One Table Fits All

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Tabling in Logic Programming

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- Tabling has proven to be particularly effective in logic (**Prolog**) programs:
  - Avoids recomputation, thus reducing the search space.
  - Avoids infinite loops, thus ensuring termination for a wider class of programs.
- Tabling has been successfully applied to real-world applications:
  - Deductive Databases
  - Knowledge Based Systems
  - Model Checking
  - Program Analysis
  - Theorem Proving
  - Non-Monotonic Reasoning
  - Natural Language Processing
  - Inductive Logic Programming

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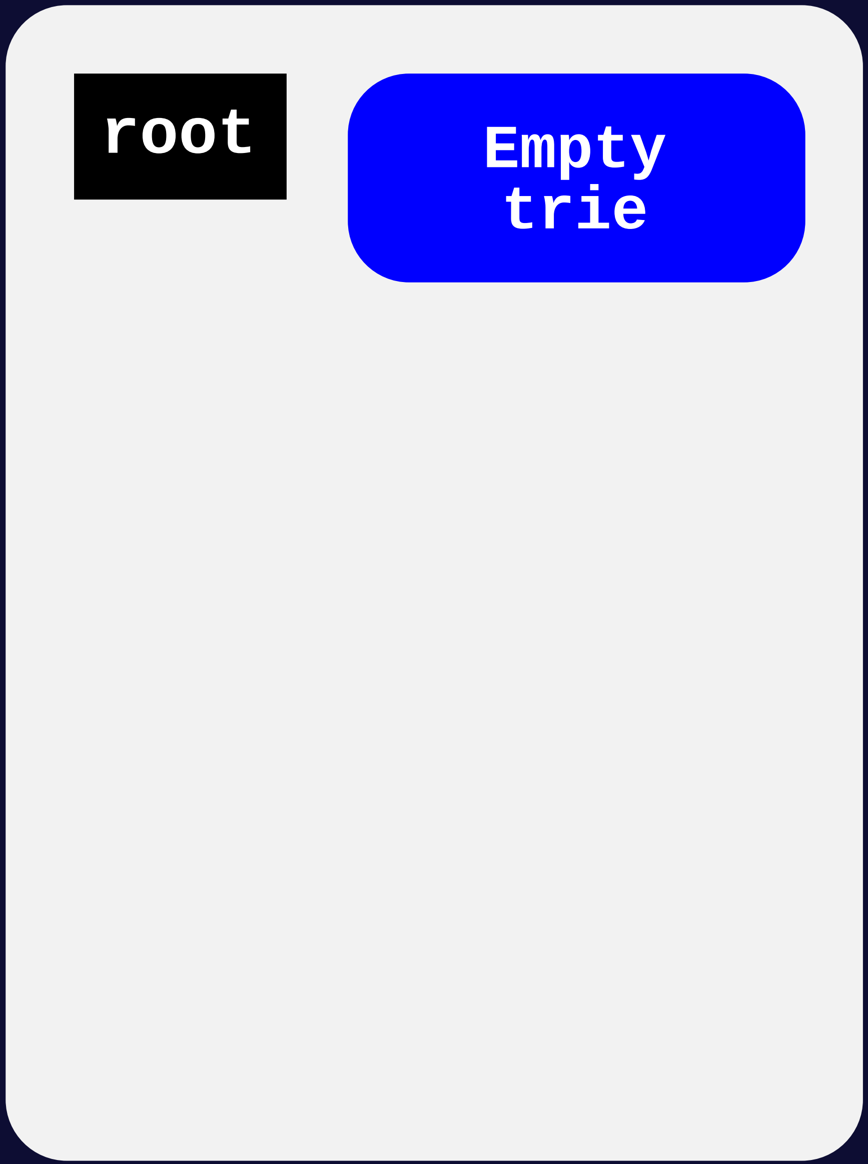
- However, while tries are efficient for variant based tabled evaluation, they are **limited in their ability to recognize and represent repeated answers for different calls**.
- In this work, we propose a new design for the table space where **all tabled subgoal calls and tabled answers are stored in a common global trie** instead of being spread over several different trie data structures.

Table Space

- **Can be accessed to:**
  - Look up if a subgoal is in the table, and if not insert it.
  - Look up if a newly found answer is in the table, and if not insert it.
  - Load answers for repeated subgoals.
- **Implementation requirements:**
  - Fast look-up and insertion methods.
  - Compactness in representation of logic terms.

Using Tries to Represent Terms

- Tries are trees in which common prefixes are represented only once.
- Each different path through the nodes in the trie corresponds to a term.
- Terms with common prefixes branch off from each other at the first distinguishing symbol.



