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: $http://cracs.fc.up.pt/$

SLATE '15
SYMPOSIUM ON LANGUAGES,
APPLICATIONS AND TECHNOLOGIES

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)

SLD Resolution: Infinite Cycles

```
c1)    a(X) :- b(X).
c2)    a(2).

c3)    b(X) :- a(X).
c4)    b(1).
```

1.a(X)

SLD Resolution: Infinite Cycles

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1.a(X)
   |
   | c1
2.b(X)
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   | c3
3.a(X)
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                 | c1
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Infinite Cycle

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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
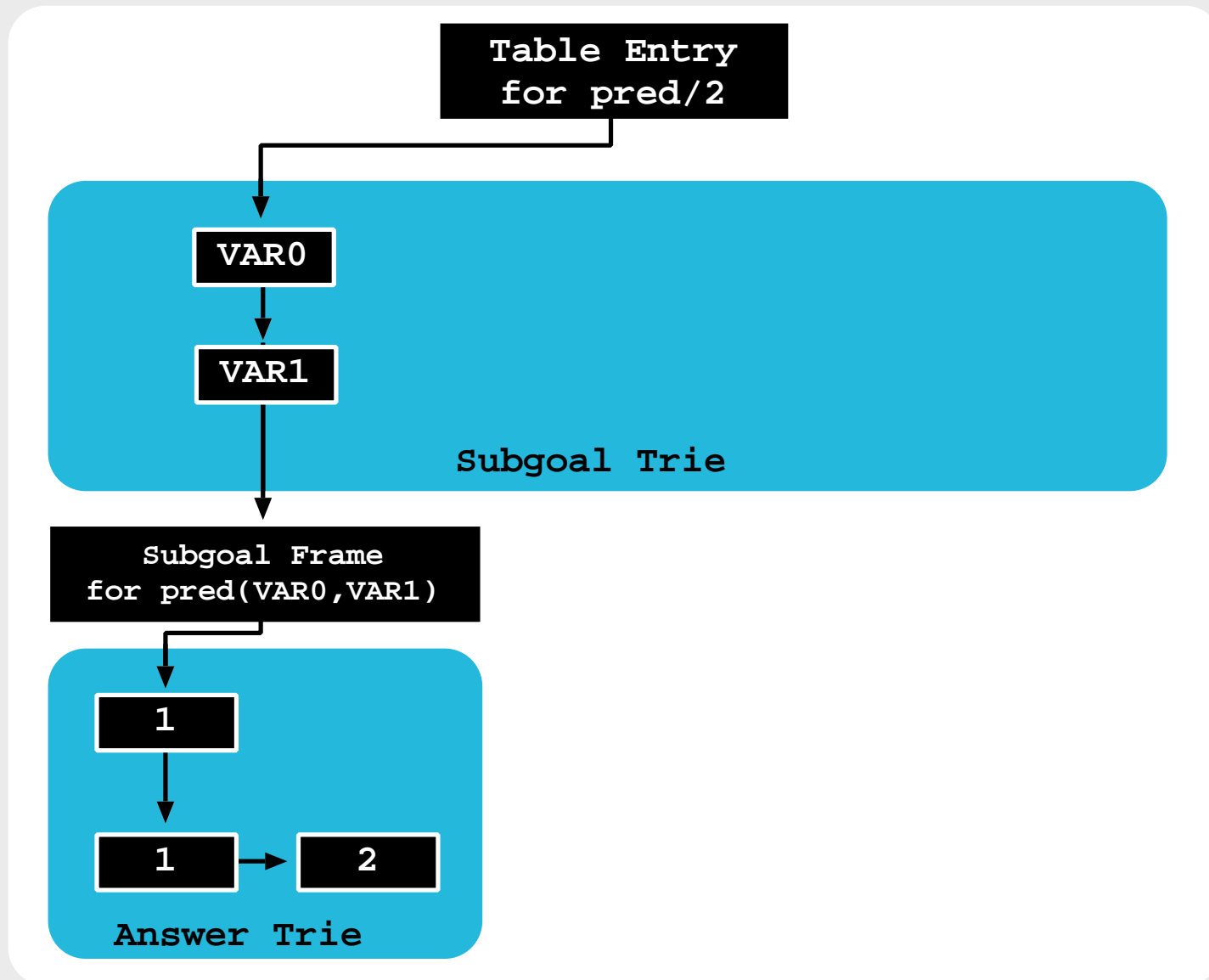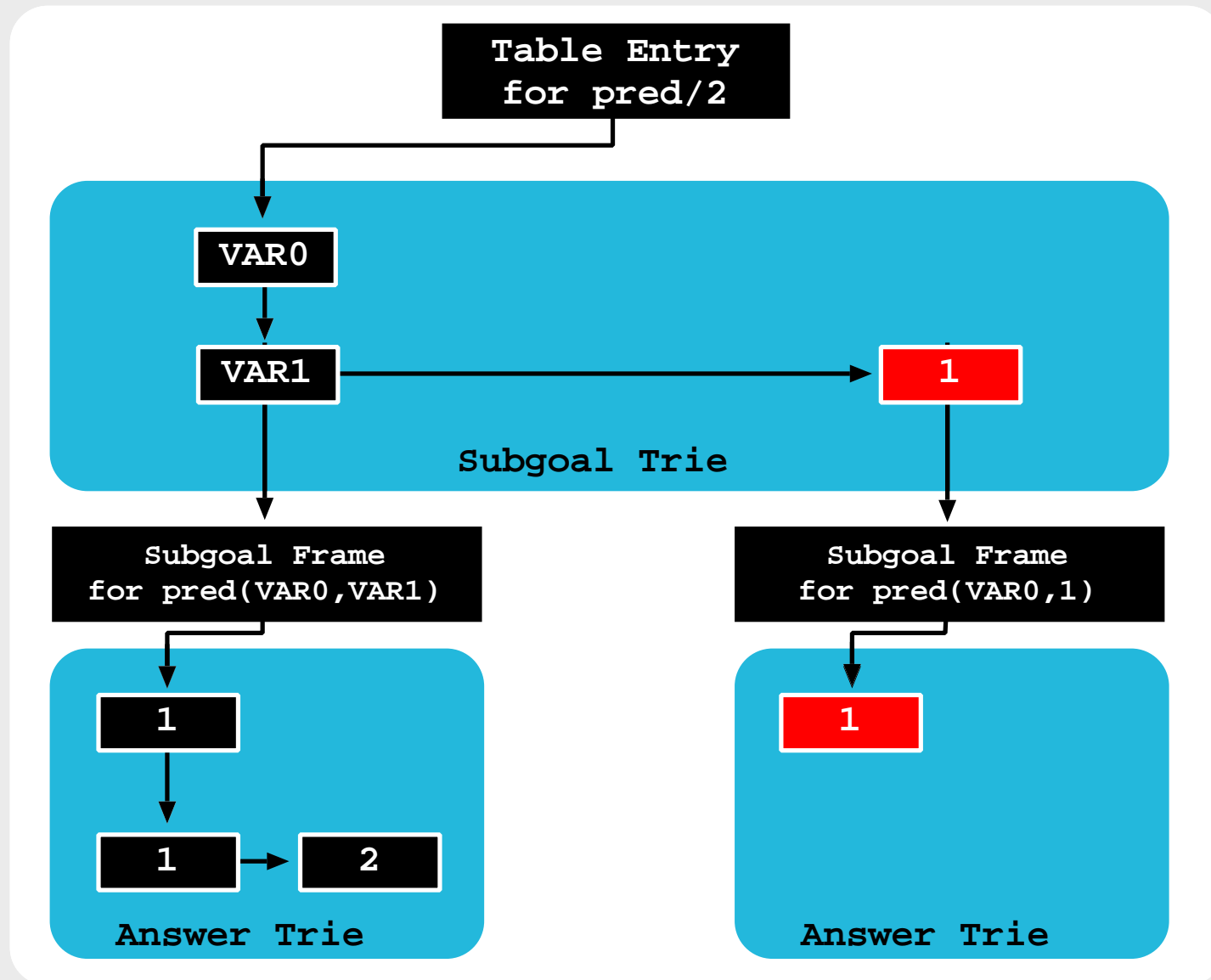♦ **YapTab-Mt [ICLP 2012]**.

