CANDY: An Efficient Framework for Updating Properties on Large Scale Dynamic Networks

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Parallel Algorithms for Updating Large Dynamic Networks

- Analysis of dynamic networks has become an important tool for studying large-scale systems of interacting entities that change over time.

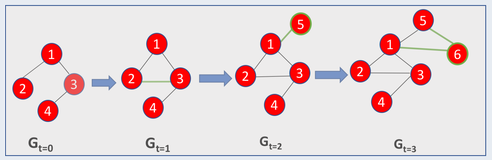


Figure: Changing of graph over time

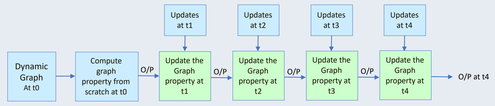


Figure: General approach for dynamic network algorithms

CANDY Architecture

- **CANDY**: a parallel, scalable, extendable, and user-friendly software platform for updating important properties of dynamic networks
- Support parallel dynamic network algorithm development on distributed memory, shared memory, and GPUs, and their use through user-friendly interfaces
- Comprehensive cyberinfrastructure supporting innovative research challenges in large-scale, complex, dynamic networks

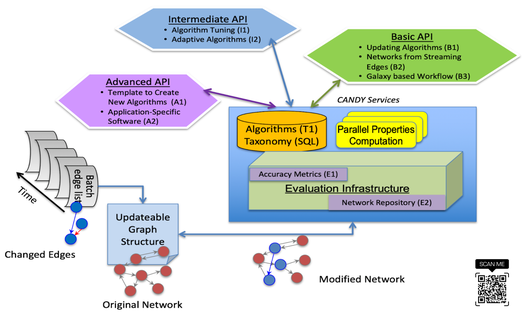


Figure: Overview of CANDY(Cyberinfrastructure for Accelerating Innovation in Network Dynamics)

Challenges and Intellectual Merits

Challenges

- Designing an efficient algorithm to update with minimal graph traversal.
- Determining the impact of changes and consider which approach is best re-computation or update algorithm.
- Creating parallel graph computation software infrastructure for modern heterogeneous architectures.

Intellectual Merits

- Includes templates for creating new scalable, parallel algorithms for dynamic network analysis
- Provides functionality and tools to create new algorithms or modify existing ones, catering to users with varying expertise
- Provides algorithms to partition streaming sets of nodes and edges into network snapshots at changing points

Graph Properties

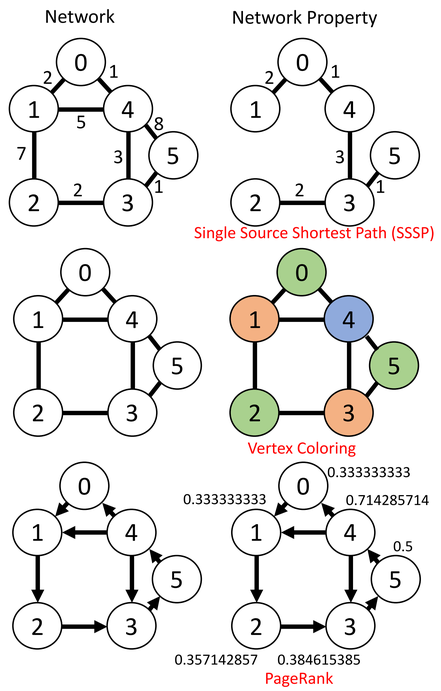


Figure: Example of common graph properties

Adaptive PageRank

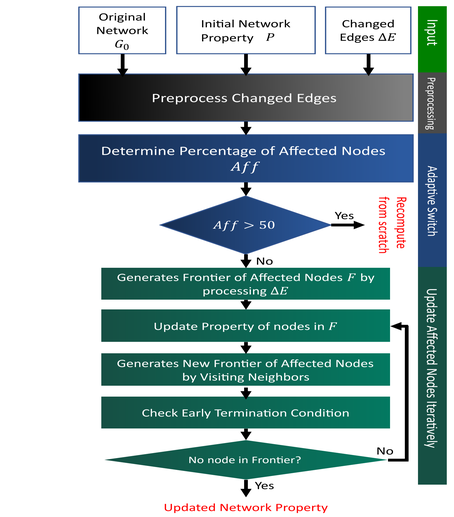


Figure: Adaptive framework template

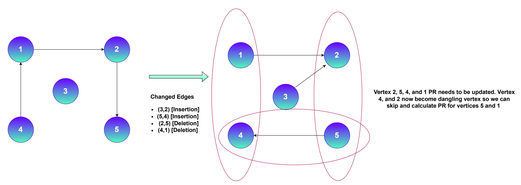
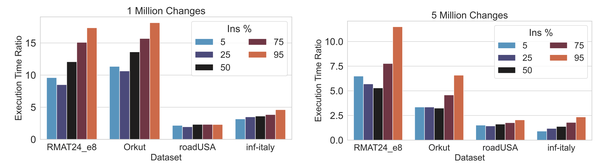


Figure: PageRank update in dynamic network

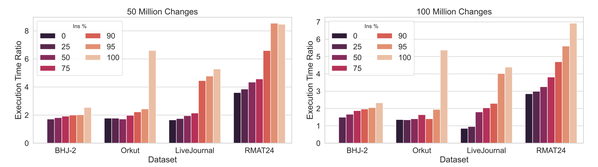
- High PageRank (PR) nodes have a cascading effect on a large number of remaining nodes.
- Adaptive Switch evaluates the total percentage of affected and high PR nodes.
- Adaptive Switch decides if updating property will be more efficient than property recomputation.
- Our update algorithm uses the previous property and iteratively computes the updated property in the affected subgraph.
- We empirically tested our adaptive implementation on real-world and synthetic networks and based on our observation we saw if the changes impact above 50% of nodes with high PR, the overall nodes affected are always above 95% of the entire network.
- When we compare our implementation with the recomputation approach if the changes impact less than 50 % of nodes with high PR values update algorithm outperforms the recomputation approach.

Results



(a) Speedup 1M (b) Speedup 5M

Figure: Kokkos color recomputation vs our Color update.



(a) Speedup 50M (b) Speedup 100M

Figure: Gunrock's SSSP recomputation vs our SSSP update.

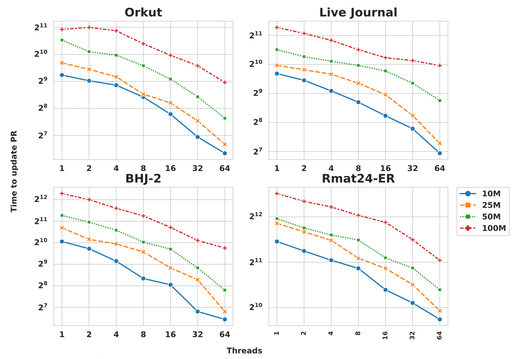


Figure: Shared Memory implementation of PR update

Conclusion

- Introduced CANDY: a high-performance network analysis software with performance optimization.
- Presented an adaptive template for creating new scalable, parallel algorithms for dynamic network property updates.

References

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