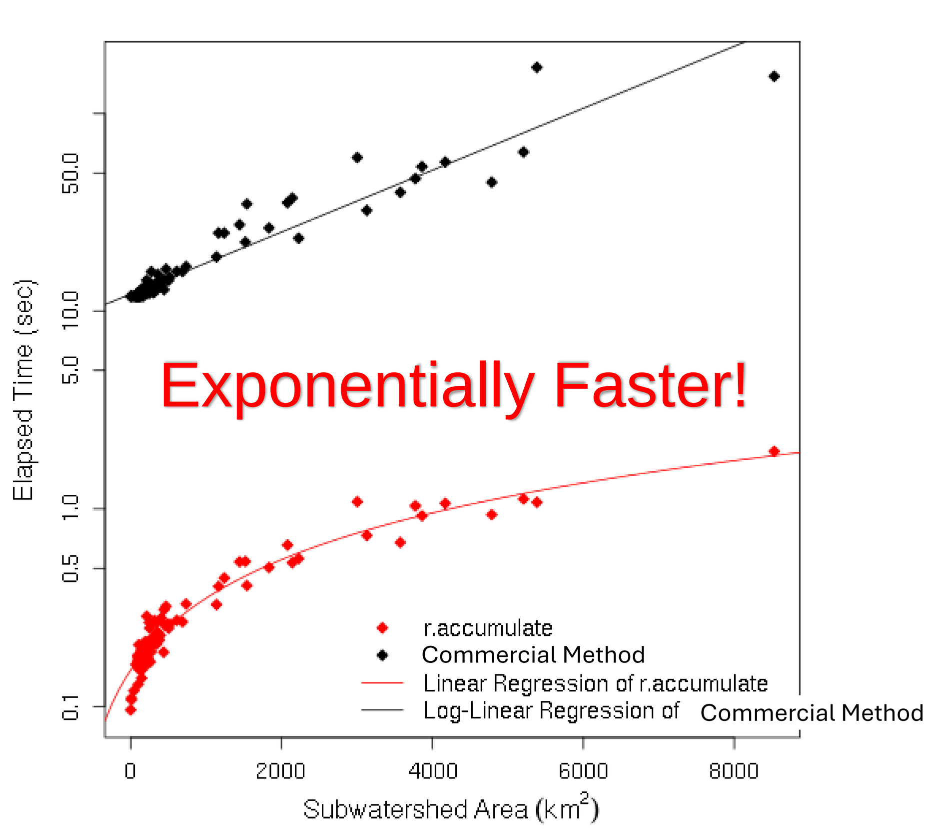
Cho's (2020) Method

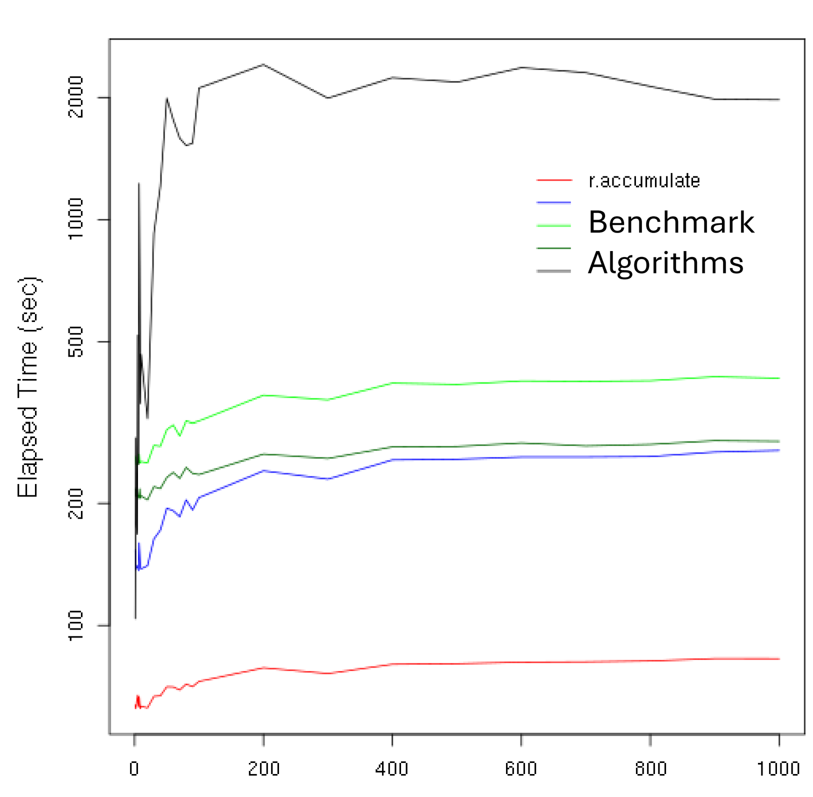
Cho's (2020) method uses a divide-and-conquer approach, eliminating non-LFP paths early based on Hack's law.



