On Extending a Full-Sharing Multithreaded Tabling Design with Batched Scheduling

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Yap Prolog: $http://www.dcc.fc.up.pt/\sim vsc/Yap$ Project SIBILA: http://cracs.fc.up.pt/





Prolog and SLD Resolution

- Prolog systems are known to have good performances and flexibility, but they are based on SLD resolution, which limits the potential of the Logic Programing paradigm.
- > SLD resolution cannot deal properly with the following situations:
 - ♦ Positive Infinite Cycles (insufficient expressiveness)
 - **♦ Negative Infinite Cycles** (inconsistence)
 - **♦ Redundant Computations** (inefficiency)



```
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c2) a(2).
```

c3)
$$b(X) := a(X).$$

c4) b(1).

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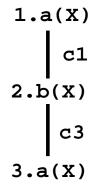
c3)
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c4) $b(1).$

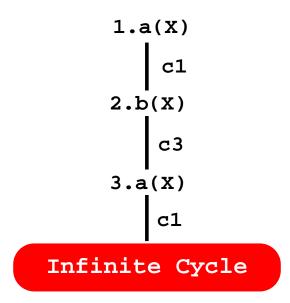
2.b(X)

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```
c1) a(X):-b(X).
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c3) b(X):-a(X).
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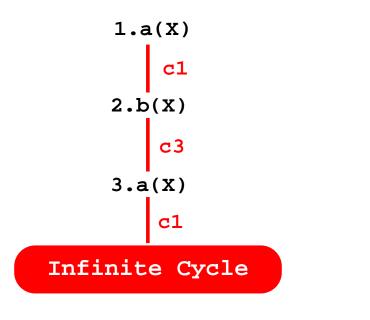


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Tabling in Prolog Systems

- ➤ Tabling is an implementation technique that overcomes some of the limitations of Prolog systems:
 - ♦ Tabled subgoals are evaluated by storing their answers in an appropriate data space, called the **table space**.
 - Repeated calls to tabled subgoals are resolved by consuming the answers already stored in the table instead of being re-evaluated against the program clauses.

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- Implementations of Tabling are currently available in systems like:
 - XSB Prolog, Yap Prolog, B-Prolog, ALS-Prolog, Mercury, Ciao Prolog and more recently Picat.
- ➤ Multithreading combined with Tabling:
 - ♦ XSB Prolog
 - ♦ YapTab-Mt [ICLP 2012].



Table Space - Example

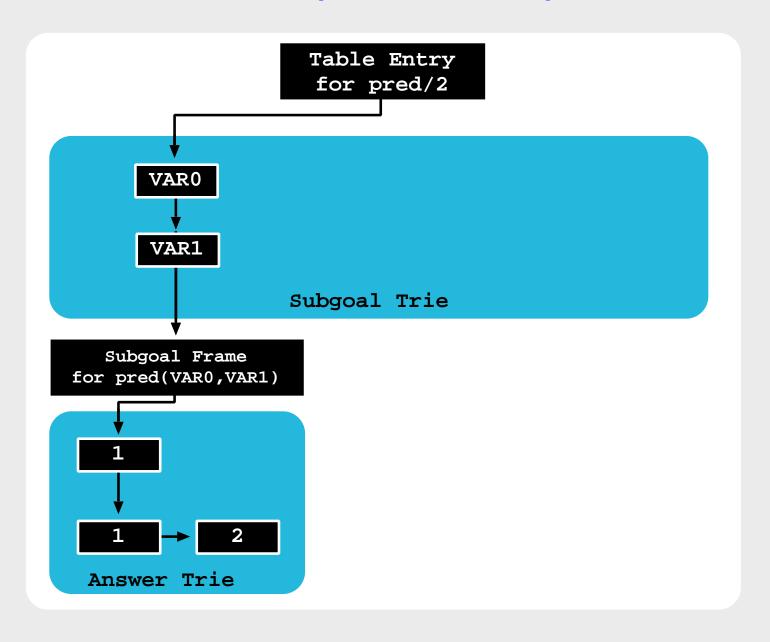
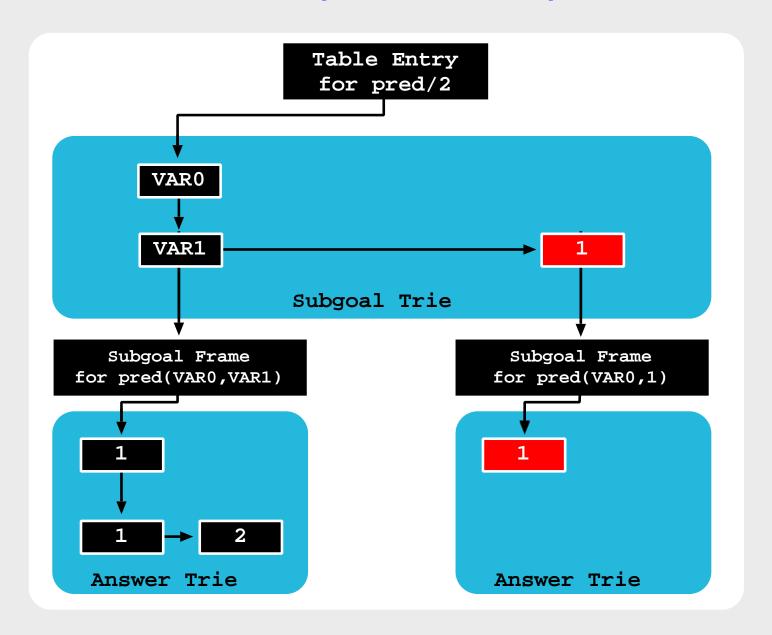


Table Space - Example





YapTab-Mt - Advantages

- ➤ An Abstraction layer with high-level constructors that provide access to the dynamic programming (tabling) support:
 - ♦ Instruction: :- table predicate/arity.
 - Scheduling: :- tabling_mode(predicate, batched).

