UNIVERSITY OF NOTRE DAME

STINGER: Spatio-Temporal Interaction Networks and Graphs Extensible Representation

Tim Shaffer

Motivation

Big problems are often represented as graphs

- **Bioinformatics:** identifying target proteins
- **Astrophysics:** outlier detection, clustering
- **Social networks:** tracking information spread, relationships

Graphs are enormous and *vary over time*

Example: Social Media

Facebook

- ~1 billion users
- Average of 130 friends, some accounts *much* higher
- 30 billion user interactions per month

Twitter

- 500 million active users
- 340 million tweets per day

Challenges

Large scale

- Memory efficiency
- Parallelism

Frequent updates

- Fast operations
- Partial recomputation

STINGER

STINGER is a high-performance graph data structure

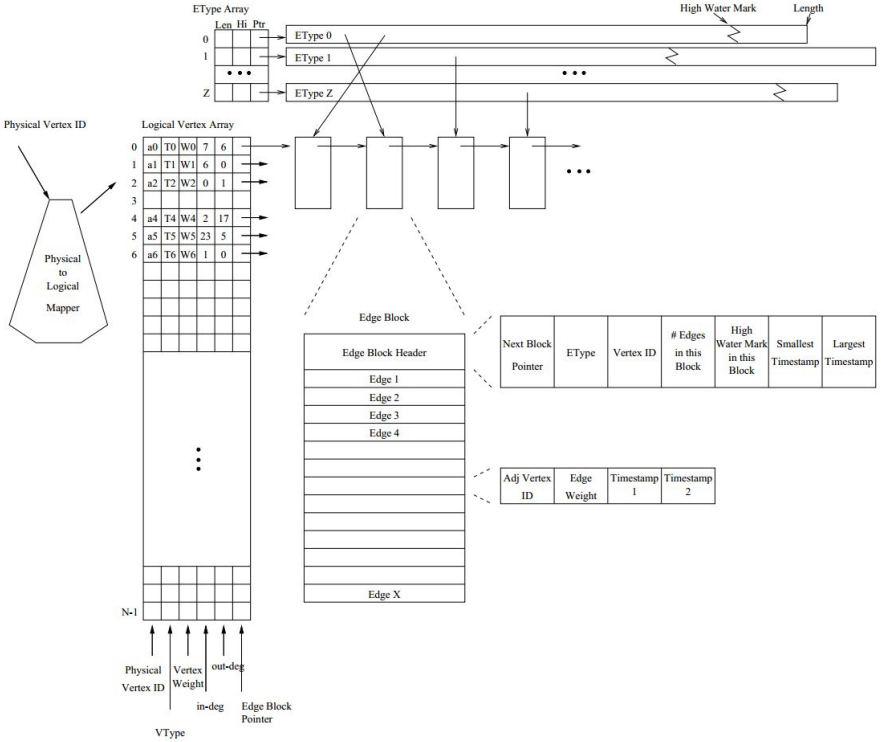
- Fast insertions, deletions, and updates
- Types and weights for edges and vertices
- Filtering by timestamp, type, etc.
- Parallel graph operations

STINGER

Also a library/API for using the data structure

- Written in C/C++
- Bindings for Python and Java
- Assumes shared memory system
- Targets x86 and Cray XMT machines

Data Structure



Data Structure

Graph consists of

- Vertex array
- EType array

Edges are stored in linked lists of edge blocks

EType array is an additional index with pointers to all edges of a given type

Data Structure

Each vertex has a

- type
- weight
- linked list of its outgoing edges

Each edge has a

- type
- weight
- creation and modification timestamp

Data Structure

Multiple parallel readers and a single writer

Algorithms can operate serially or in parallel over all nodes, edges, neighbors, etc.

Does not provide ACID semantics

Library

C/C++ library implementation, C interface (no templates)

Types, weights are 64 bit integer values

Parallelism through OpenMP and XMT pragmas

No cluster support

Implemented Algorithms

- Streaming clustering coefficients
- Streaming connected components
- Streaming community detection
- Parallel agglomerative clustering
- Streaming Betweenness Centrality
- K-core Extraction
- Classic breadth-first search

Example: Shortest Path

```
STINGER_FORALL_OUT_EDGES_OF_VTX_BEGIN(S, current.vertex) {
    //for all the neighbors of the current vertex
    int64_t new_cost = cost_so_far[current.vertex] + STINGER_EDGE_WEIGHT;
    if (new_cost < cost_so_far[STINGER_EDGE_DEST]
            || cost_so_far[STINGER_EDGE_DEST] == std::numeric_limits<int64_t>::max()) {
        cost_so_far[STINGER_EDGE_DEST] = new_cost;
        weighted_vertex_t next;
        next.vertex = STINGER_EDGE_DEST;
        next.cost = new_cost;
        frontier.push(next);
```

