Efficiently applying Fast Succinct Tries in OLTP Systems

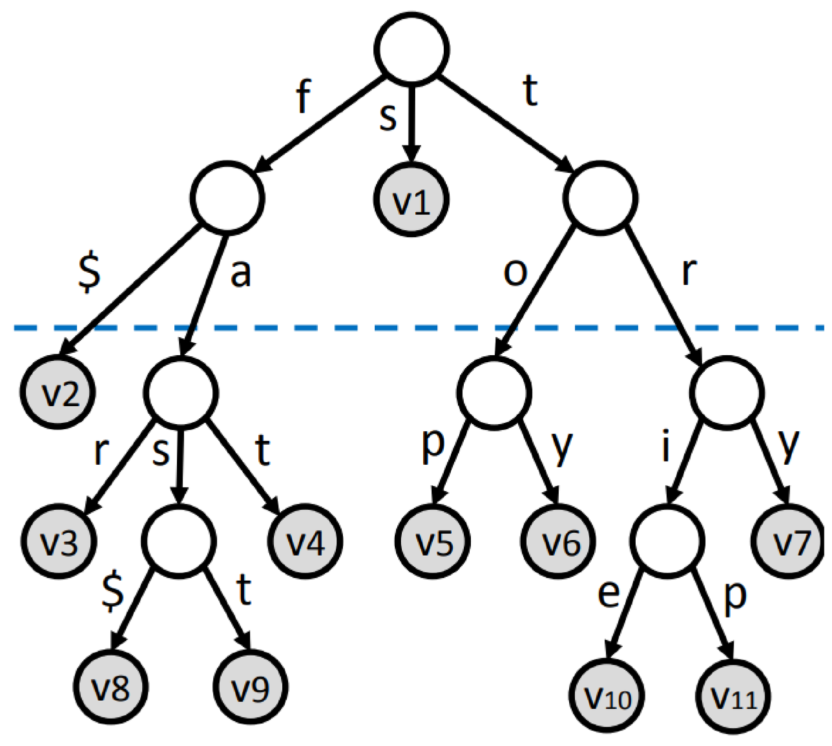
Abstract Online Transaction Processing Systems (OLTP) have high requirements regarding throughput and are insert and update-intensive. Moreover, they are used by a multitude of users, thus requiring concurrent access. As main memory still is comparably expensive, data structures that can index data with a memory consumption near the information theoretic minimum are a hot topic in data structure engineering research. One such recently published data structure is the Fast Succinct Tree (FST). However, the FST is a static data structure, thus requiring an extension to be used in OLTP Systems. Therefore, we propose an architecture that applies inserts and deletes to an FST in batches. With this project, we want to evaluate, whether the proposed architecture is still able to deliver adequate performance, while at the same time significantly reducing memory consumption for indexing in OLTP Systems.

Problem: The FST is a static data structure that does not support inserts, deletes or updates, making it unsuitable for OLTP systems.

Goal: Develop an architecture that benefits from the minimal memory consumption of the FST, while supporting the requirements of a OLTP System.

Solution: We apply insert, deletes and updates to the dynamic Adaptive Radix Tree (ART) that is optimized for performance. We then regularly apply batch merges to the FST, thereby selecting an interval that minimizes the number of merges, while at the same time keeping the ART significantly smaller than the FST, in order to keep up the memory savings.