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- ➤ Thread API is POSIX Threads compliant:
 - ♦ Management creating, joining , yielding, etc.
 - ♦ Monitoring statistics, properties, etc.
 - Synchronization mutex creation, statistics, etc.

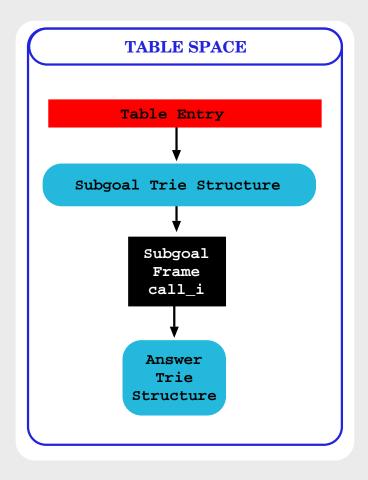
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- Write complex dynamic programming applications using the Prolog programming language.
 - ♦ Procedures in Prolog can be written as logical specifications, which are closer to mathematical notation.



Internal Table Space Architecture

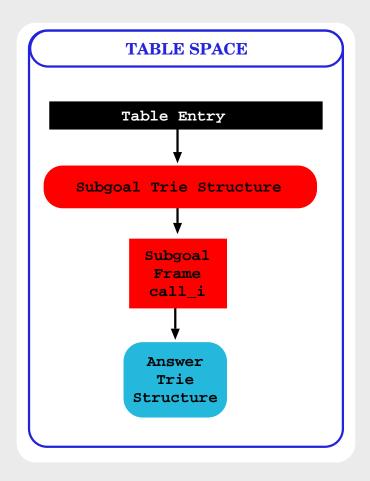
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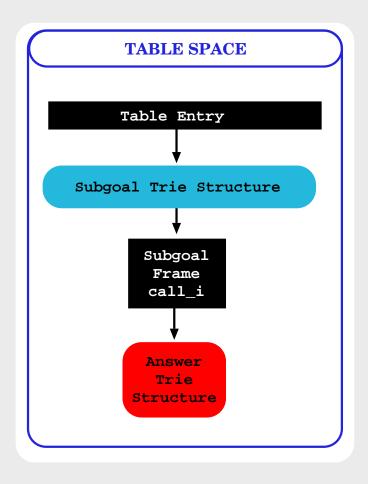
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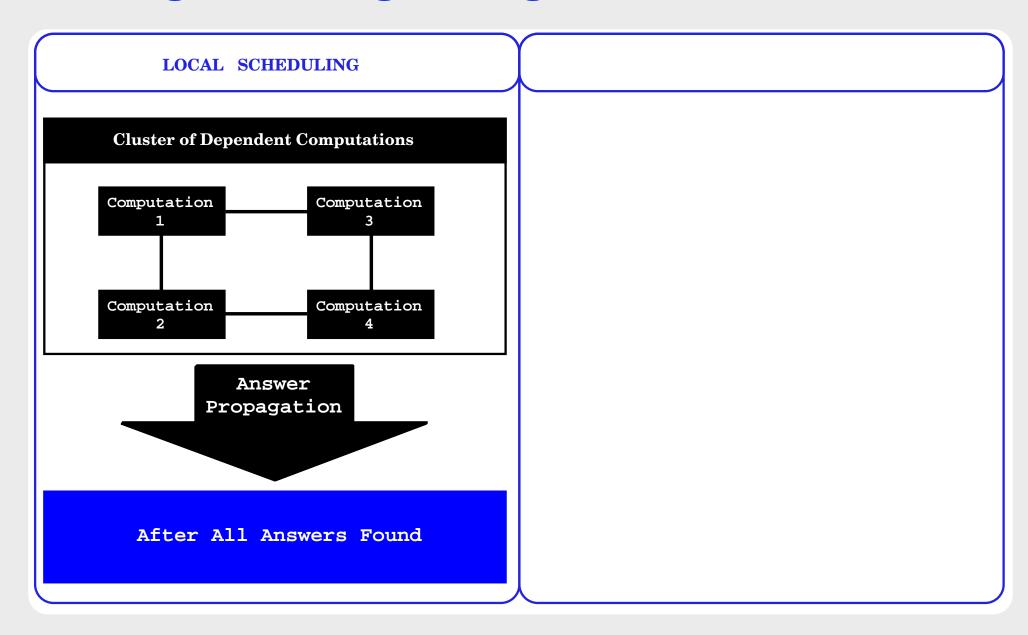
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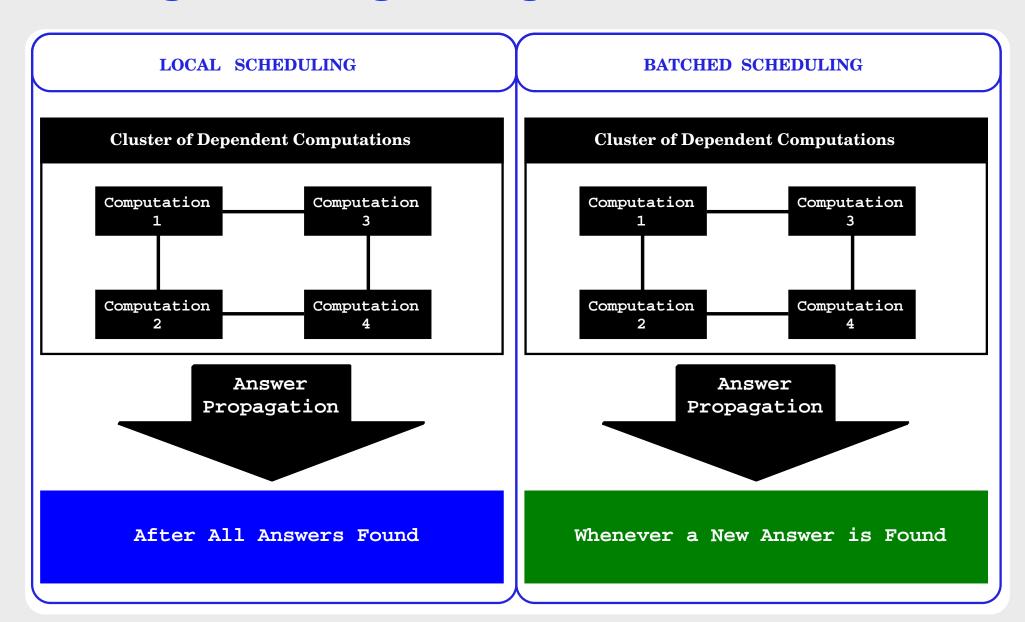