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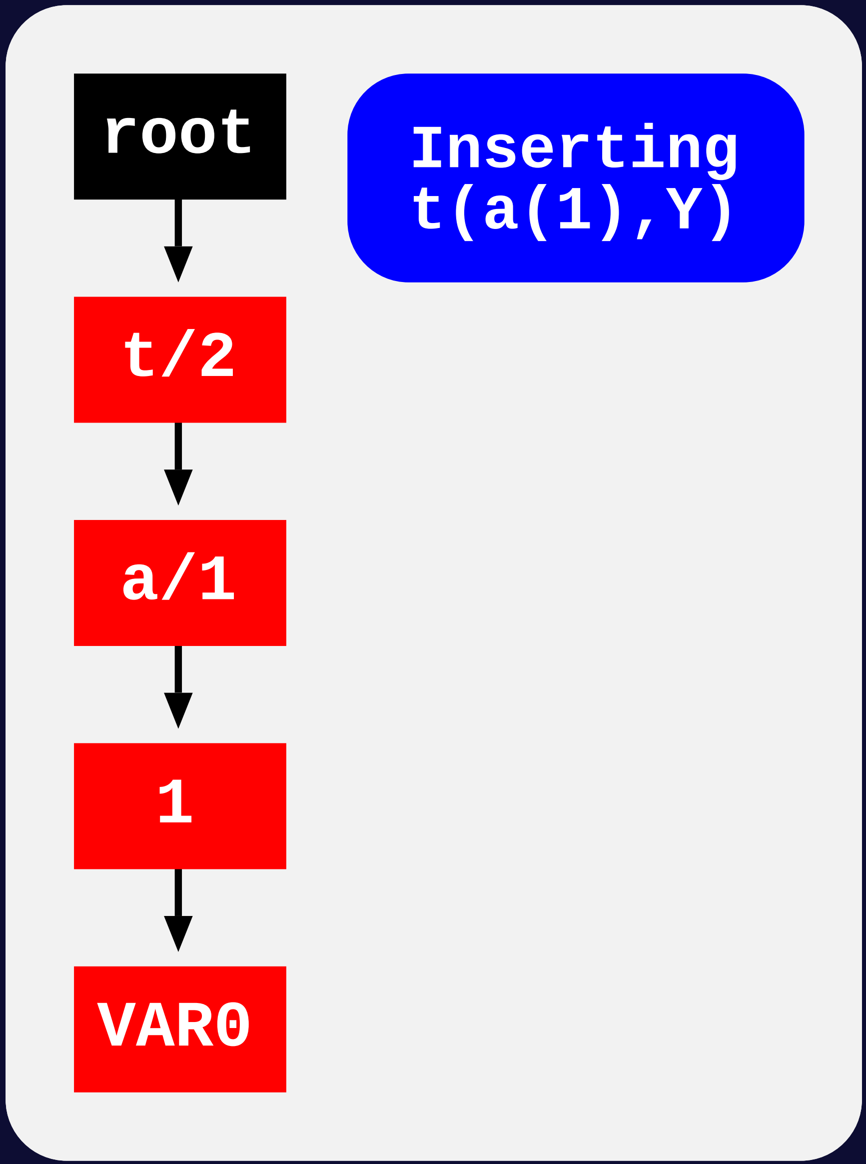