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).**
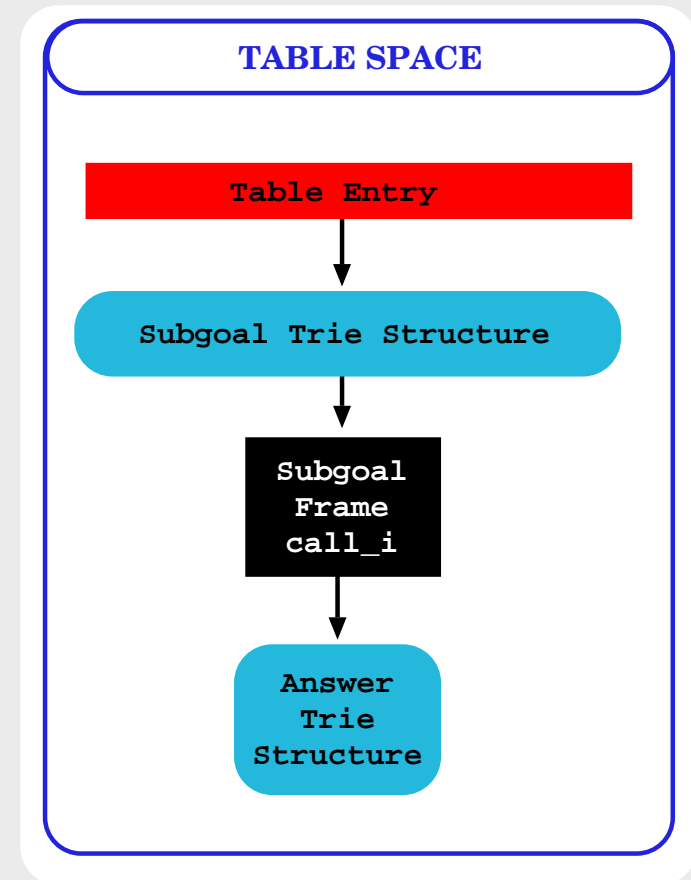
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➤ **Thread API** is **POSIX Threads compliant**:

♦ **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**.
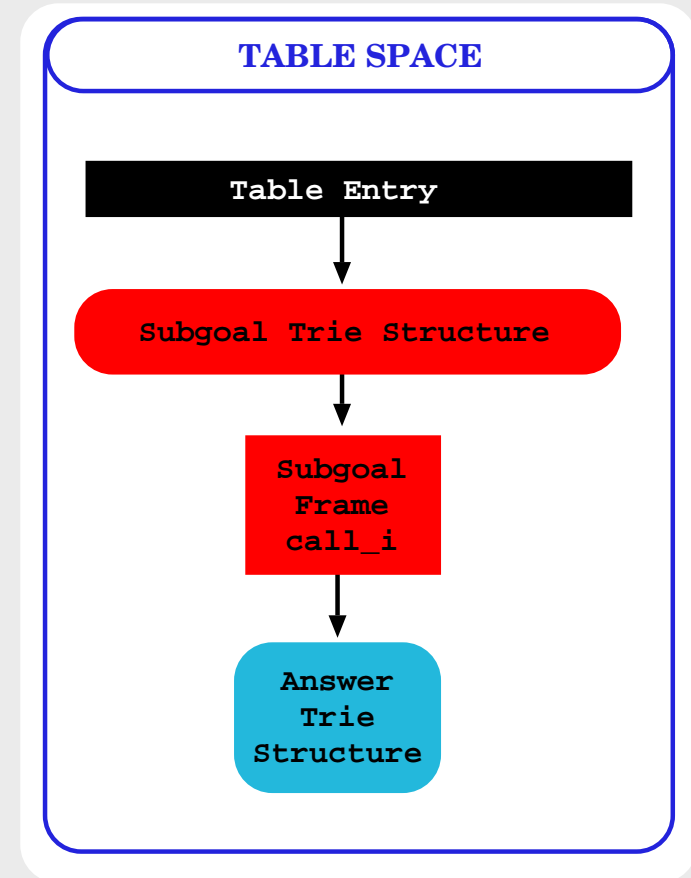
Internal Table Space Architecture

➤ **Table Entry**: stores generic about the predicates.

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◆ **predicate**(**computation_id**, Answer).

TABLE SPACE

Table Entry

Subgoal Trie Structure

Subgoal
Frame
call_i

Answer
Trie
Structure

Internal Table Space Architecture

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♦ **table predicate/2**.

➤ **Subgoal Trie Structure**: stores the **identifier** of the computations.

♦ **predicate**(**computation_id**, Answer).

➤ **Answer Trie Structure**: stores the **answers** of the computations.

♦ **predicate**(computation_id, **Answer**).
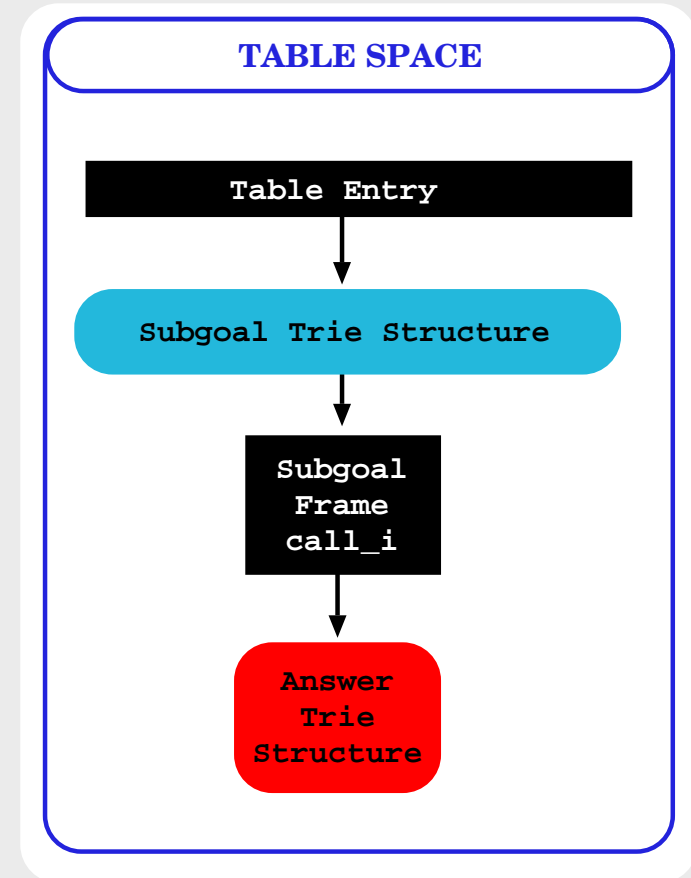
Tabling Scheduling Strategies - Local vs Batched