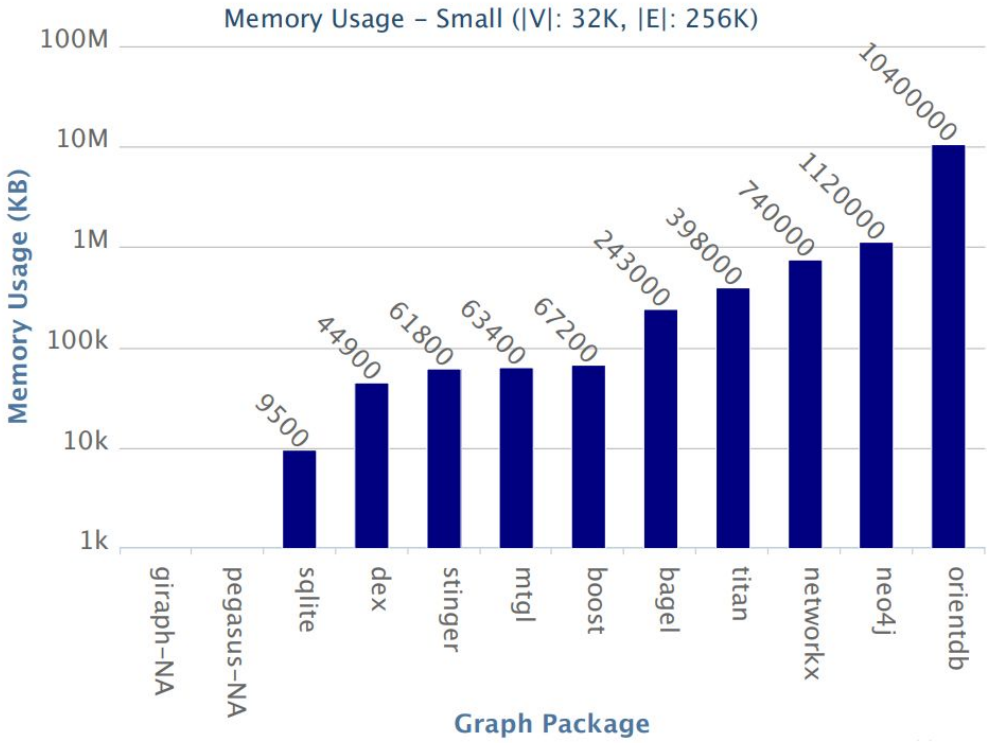
Performance

Optimized for extremely frequent updates

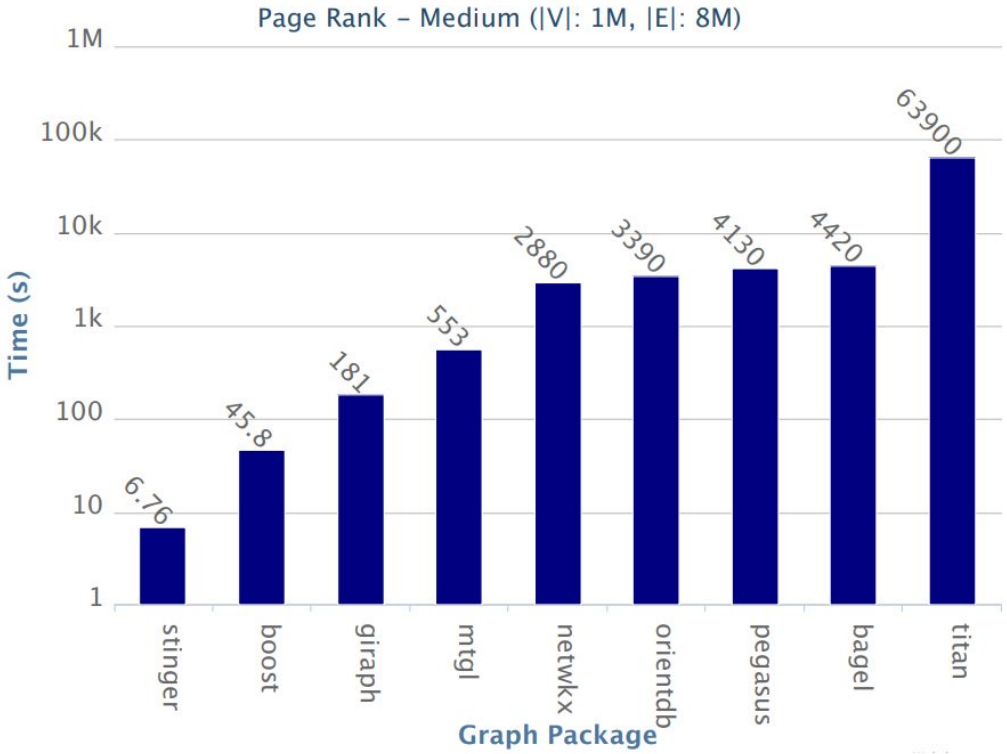
Fast locking implementation (esp. on Cray XMT)

Batched updates (big improvement)

Performance



Performance



Performance

Benchmarked at 3 million edge updates per second for graphs with 1 billion edges

Streaming and parallel operations greatly reduce computation cost

Partial recomputation greatly reduces cost of updates

Performance

Example: connected components of a graph of 500 million edges

- Measured 1.26 million updates/second
- 137x faster than recomputing

Allows desktop computer to process graphs with millions of vertices and edges

Big machines can reach billions of edges