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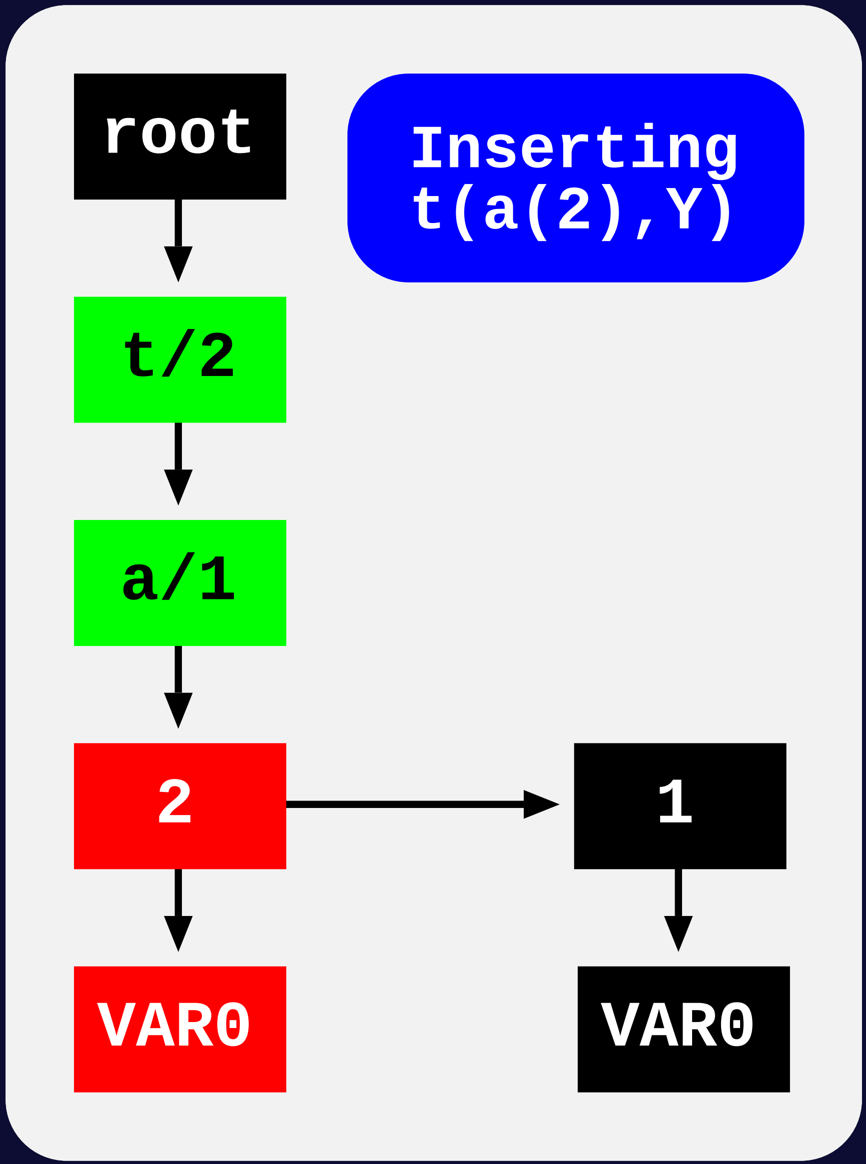


Using Tries to Represent the Table Space

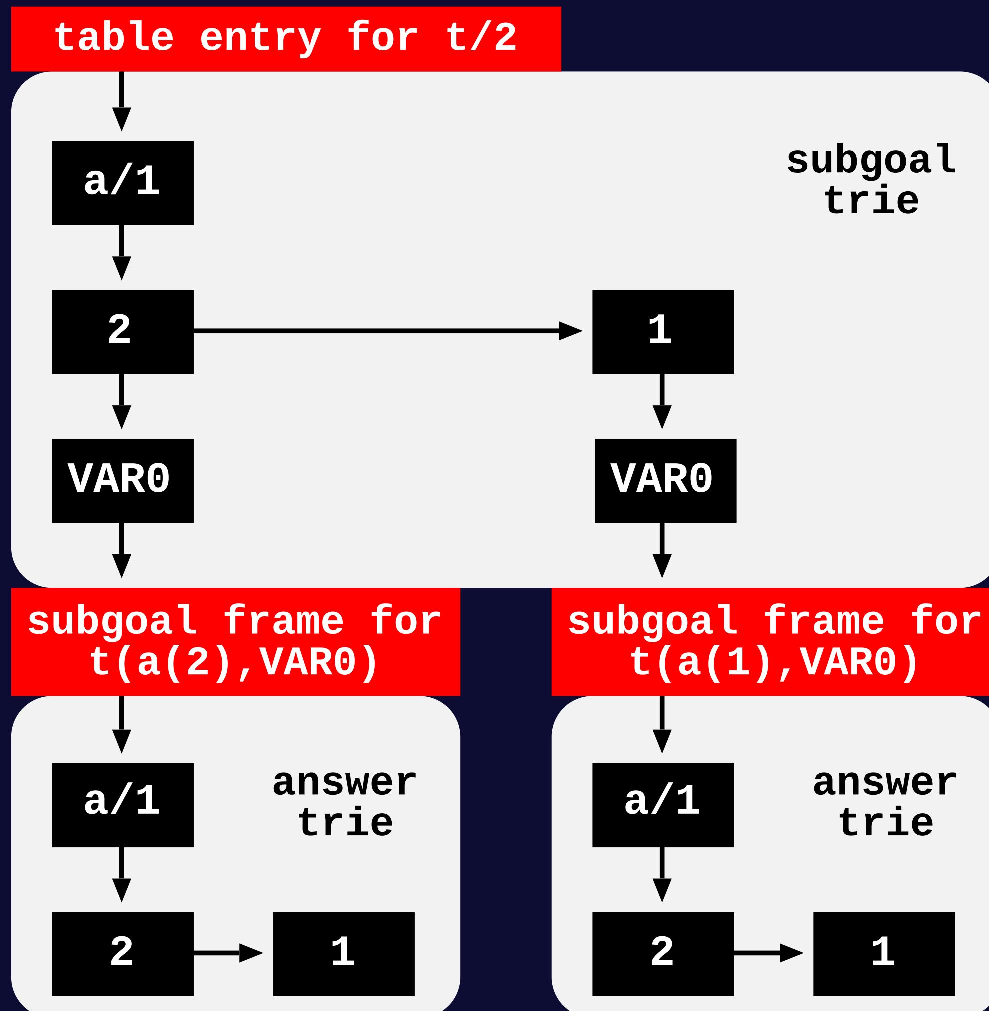
```
:- table t/2.
t(X,Y) :- term(X), term(Y).

term(a(1)).      term(a(2)).
```

