iBFS: Concurrent Breadth-First Search on GPUs

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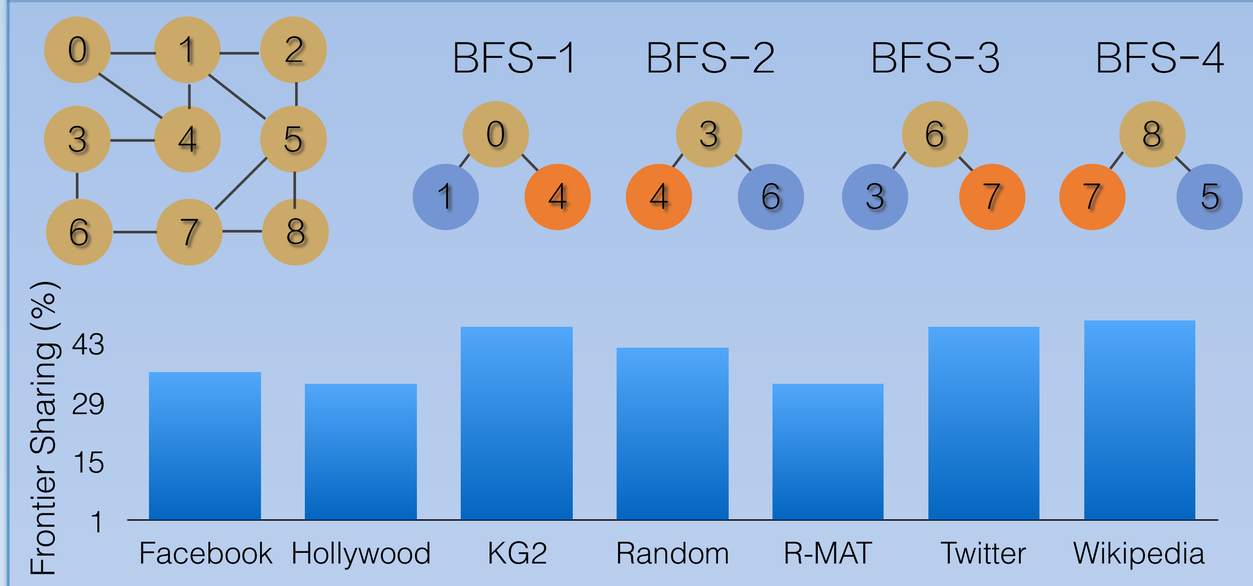
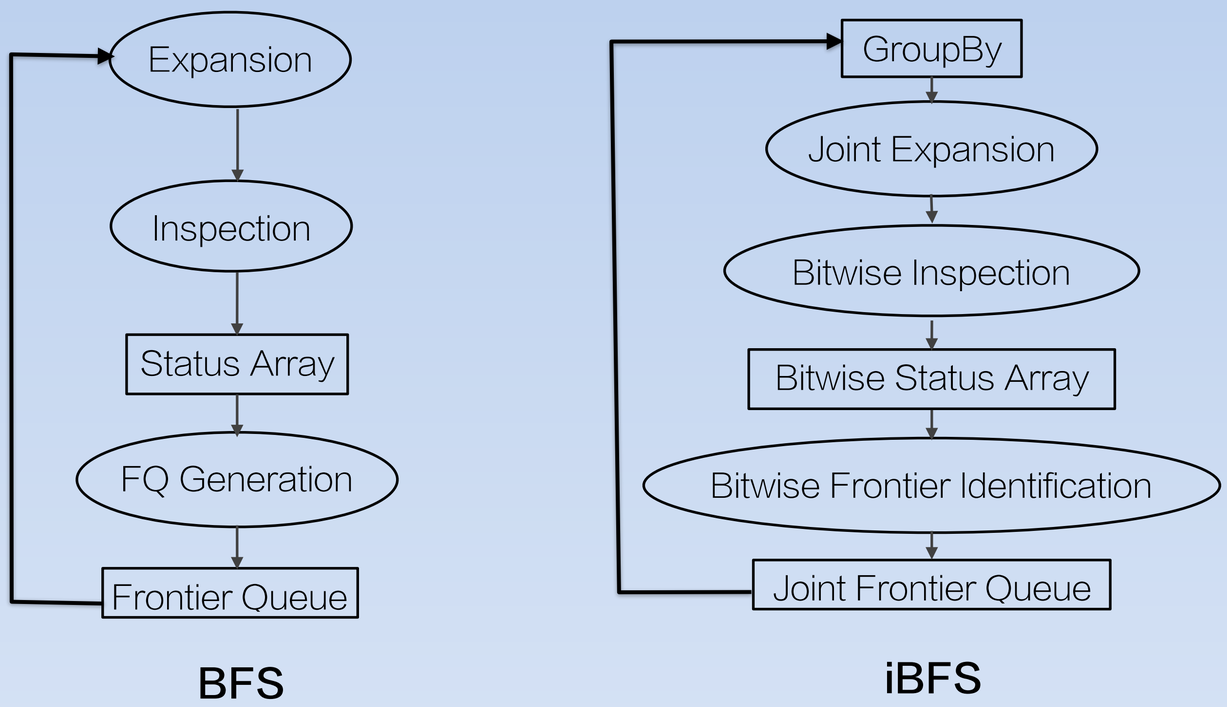
INTRODUCTION

