Partially Persistent Trees in Python

Abhishek Purushothama & Nicholas Elsasser

Agenda

- Motivation
- Foundation
- Implementation
- Performance
- Hash Consing for AMR
- Do we need persistence for Hash Consing?

Motivation

Hash Consing[1]

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Immutability is a requirement for applying this technique and hence *persistence* in data structures provide an efficient implementation for using Hash Consing.

Maximal sharing refers to a broader method for sharing data and computation.

Symbolic representations

It *may* be possible to extend this technique to symbolic representations in other areas such as computational linguistics.

An example of such symbolic representations is Abstract Meaning Representation(AMR)[2].

“He drives carelessly.” is represented as AMR,

```
(d / drive-01
   :ARG0 (h / he)
   :manner (c / care-04
              :polarity -))
```

Structurally speaking

Structurally, AMRs are *directed acyclic graph with labeled nodes and edges*.

Foundation

Partial persistence[3][4]

- Ephemeral
- Fat Node
- Path Copying
- Hybrid

Implementing Partially Persistent Trees in Python

Implementation - Node Persistence

- Persistence detail is handled by node
  - Generalize information and pointer fields w/ hash table

```python
@dataclass
class PersistentNode:
    key: int
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  - `get` – handles versioned query for specific persistence implementation

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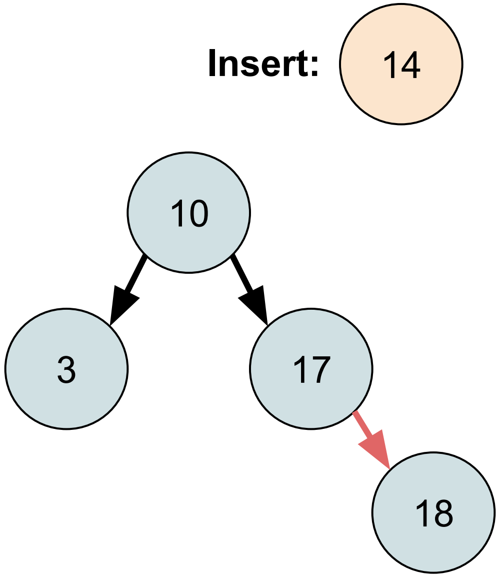
Implementation – Path Persistence

- Maintaining consistent path



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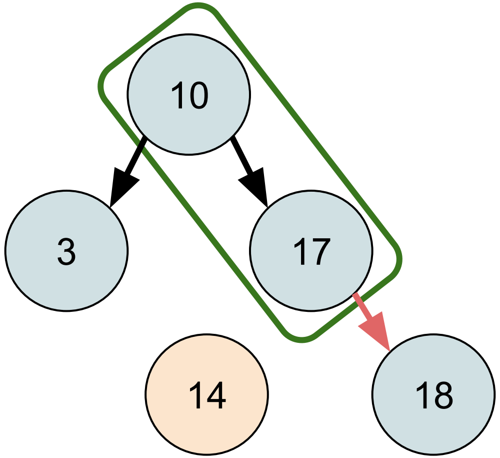

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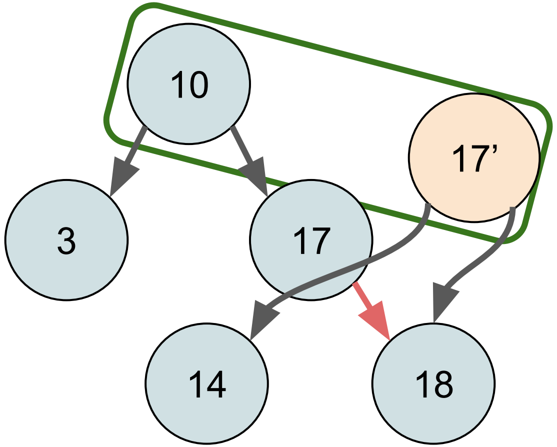

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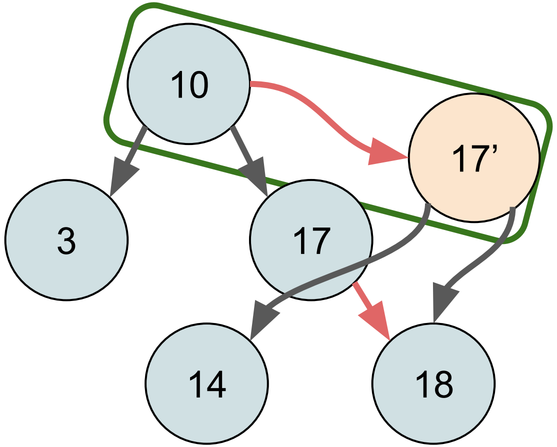

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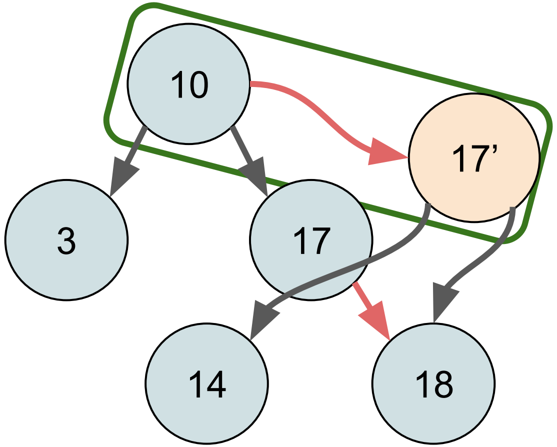

- Future work – make path updates implicit in node updates

Persistent Implementations

- Implement 4 generic tree node backends
  - Ephemeral – mutate fields in-place
  - Fat – each field maintains an ordered mutable list of versions
  - Copy – invoke a copy with updated field on each update
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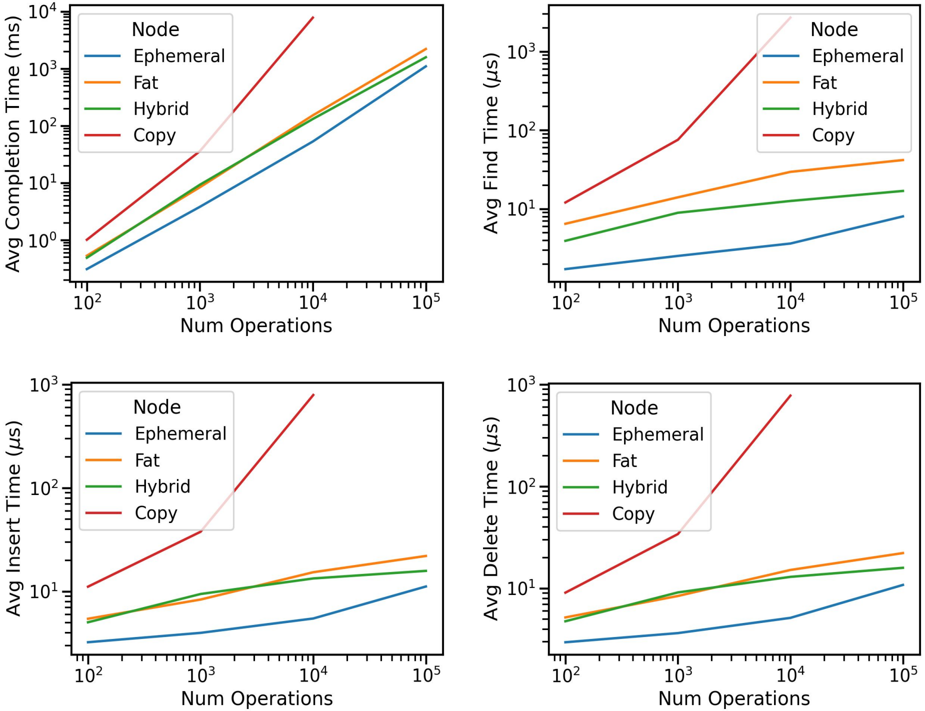
- One tree implementation can use all backends:
  - Unbalanced BST
  - Red-Black Tree
  - AMR Tree w/ maximal sharing

Performance

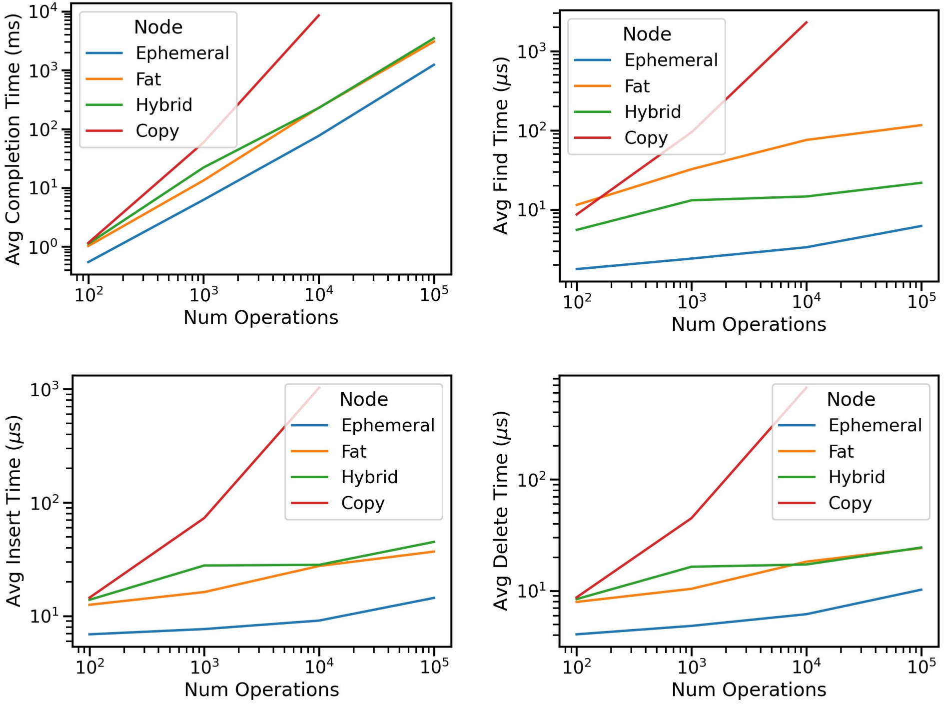