➤ Subgoal Trie

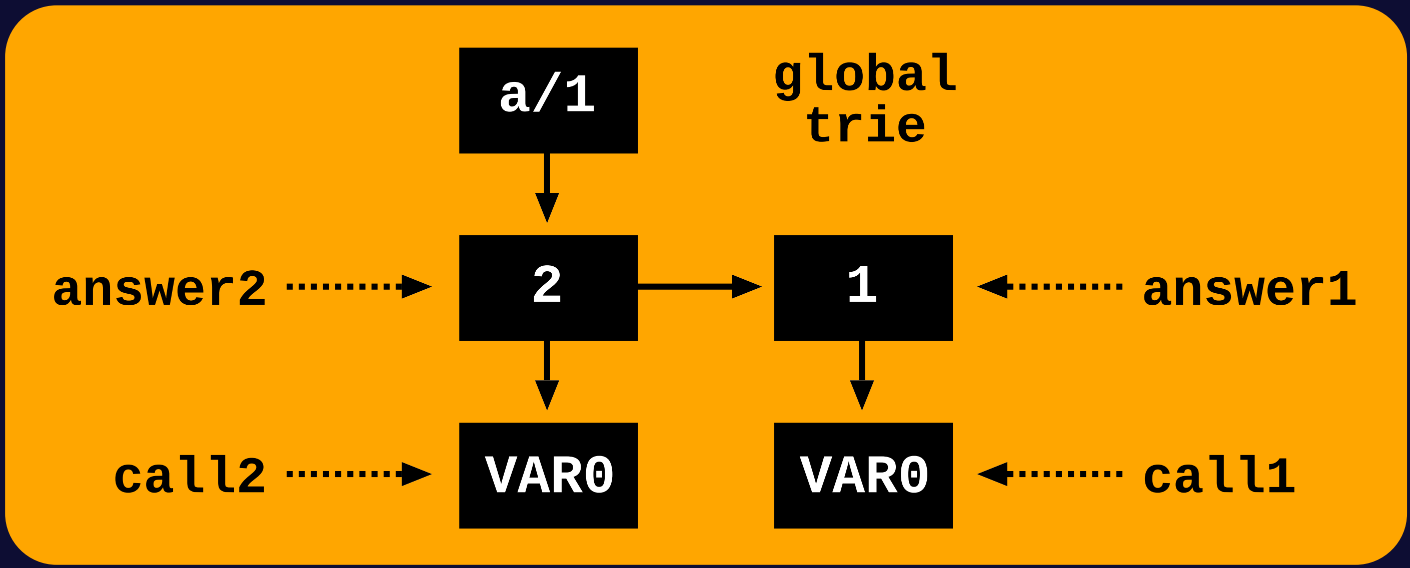
- Stores the tabled subgoal calls.
- Starts at a table entry and ends with subgoal frames.
- A subgoal frame is the entry point for the subgoal answers.

➤ Answer Trie

- Stores the subgoal answers.
- Answer tries hold just the substitution terms for the free variables which exist in the corresponding subgoal call.