LOCAL   SCHEDULING

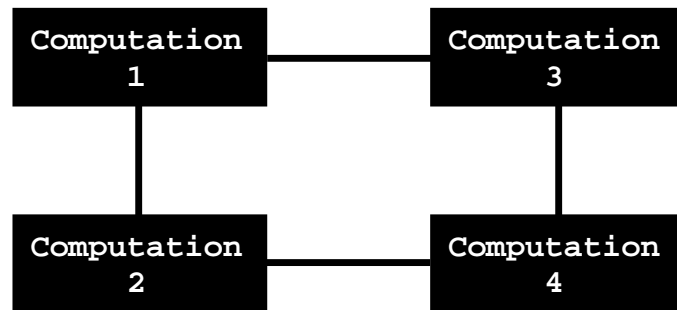**Cluster of Dependent Computations**

Computation 1	Computation 3
Computation 2	Computation 4
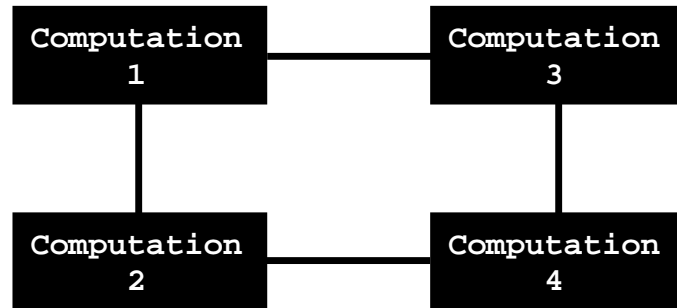
Answer Propagation