Graph-based representations are ubiquitous in many applications such as social networks, biology networks, and cybersecurity. Meanwhile, concurrent graph traversal serves as a building block for graph algorithms such as shortest path, reachability, and centrality

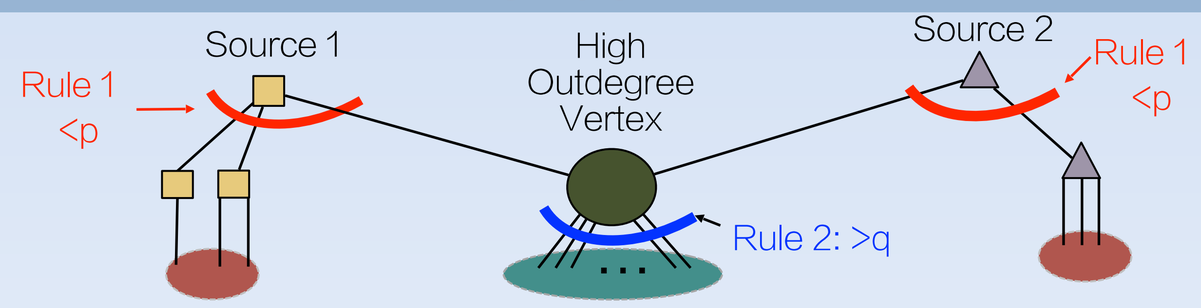
MOTIVATION



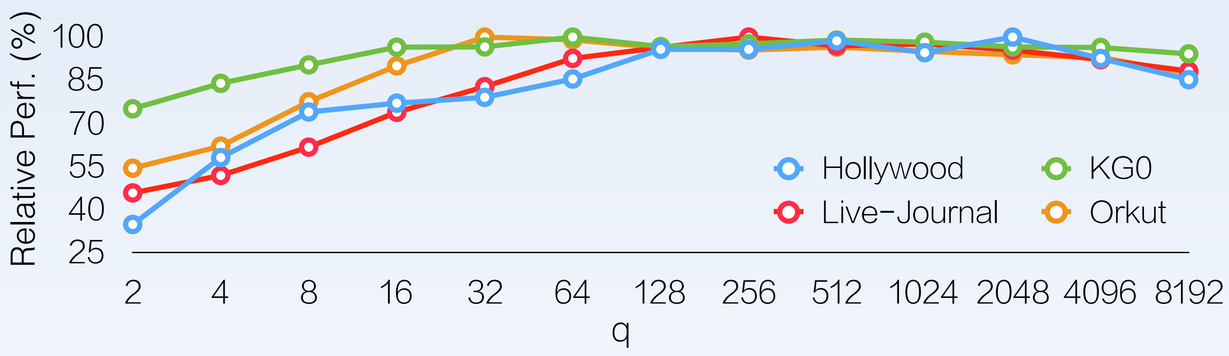
SYSTEM DESIGN

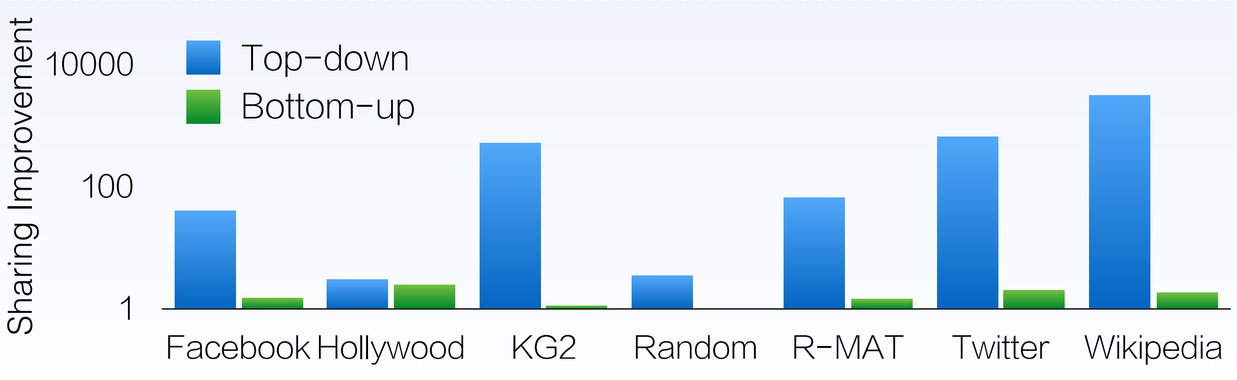


GROUPBY