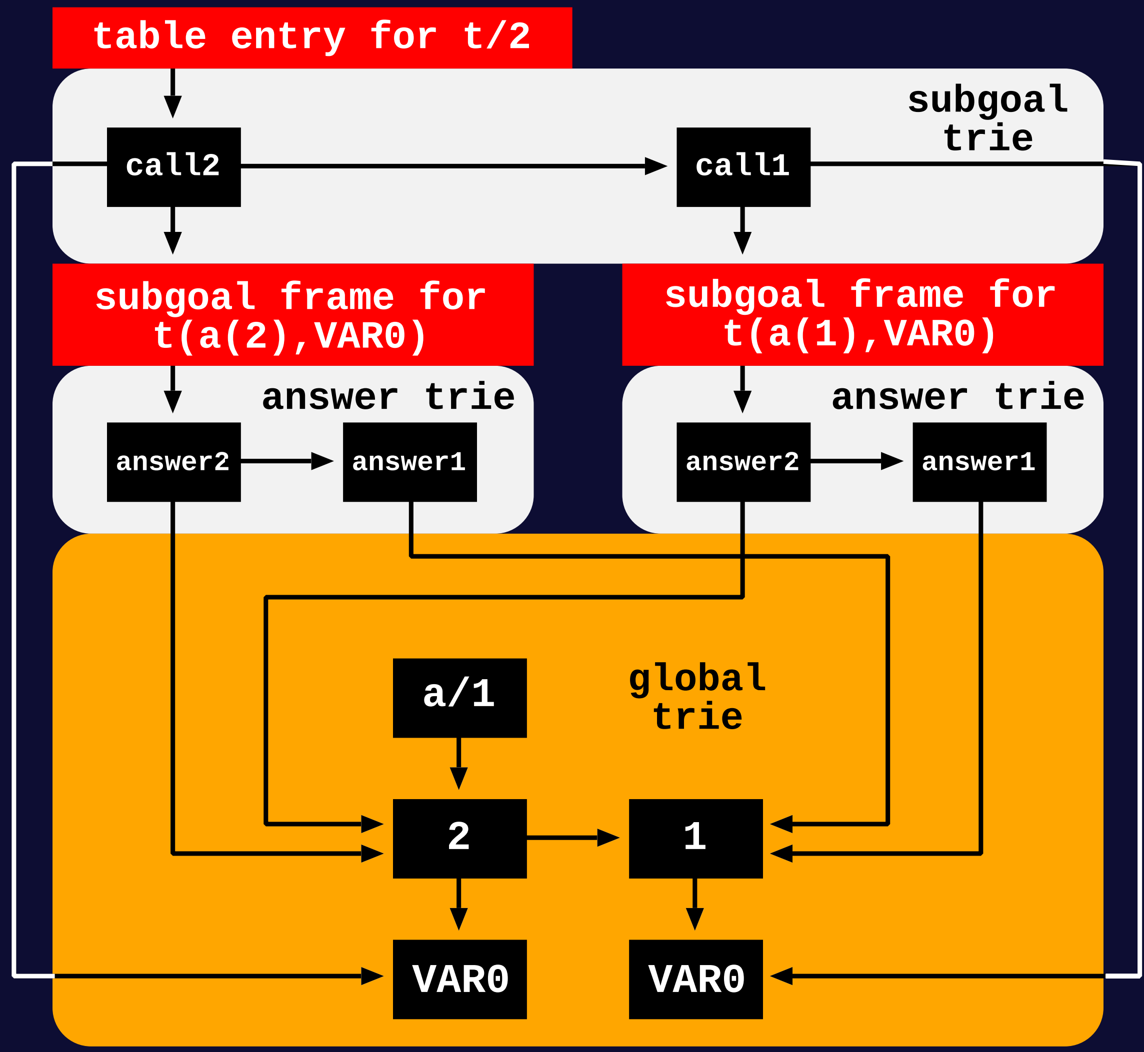


Commom Global Trie



- All tabled subgoal calls and tabled answers are stored in a **common global trie (GT)** instead of being spread over several different trie data structures.
- The GT data structure still is a tree structure where each different path through the trie nodes corresponds to a tabled subgoal call and/or answer.
- However, here a path can end at any internal trie node and not necessarily at a leaf trie node.

Commom Global Trie



- The original subgoal trie and answer trie data structures are now represented by a unique level of trie nodes that point to the corresponding paths in the GT.

Implementation Details: Tabling Operations

```
subgoal_check_insert(TABLE_ENTRY te, SUBGOAL_CALL call) {
  if (GT) {                                        // GT table design
    leaf_gt_node = trie_check_insert(GT, call)
    leaf_st_node = trie_check_insert(te, leaf_gt_node)
  } else                                     // original table design
    leaf_st_node = trie_check_insert(te, call)
  return leaf_st_node
}
```