Tabling Scheduling Strategies - Local vs Batched

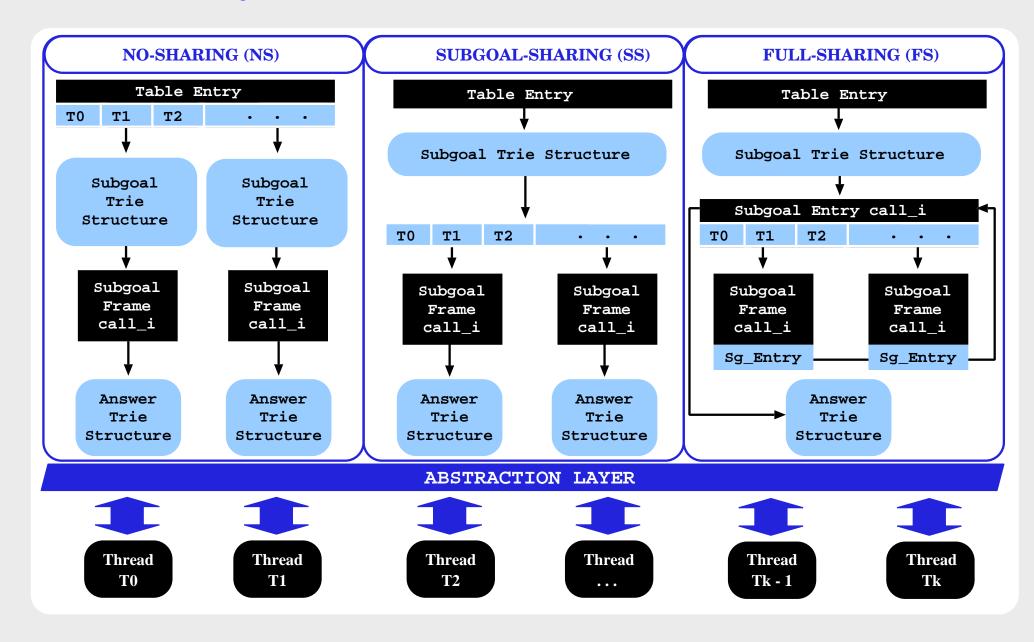


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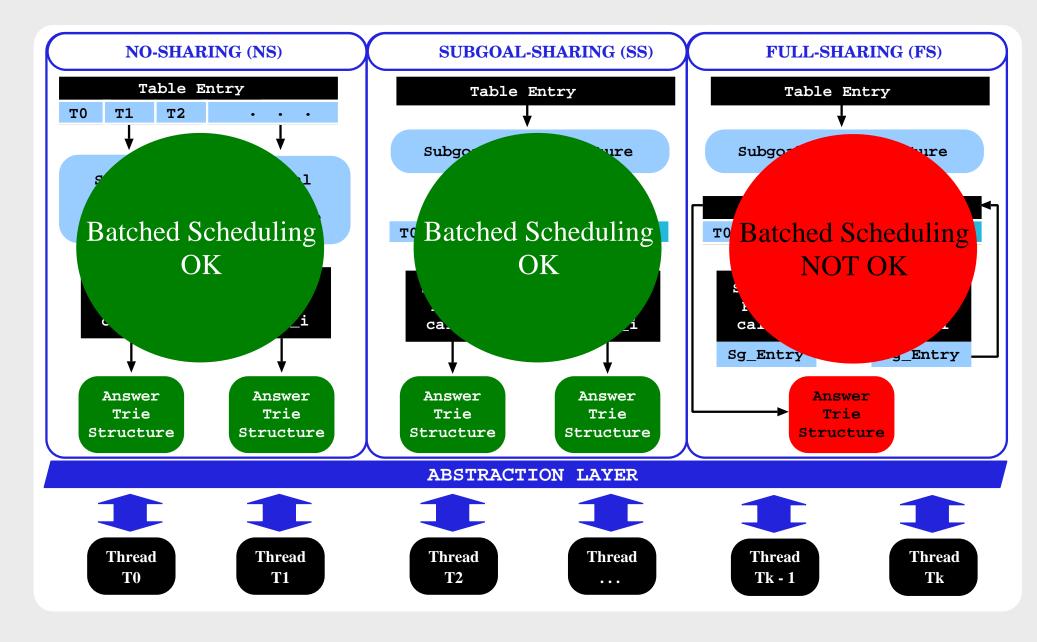