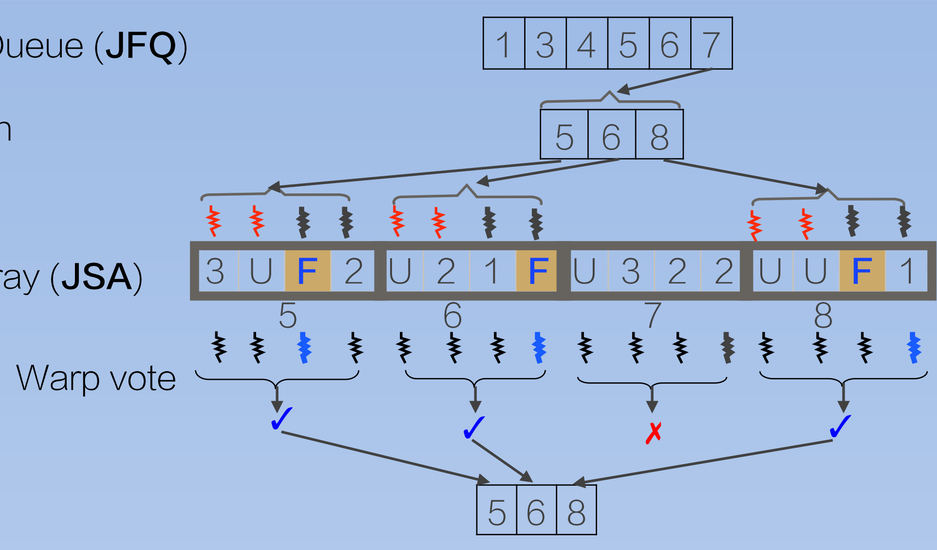
- **Rule 1**: The outdegrees of two source vertices are less than p.
- **Rule 2**: Two source vertices connect to at least one common vertex whose outdegree is greater than q.





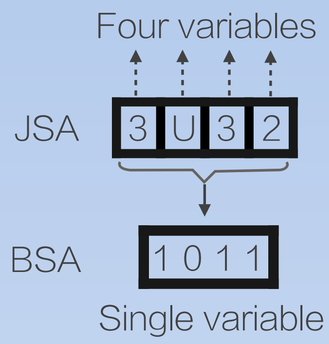
Frontier sharing ratio for top-down improves by 450x and bottom-up 75%

JOINT TRAVERSAL



Benefits: Eliminate redundant frontiers, load neighbors once, and achieve coalesce memory access to status array