Implementation Details: Tabling Operations

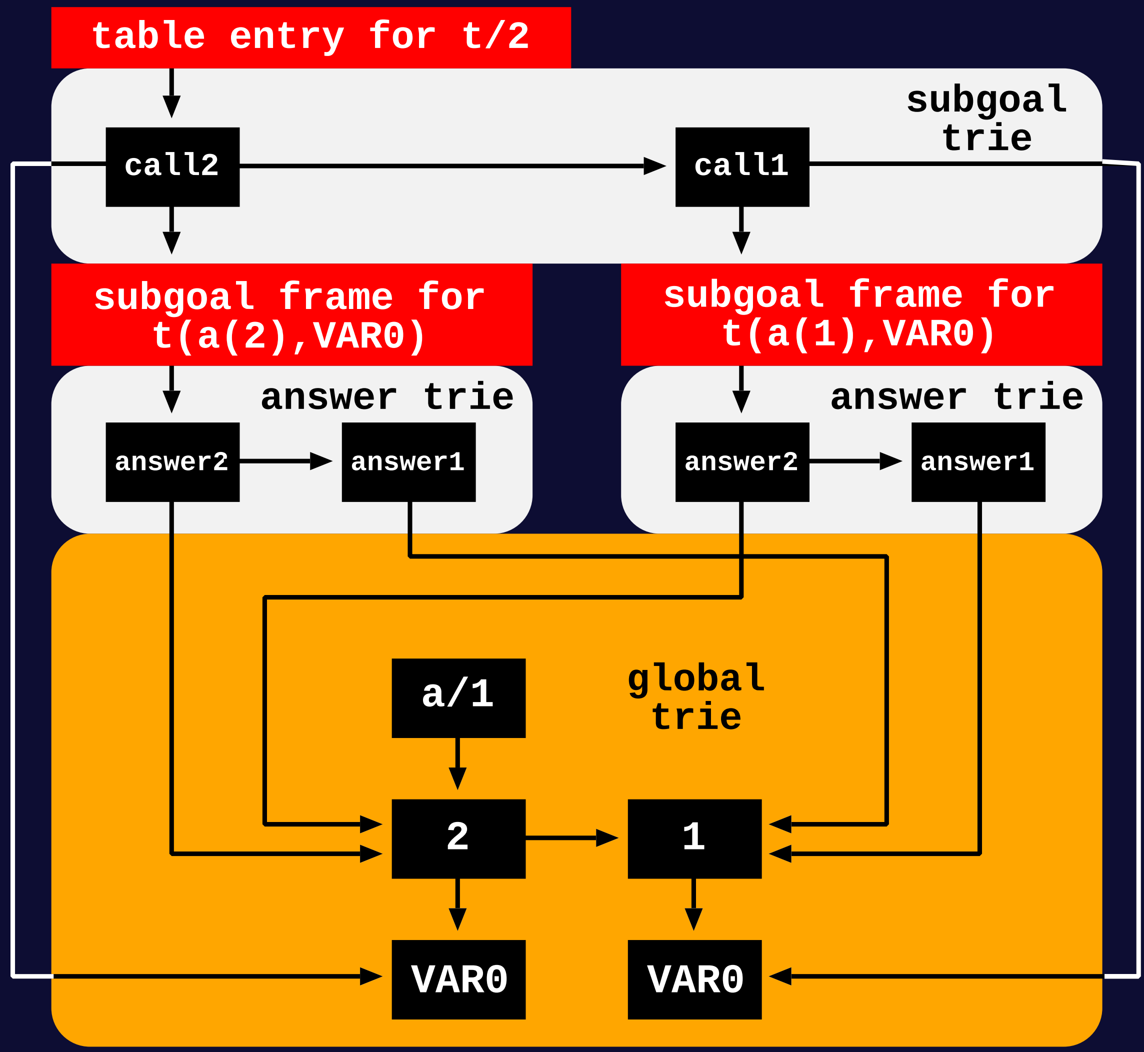
```
answer_check_insert(SUBGOAL_FRAME sf, ANSWER answer) {
  if (GT) {                                           // GT table design
    leaf_gt_node = trie_check_insert(GT, answer)
    leaf_at_node = trie_check_insert(sf, leaf_gt_node)
  } else                                        // original table design
    leaf_at_node = trie_check_insert(sf, answer)
  return leaf_at_node
}
```

Implementation Details: Tabling Operations

```
answer_load(ANSWER_TRIE_NODE leaf_at_node) {
  if (GT) {                                        // GT table design
    leaf_gt_node = leaf_at_node->symbol
    answer = trie_load(leaf_gt_node)
  } else                                     // original table design
    answer = trie_load(leaf_at_node)
  return answer
}
```