Equally LFPs were identified. See commercial software's result.

It's implemented as a GRASS addon, r.accumulate.





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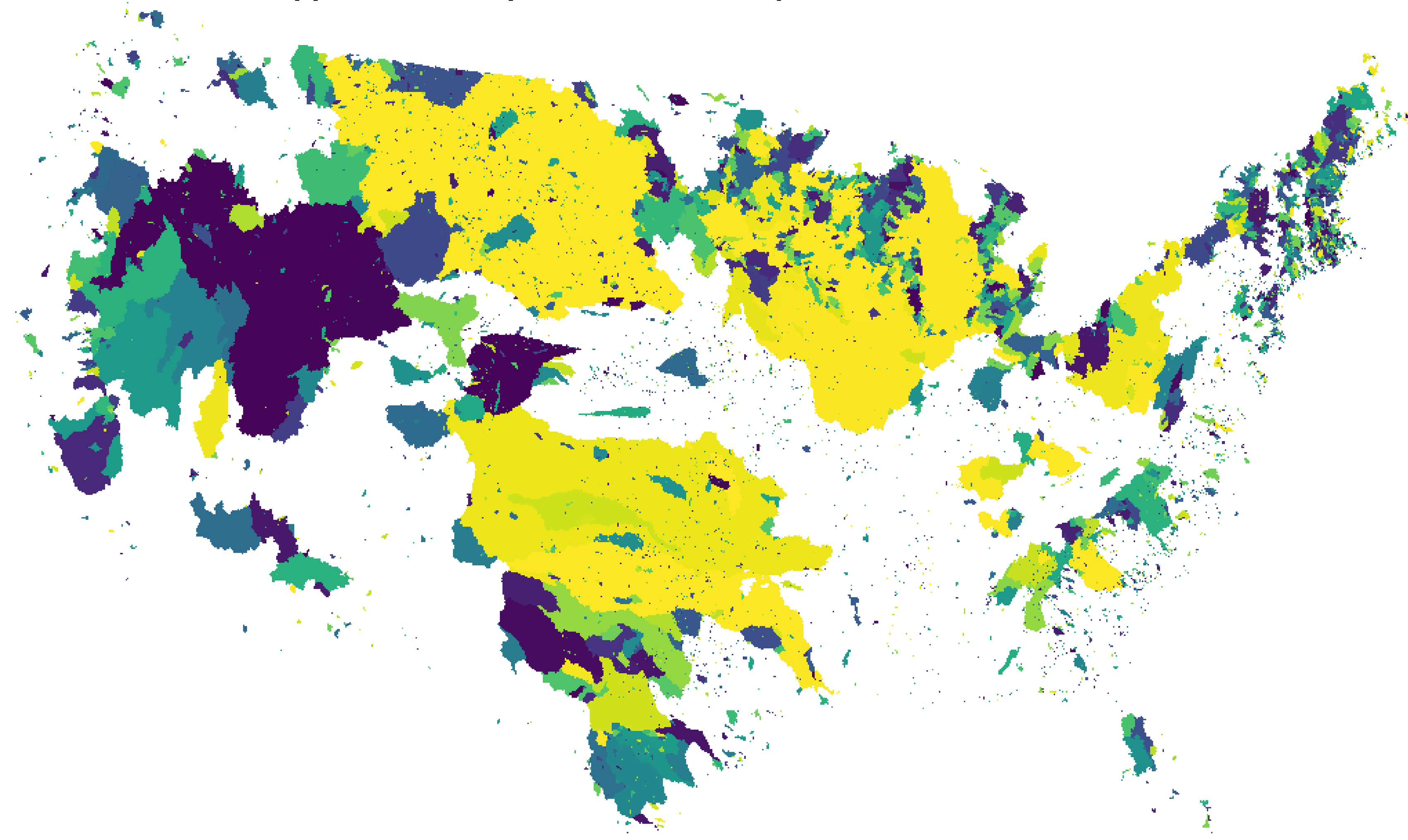
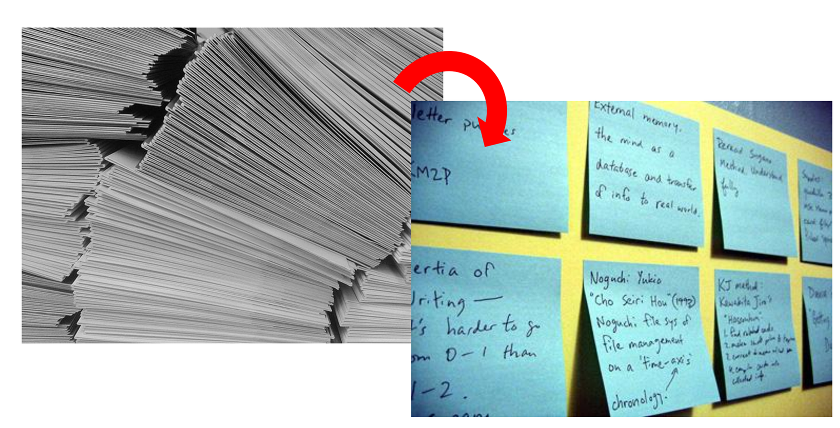
https://clawrim.isnew.info/