After All Answers Found
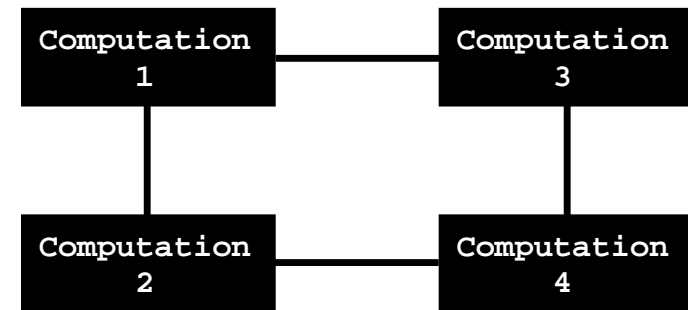
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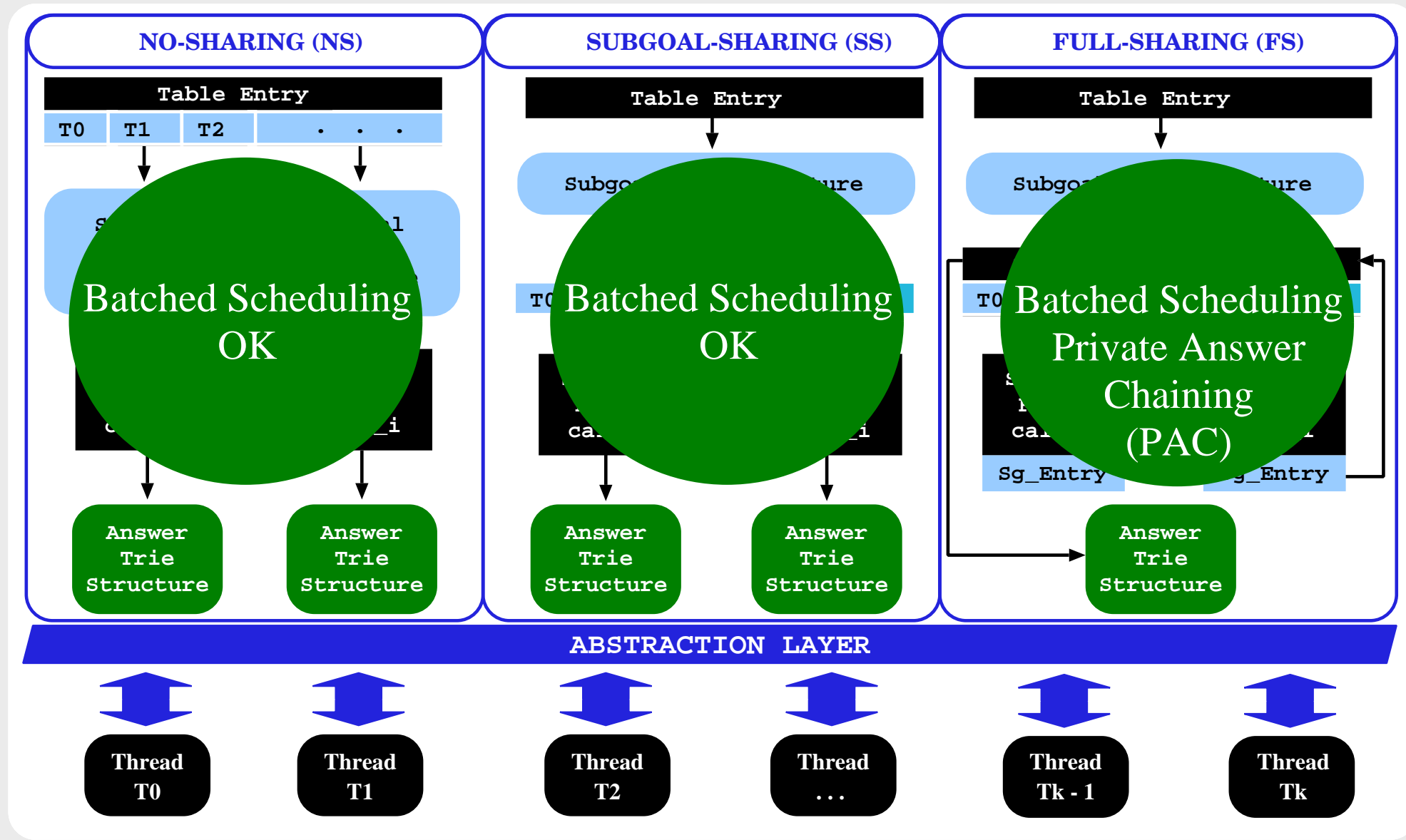
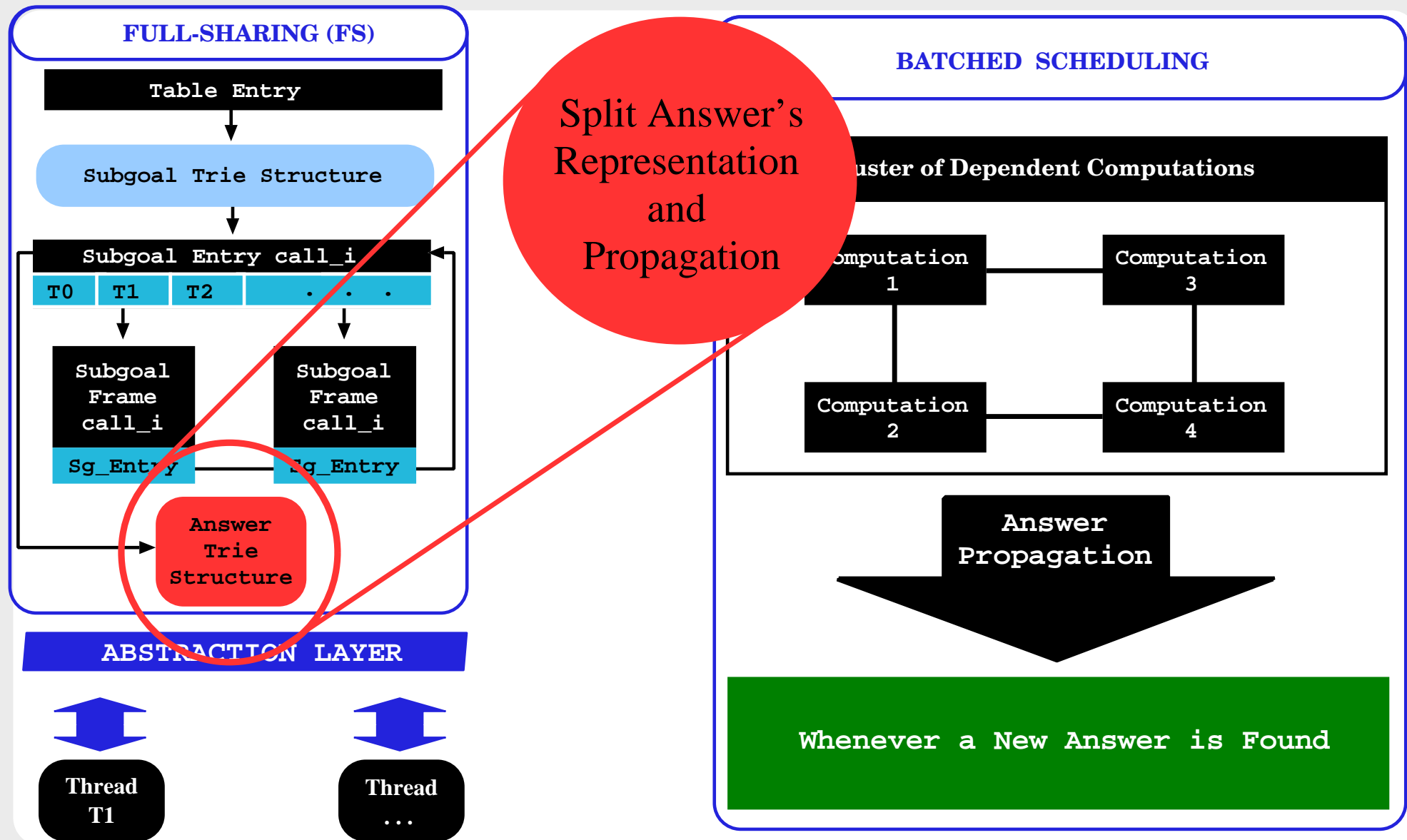# YapTab-Mt - Internal Architecture
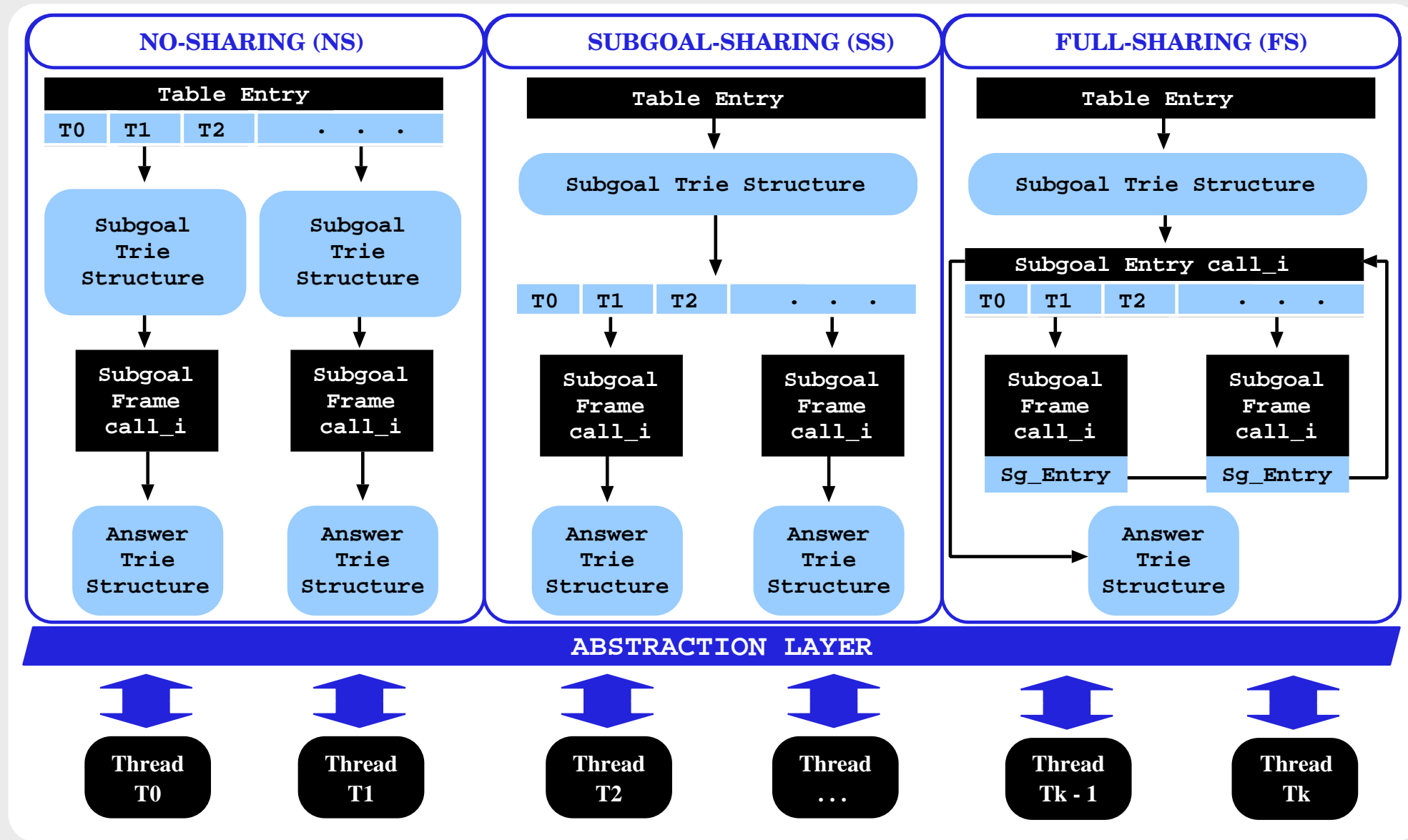
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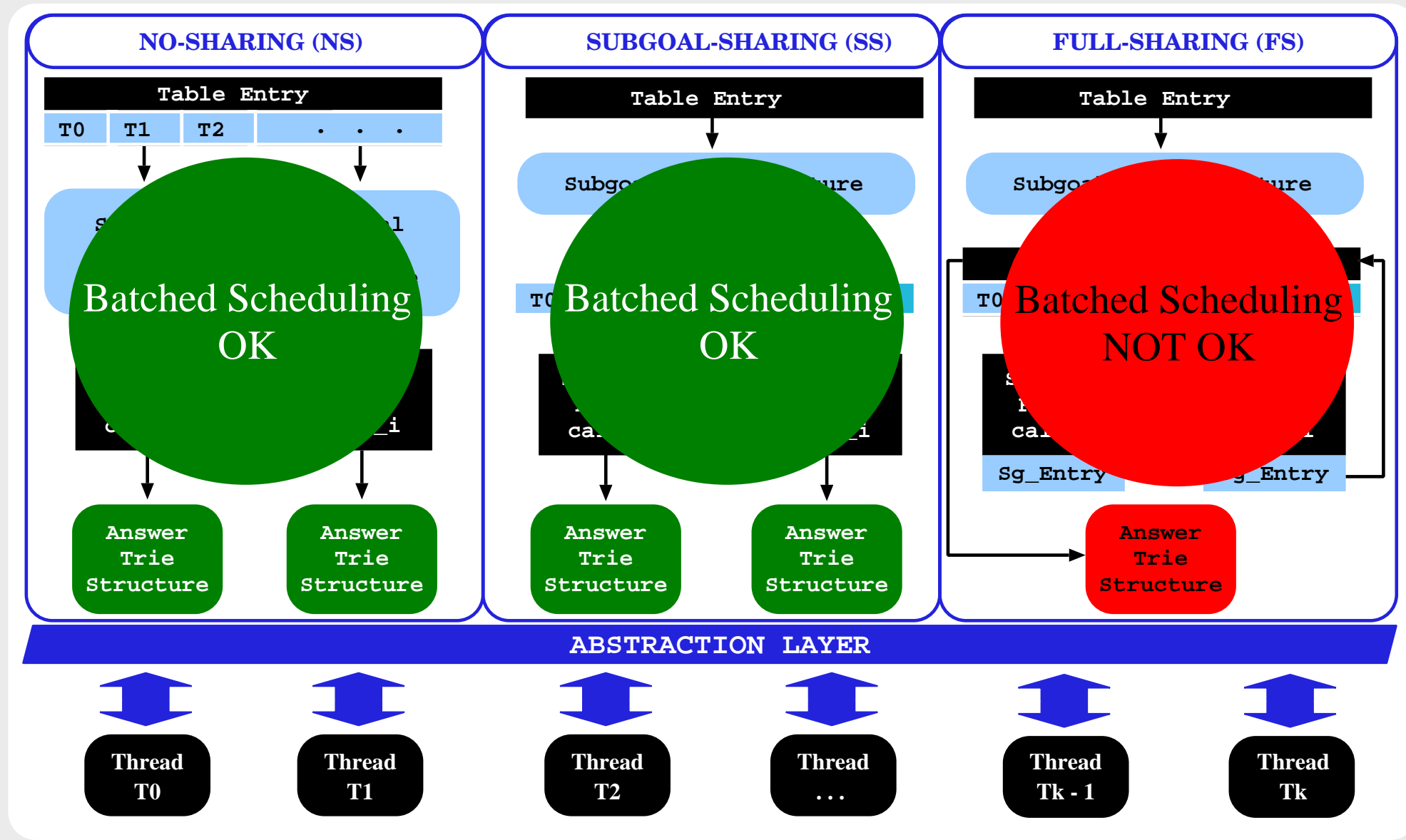
YapTab-Mt - Internal Architecture