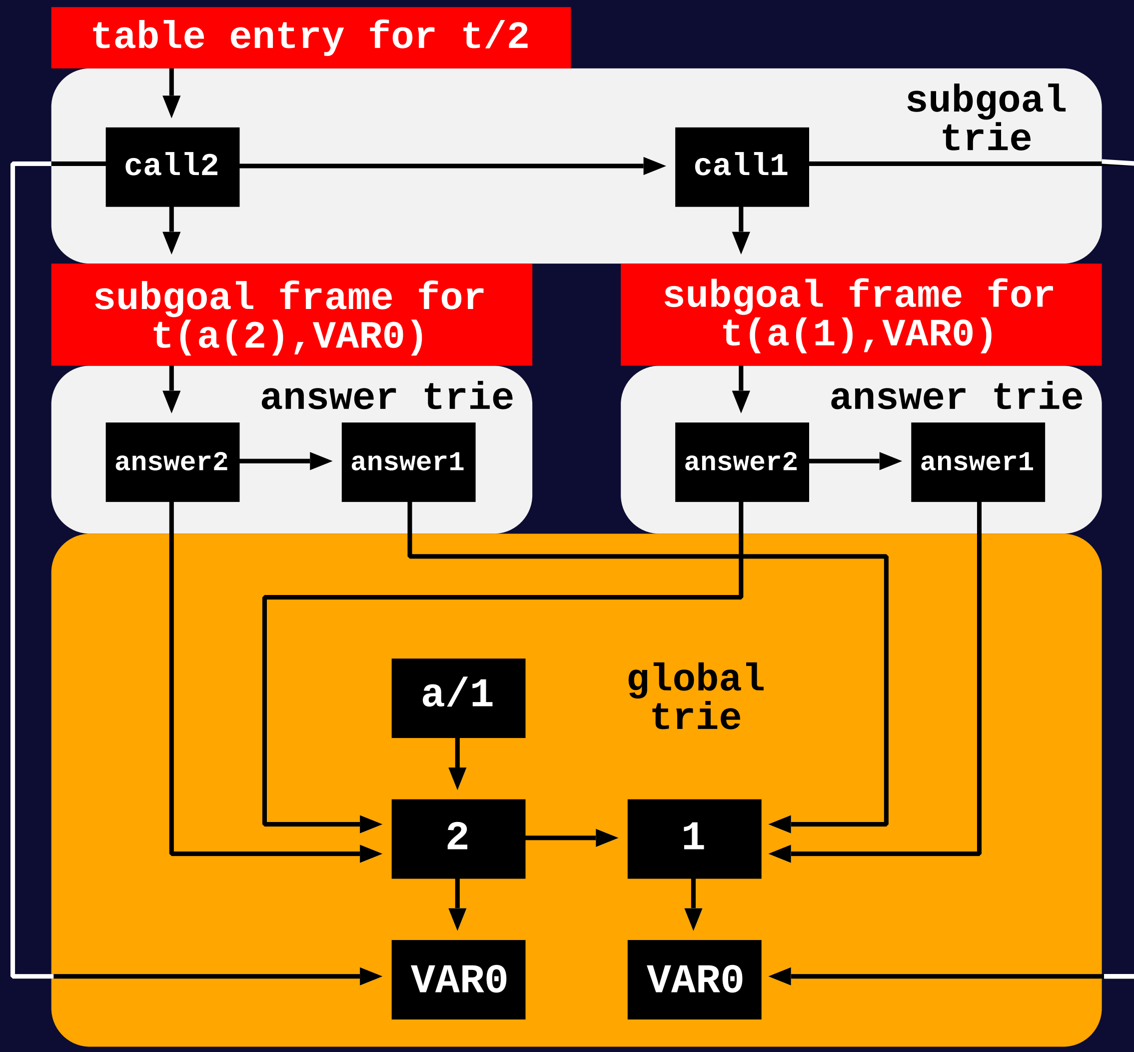
Implementation Details: Two Small Problems ;-)

- How to deal with **table abolish operations**.



Implementation Details: Two Small Problems ;-)

- How to deal with **table abolish operations**.
- How to support the **completed table optimization**, an optimization that loads answers by executing specific WAM-like code by top-down traversing the completed answer trie.



Experimental Results

Terms	YapTab			YapTab+GT / YapTab		
	Mem	Store	Load	Mem	Store	Load
500 ints	49074	238	88	1.08	1.29	1.05
500 atoms	49074	256	88	1.08	1.18	1.05
500 f/1	49172	336	176	1.07	1.33	**0.77**
500 f/2	98147	430	190	**0.58**	1.16	**0.82**
500 f/3	147122	554	220	**0.41**	1.04	**0.80**
500 f/4	196097	596	210	**0.33**	1.07	**0.94**
500 f/5	245072	676	258	**0.28**	1.00	**0.84**
500 f/6	294047	796	290	**0.25**	1.01	**0.83**
Average				**0.64**	**1.14**	**0.89**

Memory usage in KBytes and store/load times in milliseconds for a t/5 tabled predicate that simply stores in the table space terms defined by `term/1` facts, called with all combinations of one and two free variables in the arguments.