Cho's (Under Revision) Method

Cho's (2020) method is faster than other sequential algorithms, but it is still sequential. Cho's (Under Revision) new method called Memory-Efficient Longest Flow Path (MELFP) is an OpenMP parallel algorithm for computing longest flow paths for many outlets. The **motivation** was to calculate longest flow paths for 91,611 dams in the CONUS.

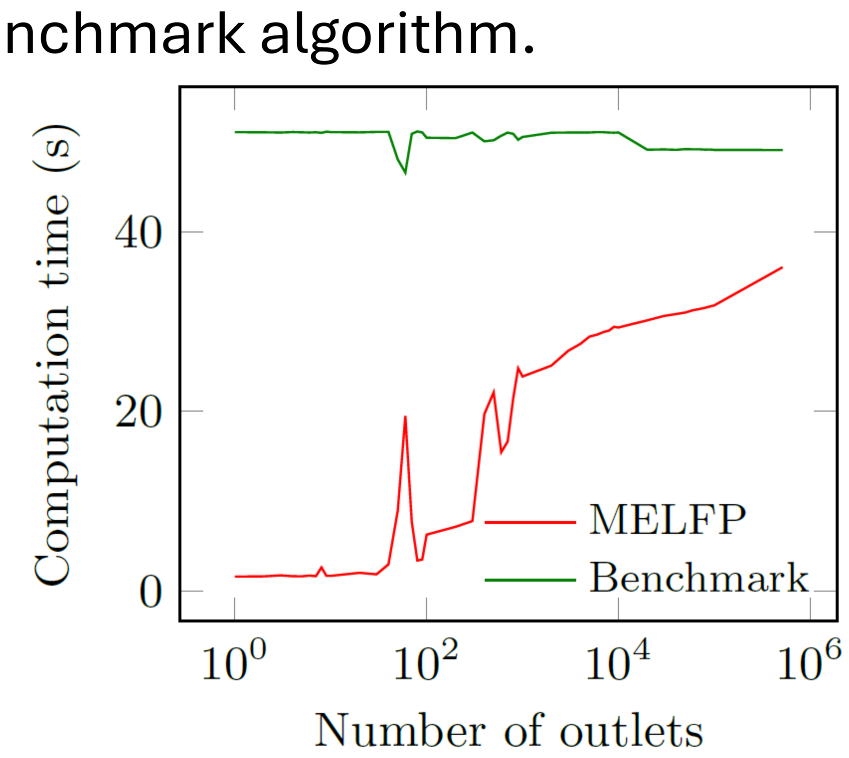


The major **challenge** was data size (15 billion cells, 14GB input data, large 14GB intermediate data required by existing methods). Input + Intermediate + Output = 84GB+ > System 64GB!



Stack-based looping then tasking for improved load balancing, No more large intermediate data!

MELFP achieved a 66% reduction in computation time utilizing 79% less peak memory (20GB vs. 96GB) and 33% higher CPU resources (like it or not?) compared to its **only** parallel OpenMP benchmark algorithm.



Acknowledgments

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- https://www.pickpik.com/stack-white-papers-letters-envelopes-letter-stack-post-60116
- https://www.flickr.com/photos/ayalan/317935661

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