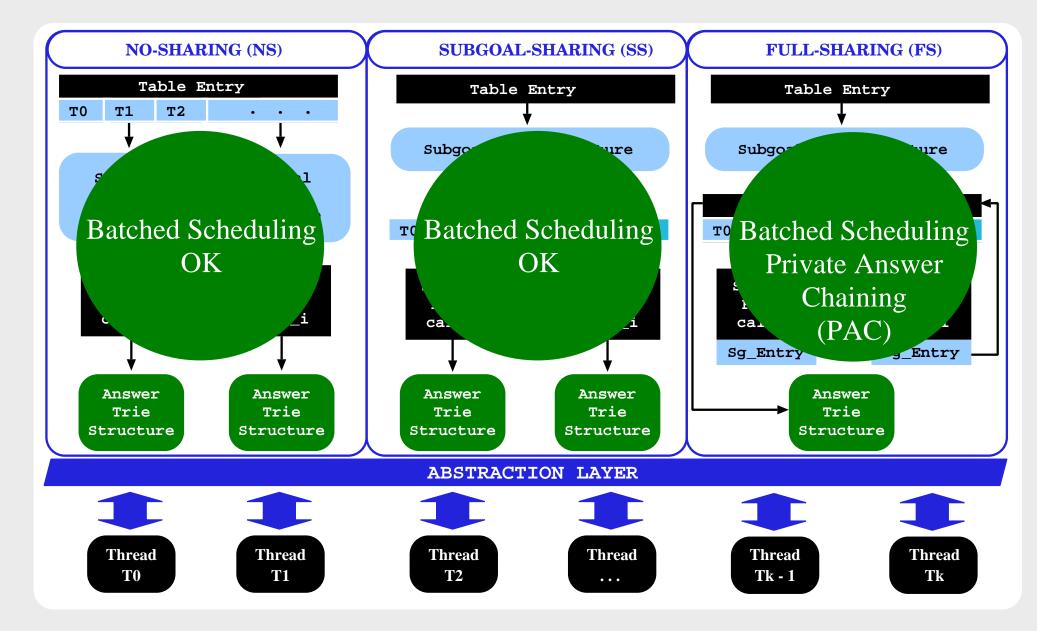
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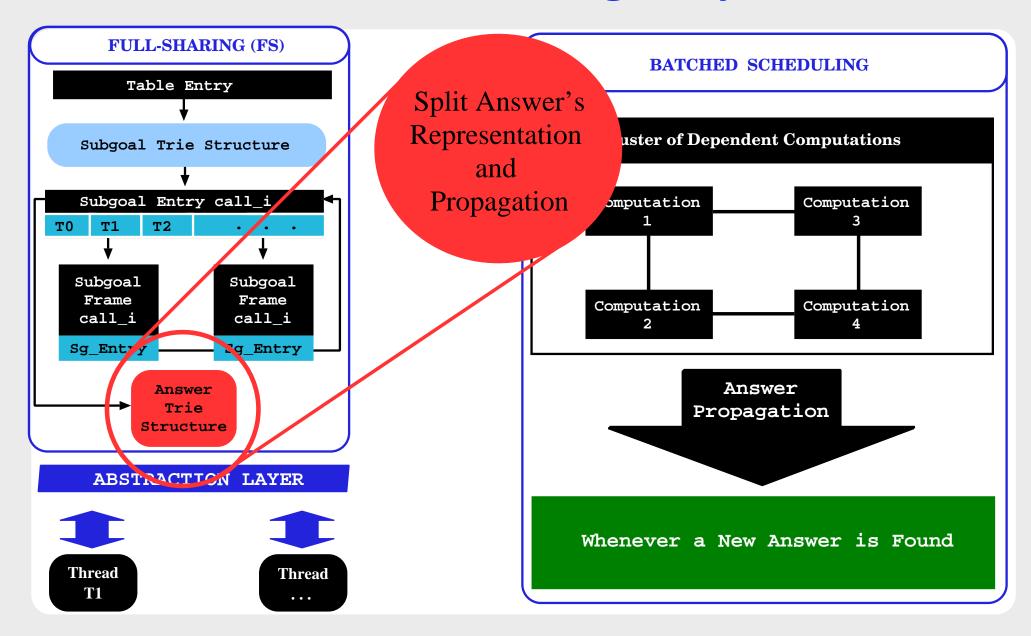