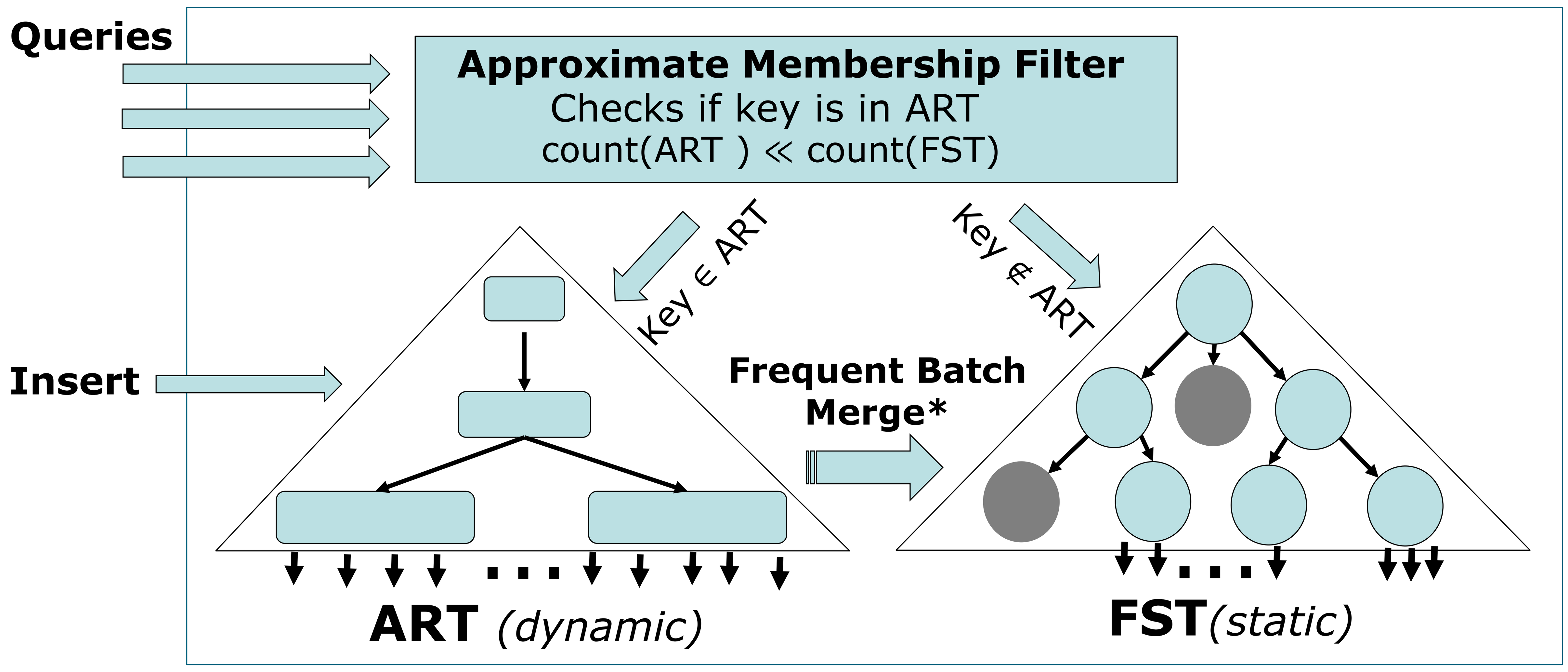
Fast Succinct Tries (FST)



Frequently accessed top layers optimized for performance. (child node search = 1 array lookup)

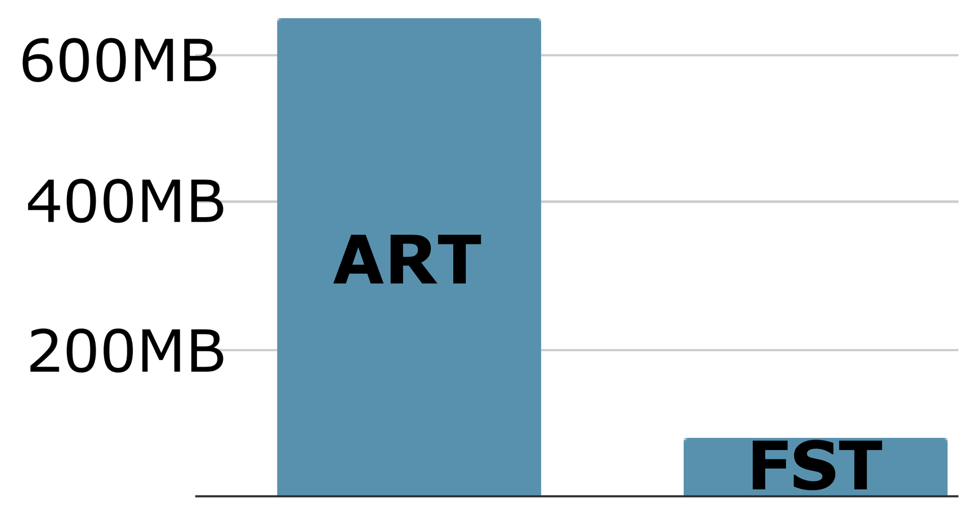
Less frequently accessed bottom layers optimized for memory reduction.