Experimental Results

Data Set	YapTab			YapTab+GT / YapTab		
	Mem	Store	Load	Mem	Store	Load
carcinogenesis	1020	42290	42211	**0.97**	1.02	1.02
mutagenesis	432	116139	7516	**0.73**	**0.97**	**0.97**

Memory usage in KBytes and store/load times in milliseconds for two well-known ILP benchmarks. These data sets are good real-world applications to test the two situations observed in the previous table: the *carcinogenesis* data set mainly stores atomic terms and the *mutagenesis* data set stores more diverse terms.

Conclusions and Further Work

- We have presented a new design for the table space organization that uses a common global trie to store terms in tabled subgoal calls and answers.
- Our goal is to reduce redundancy in term representation, thus saving memory by sharing data that is structurally equal.
- Our preliminary experiments showed that our approach has potential to achieve significant reductions on memory usage without compromising running time.
- As further work we intend to study how alternative designs for the table space organization can efficiently solve our two small problems and/or further reduce redundancy in term representation.

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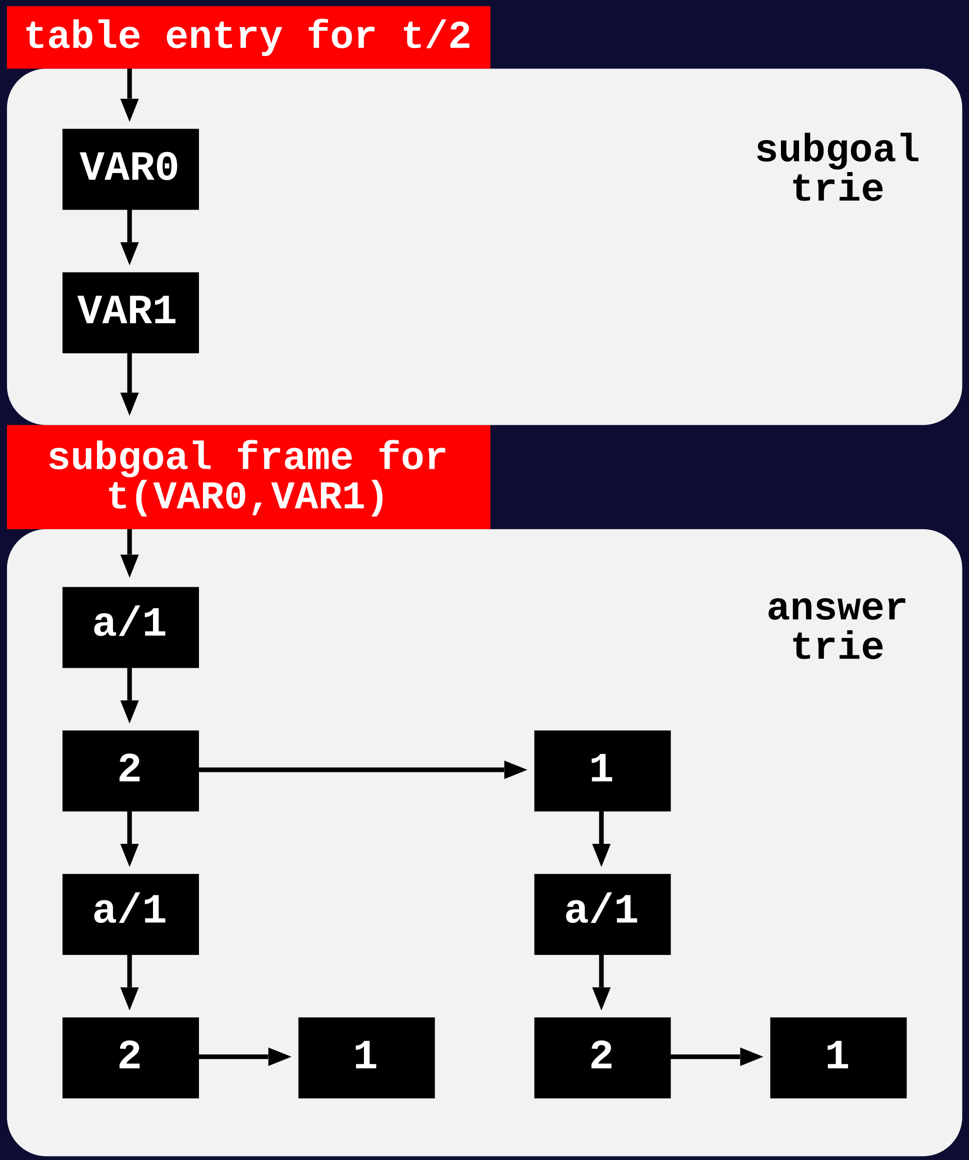

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