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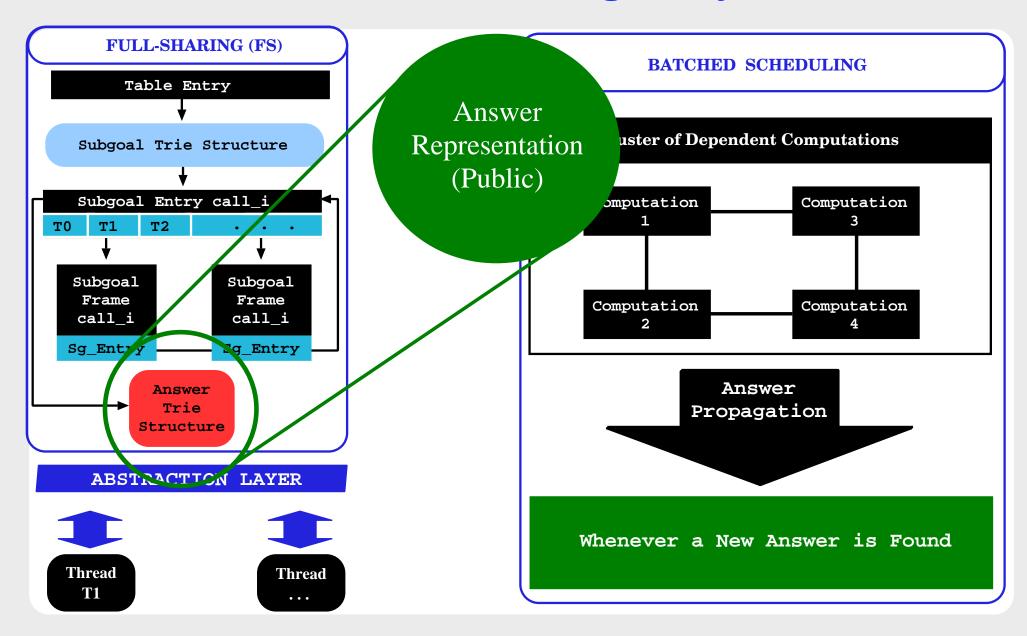