- Compare performance of node backends
  - Unbalanced BST and Red-Black tree support
    - `insert(self, key: int, value: Any)`
    - `delete(self, key: int) -> Any`
    - `find(self, key: int, version: int) -> Any`

- 100 trials
- Random sequence of 4*N* `insert`/`delete` and **keys** drawn from {0…*N*-1}
- On final version, execute `find` on 4*N* **keys** and **versions** drawn from {0…*N*-1} and {0…4N-1} respectively

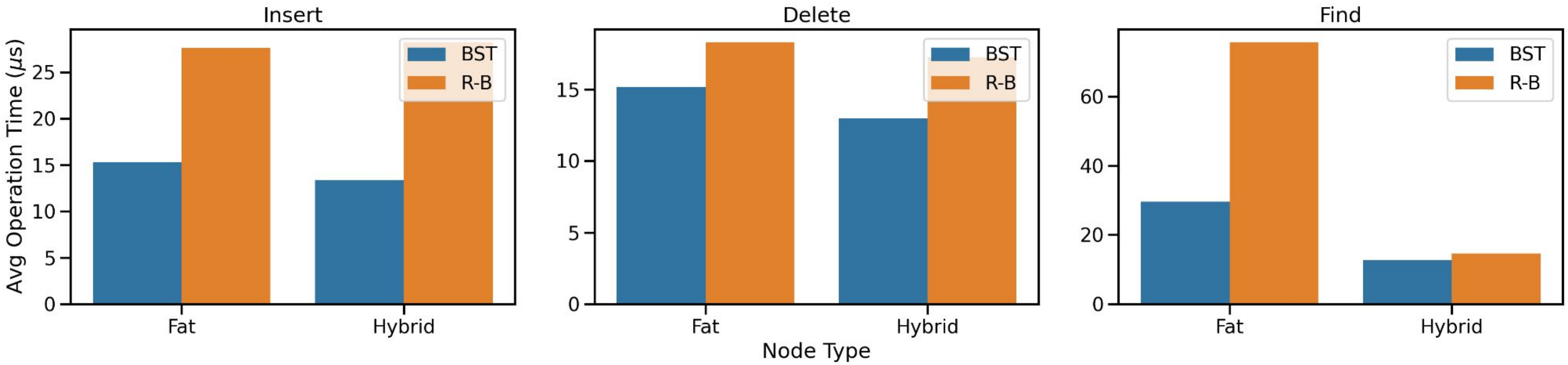
Unbalanced BST Performance



Red-Black Tree Performance



Backend v.s. Use-Case



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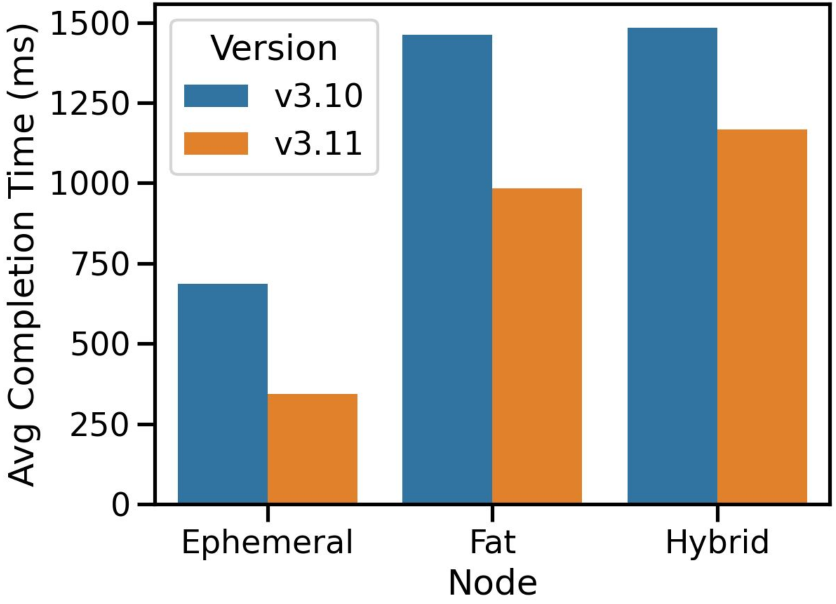

Hash Consing for AMR

The main library for working with AMR is *penman* package[5] in python.

It is relatively adhoc in its implementation, but it does hold to the AMR specifications.

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In a analysis of dev split, consensus set (from AMR 3.0[6]) of 100 AMRs, made from Wall Street Journal and Weblog, there were ~190 instance of subtree(including leaf) duplication out of ~1500 (sub)trees.

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The meaning representation sub-structure for “country of South Korea” was present 4 times

```
(c / country
     :wiki "South_Korea"
     :name (s / name
          :op1 "South"
          :op2 "Korea"))
```

Implementation

We also implemented a sample bottom-up AMR serializer using hash-based maximal sharing.

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- Immutability
- Functional? “Cons”ing
    - Inductive definition
    - Penman plan (grammar)

Do we really need persistence to do ‘Maximal sharing’?

Maybe not

Hash Consing vs Maximal Sharing

Just semantics?

Do we *really* need Hash Consing (or Maximal Sharing) for AMRs?

The total set of AMRs is about ~200,000 right now.

It’s practical impact may feel pennies in a game of thousand pounds.

“Take care of the pennies and the pounds will take care of themselves”

(attributed to Victorian era Lord Chesterfield and William Lowndes.)

Next step

1. Formal definition of Maximal Sharing for AMR
2. Implementation of Maximal Sharing de-serialization for AMR
3. Formal definition of Functional AMR
4. Implementation of Functional-ish AMR
5. Implementation of Functional-ish AMR de-serialization with Hash Consing

Acknowledgement

Thanks to Dr, Martha Palmer and CLEAR lab for providing access to AMR 3.0 release.

Thanks to Linguistic Data Consortium for the work on AMR 3.0 release.

Thanks

Questions

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