Architecture Proposal

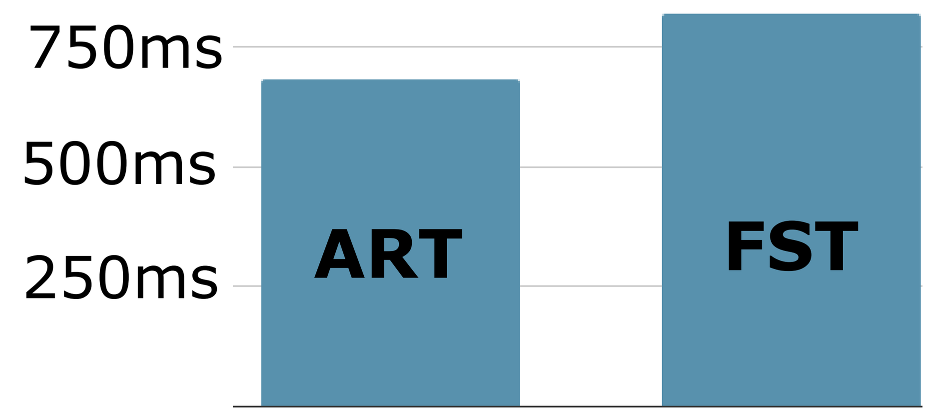


*See limitations regarding the merge

Memory for Indexing 25M Emails



Latency for Point Queries



ART Data

n Databits | 1 mode-bit

Data in the ART will be used to create a log. An additional bit classifies the entry as insertion(0) or deletion(1).

Deletions

delete(key) => key in ART ?
ART.delete(key) : ART.insert(key, 1)

Updates

update(key, val) => key in ART ?
ART.update(key, val|1) :
ART.insert(key, val|1)

Multi-User Support

Goal: Allow concurrent accesses, also during merge.

Solution:
1) ART + Optimisic Lock Coupling *(Leis, 2016).*
2) Static FST is natively concurrent.
3.1) Apply changes that incoming during the merge phase to a new ART -> current ART becomes read-only.
3.2) Apply modifications from old ART to FST. Incrementally apply changes *(see limitations).*

Possible Limitations

As the FST requires rebalancing/reorderding depending on newly inserted keys, it has to be investigated whether such a merge procedure exists or whether applying changes requires a complete reubuild of the FST. We then have to evaluate whether the memory - efficiency tradeoff that is introduced by the filter is adaquate or whether the filter might be ommitted, while still maintaing accaptable performance.

Rohan Sawahn
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Sources
(1) Zhang, Huanchen, et al. "Surf: Practical range query filtering with fast succinct tries." *Proceedings of the 2018 International Conference on Management of Data*. 2018.
FST detail image taken from (1)
(2) Leis, Viktor, et al. "The ART of practical synchronization." *Proceedings of the 12th International Workshop on Data Management on New Hardware*. 2016.
(3) Zhang, Huanchen, et al. "Reducing the storage overhead of main-memory OLTP databases with hybrid indexes." *Proceedings of the 2016 International Conference on Management of Data*. 2016.

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