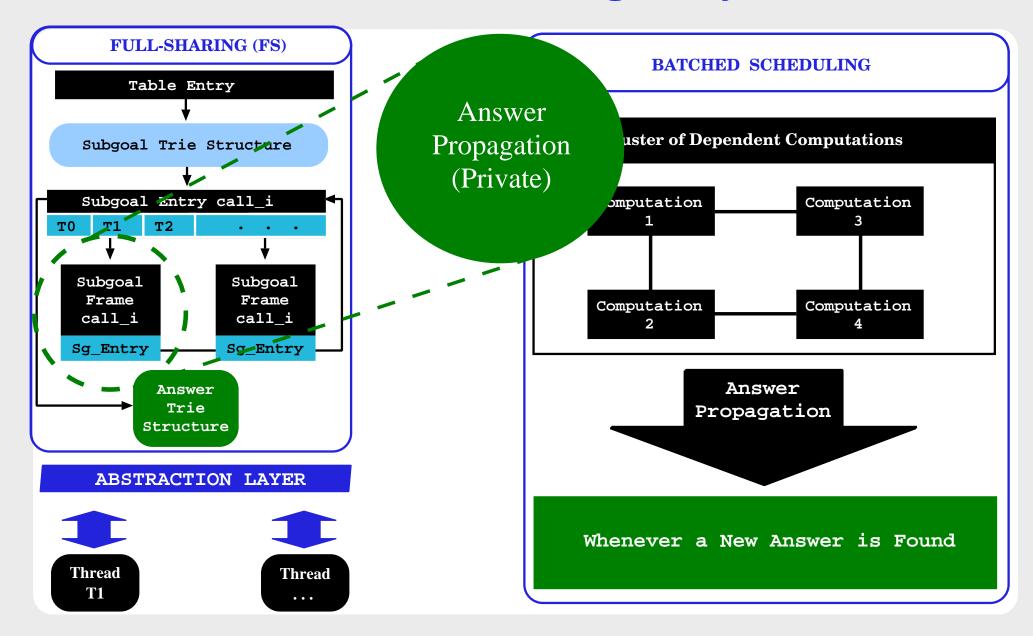
Private Answer Chaining - Key Idea



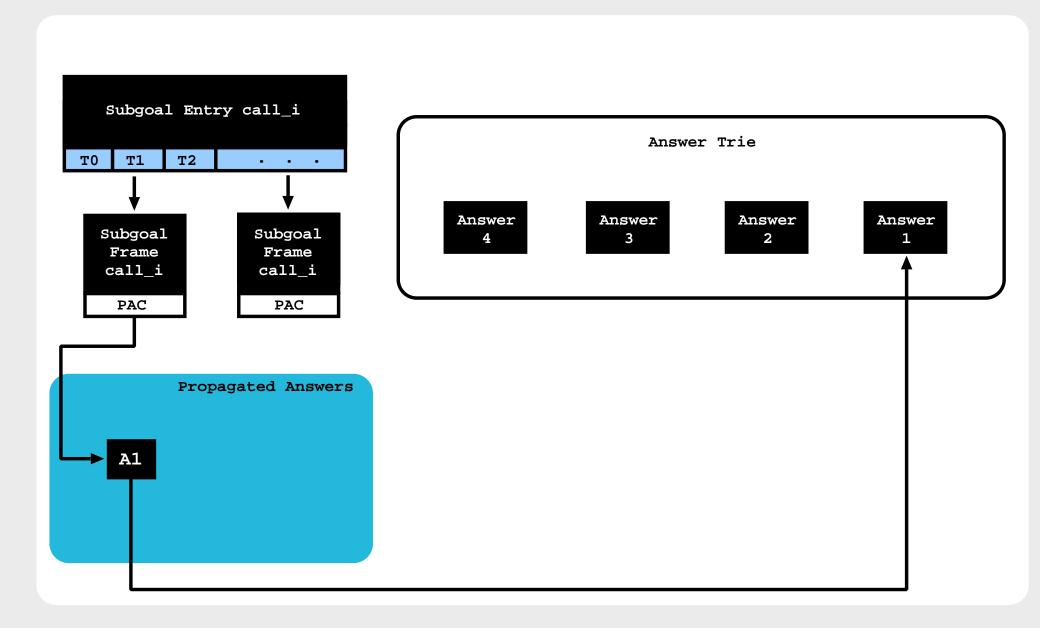
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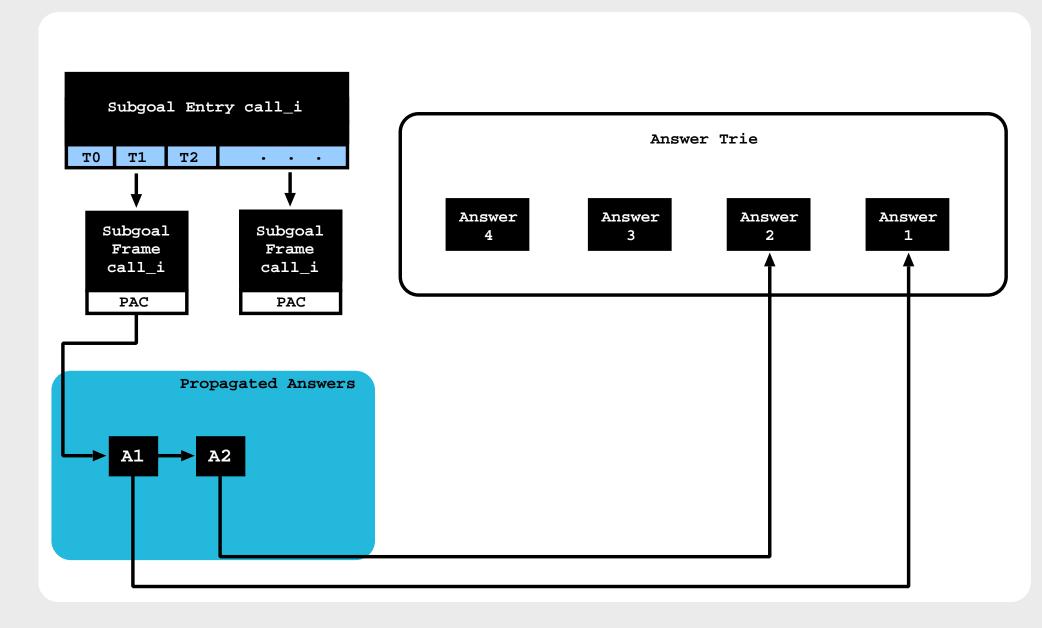