Private Answer Chaining - Key Idea

FULL-SHARING (FS)

Table Entry

Subgoal Trie Structure

Subgoal Entry call_i

T0	T1	T2	. . .

Subgoal Frame call_i

Sg_Entry

Subgoal Frame call_i

Sg_Entry

Answer Trie Structure

ABSTRACTION LAYER

Thread T1

Thread ...

Split Answer's Representation and Propagation

BATCHED SCHEDULING

Cluster of Dependent Computations

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Answer Propagation

Whenever a New Answer is Found

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Answer Representation (Public)

BATCHED SCHEDULING

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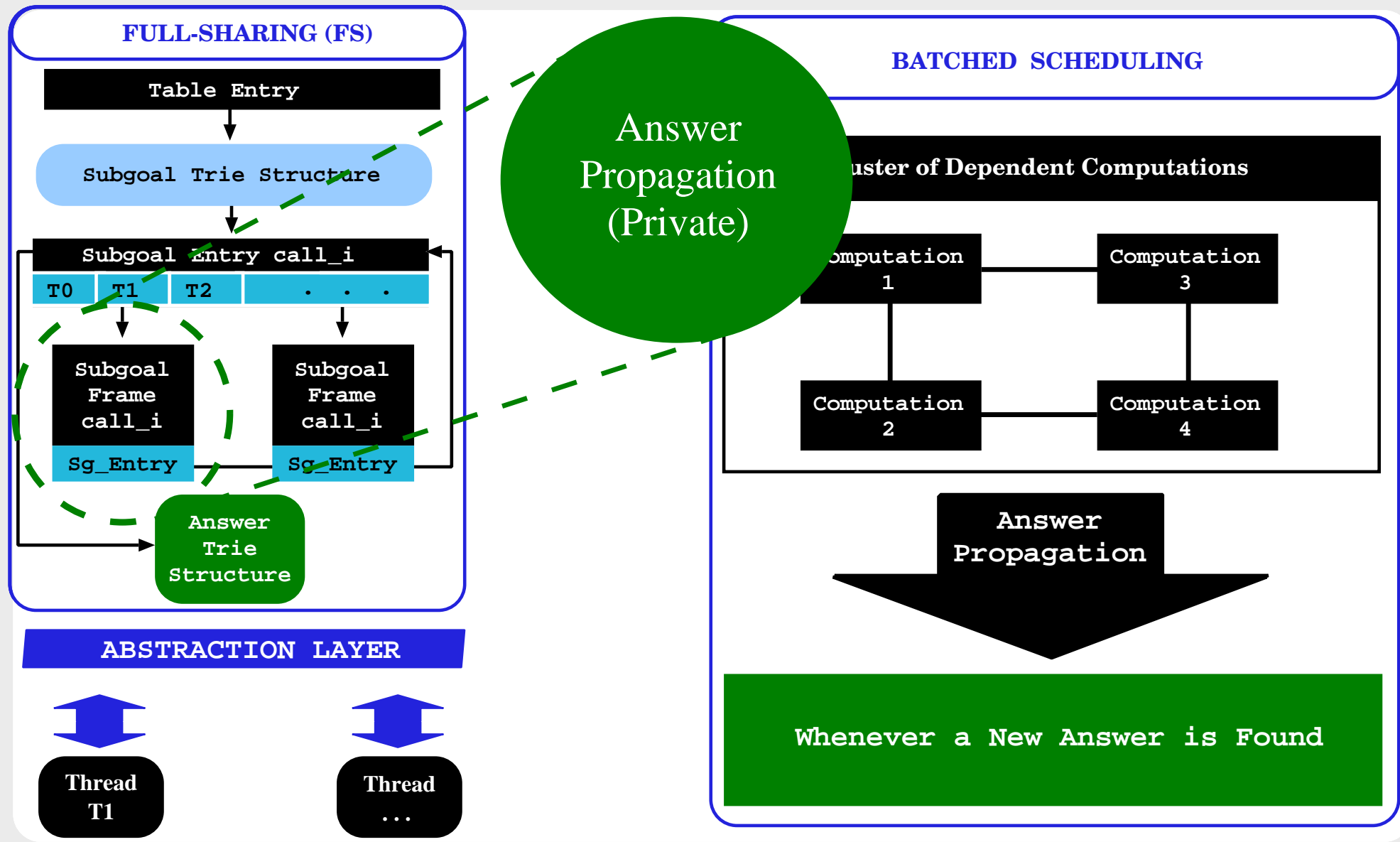
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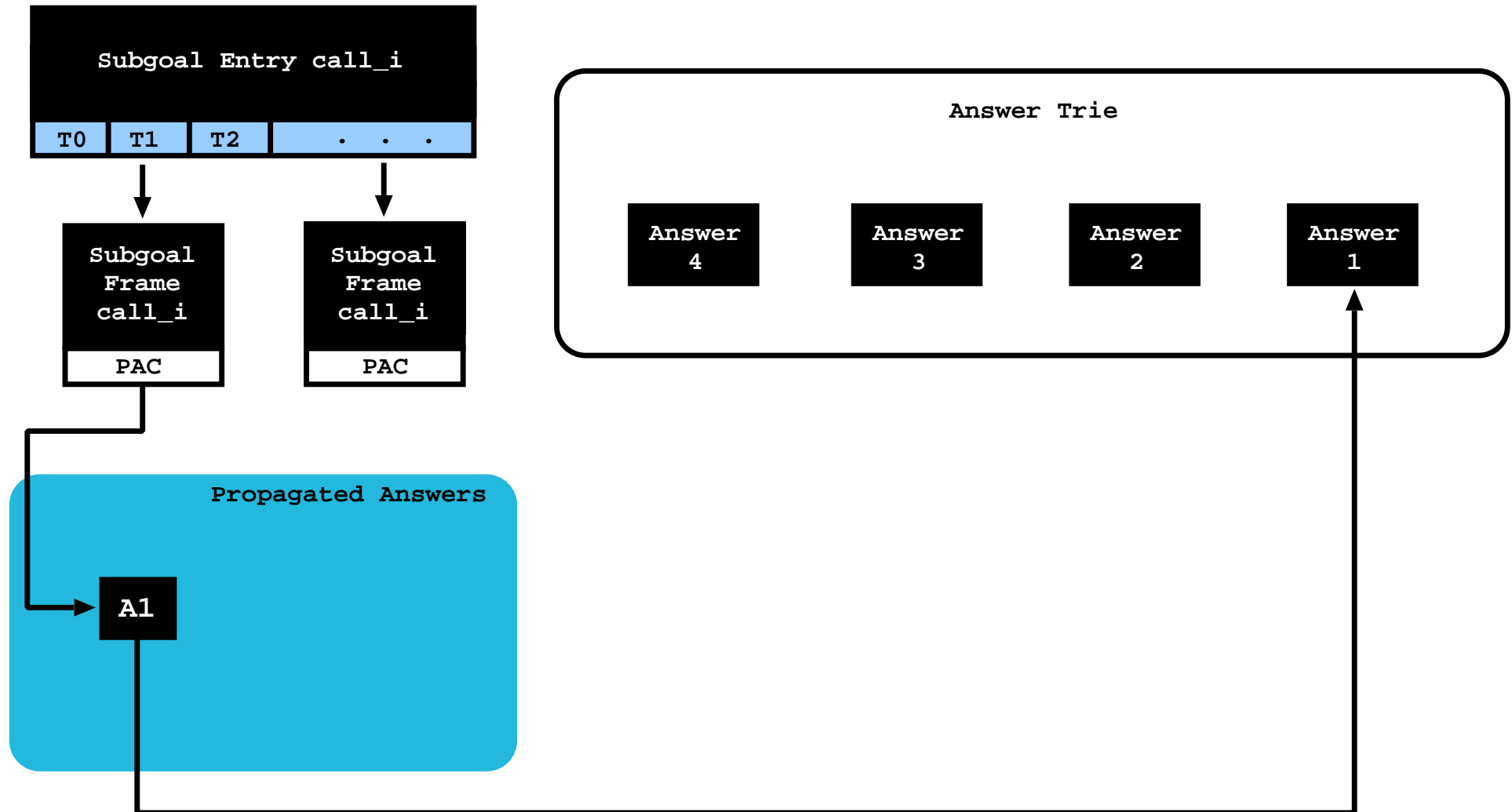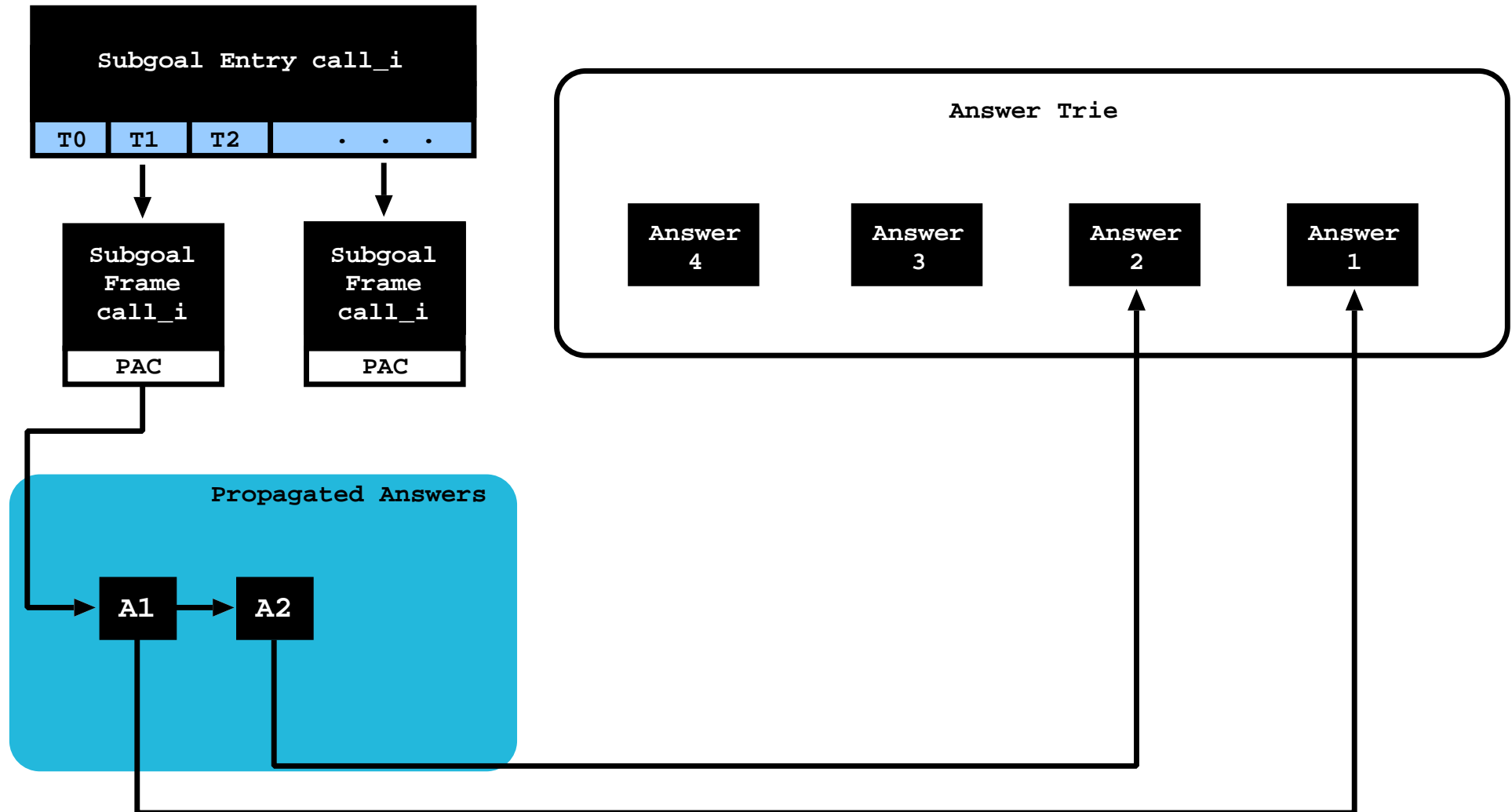
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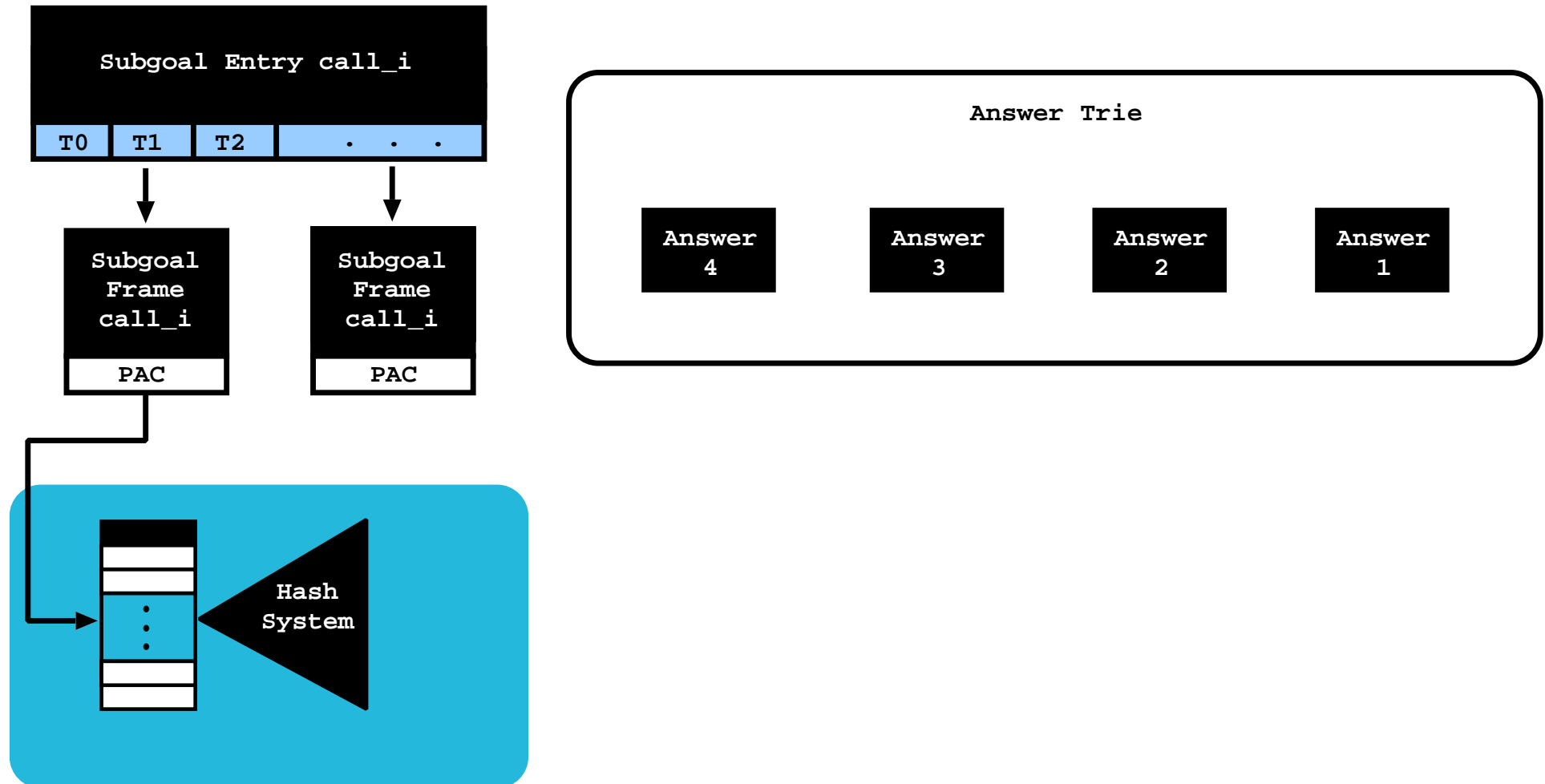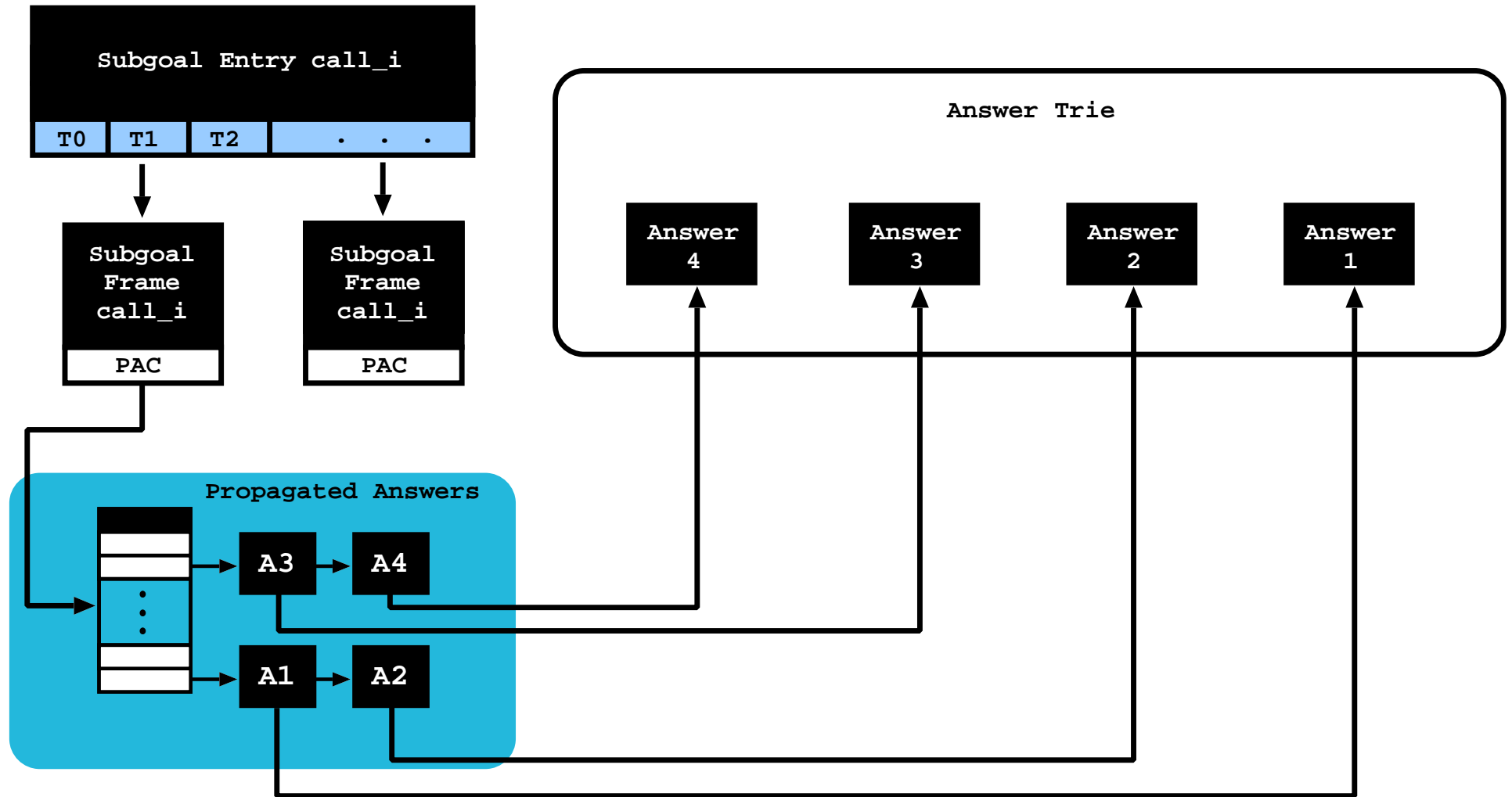# Private Answer Chaining - Key Idea

