**Temporal Graphs**

Querying/Memory/Storage

Title: Distributed Storage & Querying of Large Temporal Graphs with Real-Time Streaming Updates

Proposer: Shriram R.

Participant: Shriram R. + 1

Problem Statement, Gaps & Motivation:

This work is to come up with an efficient distributed storage and query processing system for temporal graphs with streaming updates on commodity hardware. Efficiency is to be measured based on graph size, query latency and streaming update rate supported for a given hardware configuration.

Existing streaming graph processing systems mainly focus on continual maintenance of dynamic graph from streaming updates but limit their support for TD (time dependent) and MS (multi snapshot) queries. There are several challenges in building this system in terms of repartitioning graph due to imbalance introduced by updates, incremental update of indices for supporting queries, storage and in-memory layout of graph, integration with temporal graph processing framework like Graphite to process temporal queries that makes this interesting as a research problem.

Novelty & Related Work:

Novelty stems from the following contributions of this work: 1. Repartitioning strategy based on a cost model 2. Graph layout offering a balanced trade-off between updates and querying 3. Index to retrieve snapshots containing a vertex/edge satisfying a given predicate 4. Support for ad-hoc & continuous queries which are time dependent (TD).

[2] & [4] looks into updating graphs based on streaming updates. While [2] focusses on creating consistent snapshots for graph mining, [4] implements a RDMA based hybrid store to support both timing and timeless queries on the dynamic graph. [1] provides a general algebra for temporal graph queries spanning both MS and TD categories. [5] proposed novel compression techniques for property graphs while supporting queries without decompression. [6] proposed a novel tree based data structure to store and retrieve snapshots of graph with minimum redundancy and computational requirements.

Further Reading:

1. Moffitt, Vera Zaychik, and Julia Stoyanovich. "Temporal graph algebra." *Proceedings of The 16th International Symposium on Database Programming Languages*. ACM, 2017.
2. Cheng, Raymond, et al. "Kineograph: taking the pulse of a fast-changing and connected world." Proceedings of the 7th ACM european conference on Computer Systems. ACM, 2012.
3. Zhang, Yunhao, Rong Chen, and Haibo Chen. "Sub-millisecond stateful stream querying over fast-evolving linked data." *Proceedings of the 26th Symposium on Operating Systems Principles*. ACM, 2017.
4. Khandelwal, Anurag, et al. "Zipg: A memory-efficient graph store for interactive queries." *Proceedings of the 2017 ACM International Conference on Management of Data*. ACM, 2017.
5. Khurana, Udayan, and Amol Deshpande. "Efficient snapshot retrieval over historical graph data." 2013 IEEE 29th International Conference on Data Engineering (ICDE). IEEE, 2013.

Title: Indexing mechanisms for accelerating time dependent queries on temporal graphs

Proposer: Shriram R.

Participant: Shriram R.

Problem Statement & Motivation: Existing literature [3] on temporal graph processing focusses largely on indexes to compress graph topology of different snapshots by exploiting redundancy. However, specific indexing structures that can minimize the time to compute time dependent (TD) [2] algorithms like SSST, EAT etc. have not been explored in detail in the context of temporal graph querying. There are interesting challenges in terms of index layout, rebuild based on streaming updates with trade-off between stream throughput and query latency, partitioning indexes to support distributed processing which can be studied as part of this problem.

Further Reading:

1. Li, Lei, et al. "Minimal on-road time route scheduling on time-dependent graphs." Proceedings of the VLDB Endowment 10.11 (2017): 1274-1285.
2. Moffitt, Vera Zaychik, and Julia Stoyanovich. "Temporal graph algebra." *Proceedings of The 16th International Symposium on Database Programming Languages*. ACM, 2017.
3. Semertzidis, Konstantinos, Evaggelia Pitoura, and Kostas Lillis. "TimeReach: Historical Reachability Queries on Evolving Graphs." EDBT. 2015.
4. Khurana, Udayan, and Amol Deshpande. "Efficient snapshot retrieval over historical graph data." 2013 IEEE 29th International Conference on Data Engineering (ICDE). IEEE, 2013.
5. Semertzidis, Konstantinos, and Evaggelia Pitoura. "Top-$ k $ Durable Graph Pattern Queries on Temporal Graphs." IEEE Transactions on Knowledge and Data Engineering 31.1 (2018): 181-194.

Title: Declarative time dependent querying on streaming temporal graphs

Proposer: Shriram R.

Participant: --

Problem Statement & Motivation: Processing streaming dynamic graphs [1] and storing dynamic graphs [3] has been well studied in literature. Most of these studies focusses on efficient update of graph structure & properties along with MS (multi-snapshot) queries. Designing a declarative graph store supporting one-shot and continuo TD algorithms in addition to MS on top of graph streams poses challenges in query optimization, integration with temporal graph processing framework.

Further Reading:

1. Zhang, Yunhao, Rong Chen, and Haibo Chen. "Sub-millisecond stateful stream querying over fast-evolving linked data." *Proceedings of the 26th Symposium on Operating Systems Principles*. ACM, 2017.
2. Khandelwal, Anurag, et al. "Zipg: A memory-efficient graph store for interactive queries." *Proceedings of the 2017 ACM International Conference on Management of Data*. ACM, 2017.
3. Kumar, Pradeep, and H. Howie Huang. "GraphOne: A data store for real-time analytics on evolving graphs." 17th {USENIX} Conference on File and Storage Technologies ({FAST} 19). 2019.
4. Wang, Siyuan, et al. "Fast and Concurrent {RDF} Queries using RDMA-assisted {GPU} Graph Exploration." 2018 {USENIX} Annual Technical Conference ({USENIX}{ATC} 18). 2018.