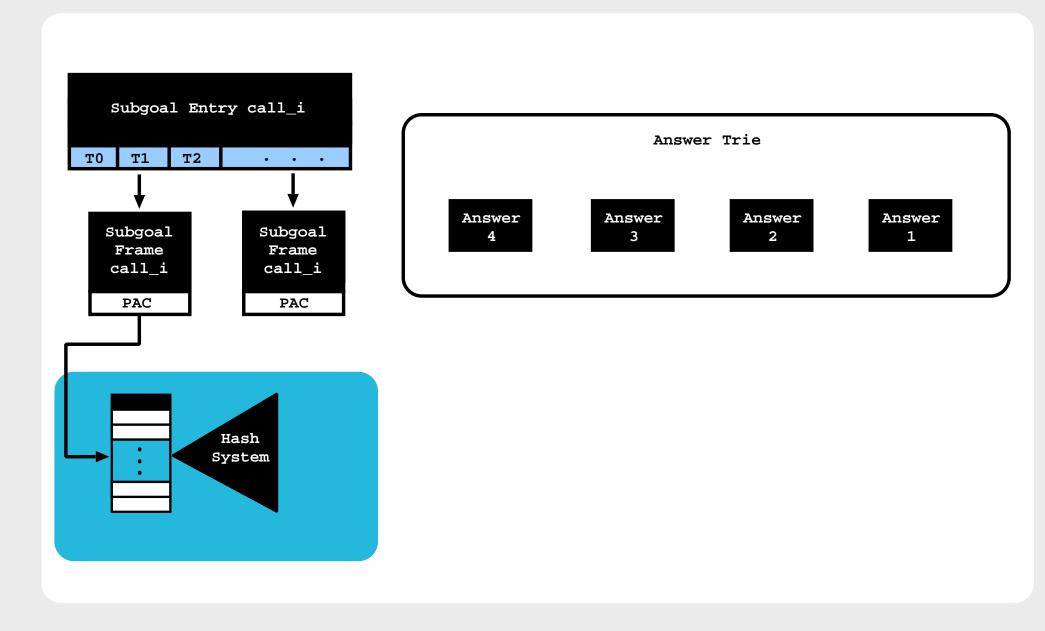
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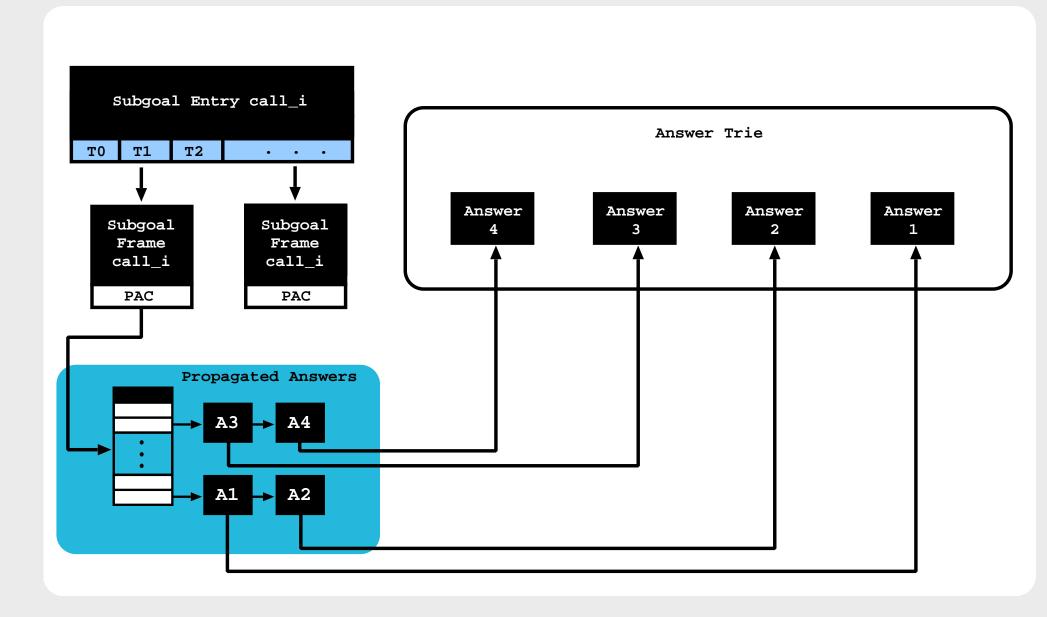


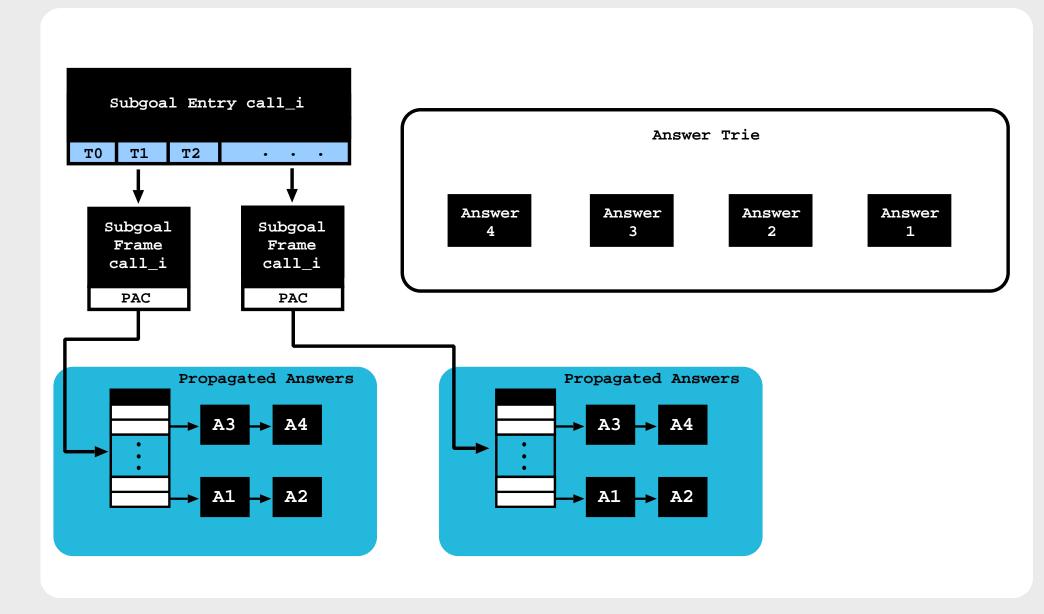














Experimental Results - Worst Case Scenarios

Threads		NS		FS	
		Local	Batched	Local	Batched
	Min	0.53	0.55	1.01	0.95
1	Avg	0.78	0.82	1.30	1.46
1	Max	1.06	1.05	1.76	2.33
	Min	0.66	0.63	1.16	0.99
8	Avg	0.85	0.88	1.88	1.95
O	Max	1.12	1.14	2.82	3.49
	Min	0.85	0.75	1.17	1.06
16	Avg	0.98	1.00	1.97	2.08
	Max	1.16	1.31	3.14	3.69
	Min	0.91	0.93	1.16	1.09
24	Avg	1.15	1.16	2.06	2.19
	Max	1.72	1.60	3.49	4.08
	Min	1.05	1.04	1.33	1.26
32	Avg	1.51	1.49	2.24	2.41
	Max	2.52	2.63	3.71	4.51