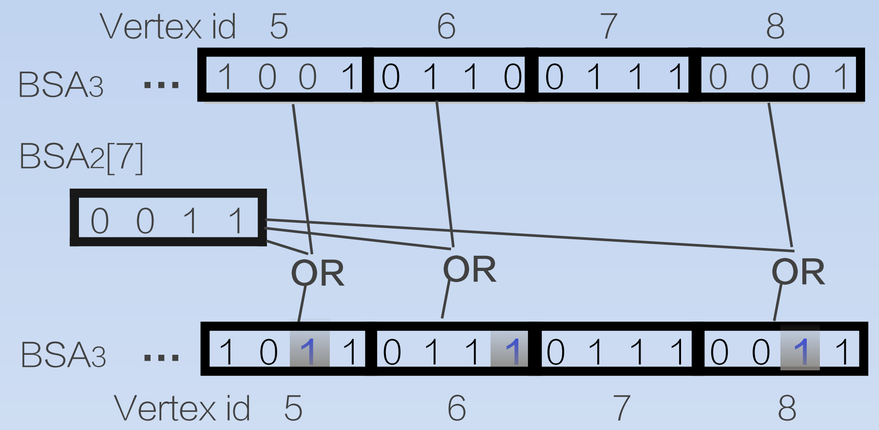
BITWISE OPTIMIZATION

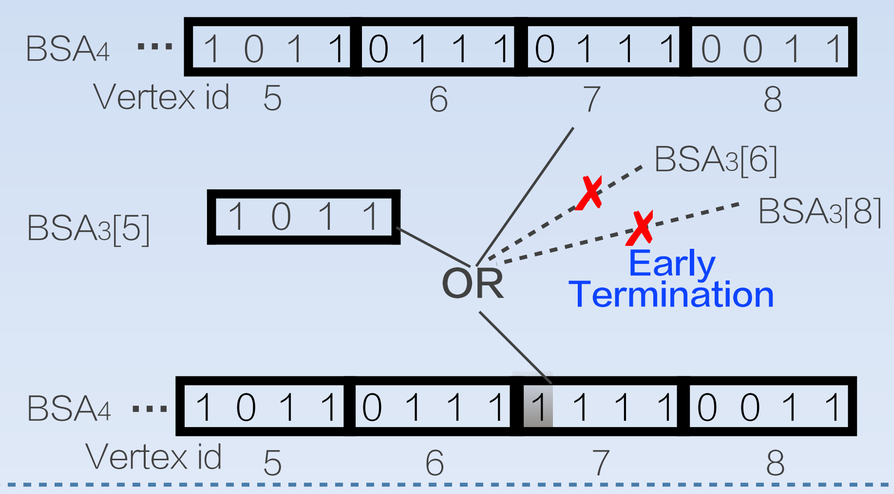


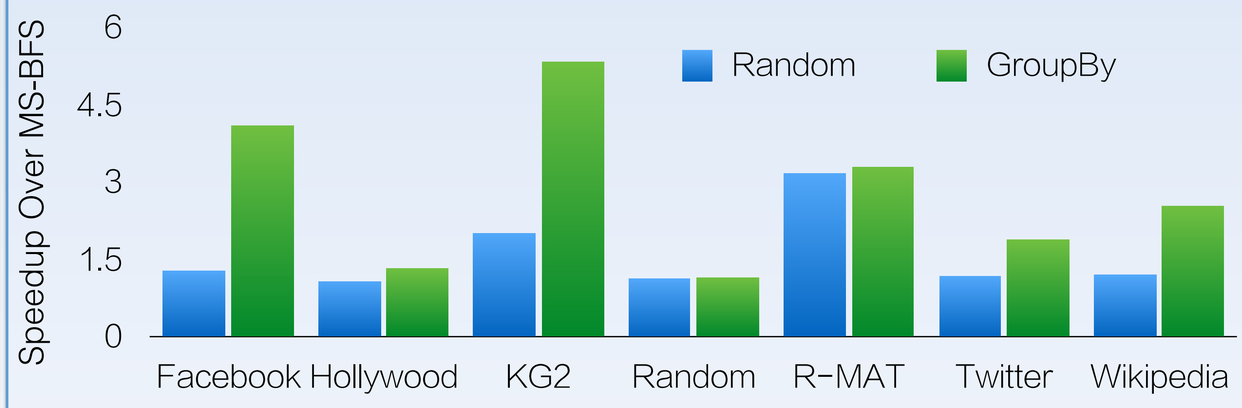
Pack statuses of multiple traversals in one variable

Bitwise Traversal Rule:

- Top-down: $BSA_{k+1}[v] = BSA_{k+1}[v]$ OR $BSA_k[F]$
- Bottom-up: $BSA_{k+1}[F] = BSA_{k+1}[F]$ OR $BSA_k[v]$







40% without GroupBy and 2.6x with GroupBy

CONCLUSION

Joint traversal improves performance by 40%, Bitwise optimization additional 11x, and GroupBy additional 2x

iBFS is able to accelerate concurrent traversals by up to 30x and scale to more than 112 GPUs, achieving 52,267 billion TEPS.

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