Conclusions and Further Work

- Batched scheduling is a useful strategy in tabled logic programs that:
 - require an eager propagation of answers.
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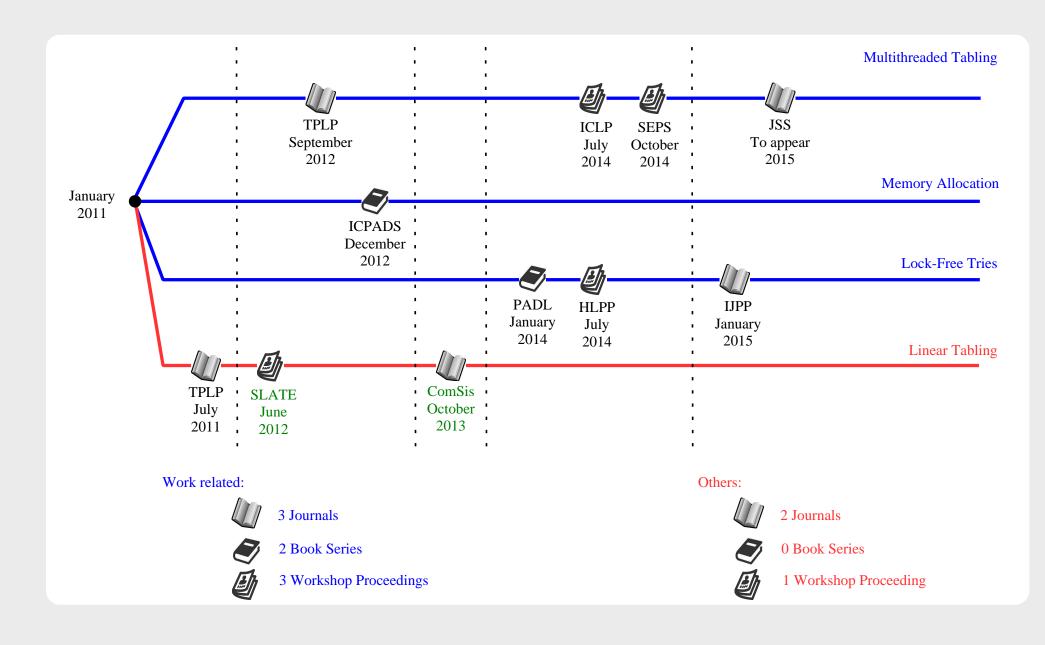
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- ➤ We have presented the PAC (Private Answer Chaining) strategy that enables the combination of Batched scheduling with Full-Sharing.
 - ♦ Split's answers representation (public) and answer propagation (private).
- Experimental results showed that the PAC strategy is a **good first approach**, however there is still **room for improvement**.

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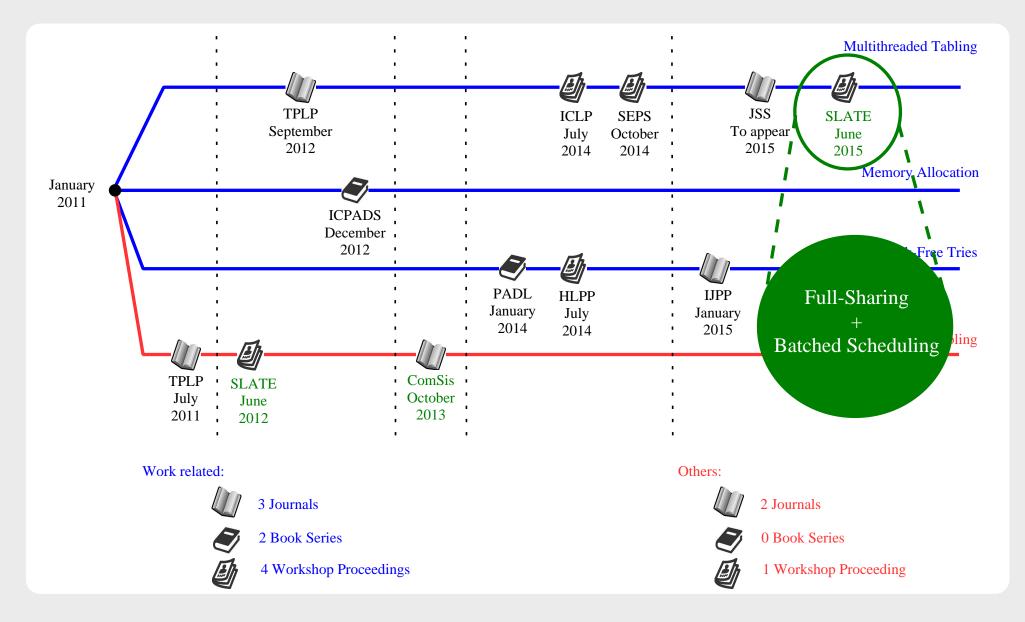
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 - Split's answers representation (public) and answer propagation (private).
- Experimental results showed that the PAC strategy is a **good first approach**, however there is still **room for improvement**.
- > Further work will include:
 - Use timestamped tries to avoid the search for the already propagated answers.
 - Seek for new real-world problems that allow us to improve and consolidate our framework.



Research Outline



Research Outline





Thank You !!!