Private Answer Chaining - Internals
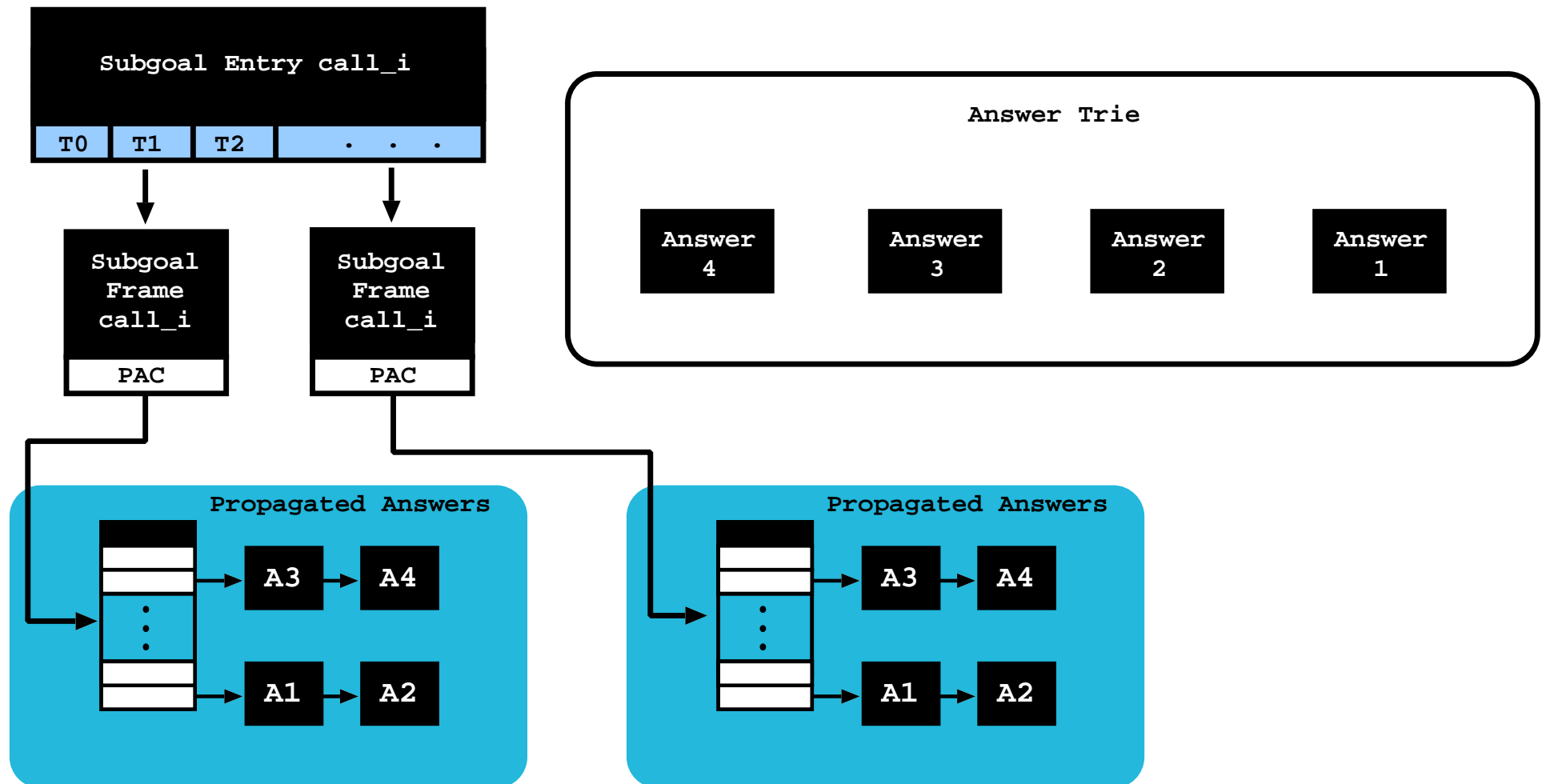
Private Answer Chaining - Internals

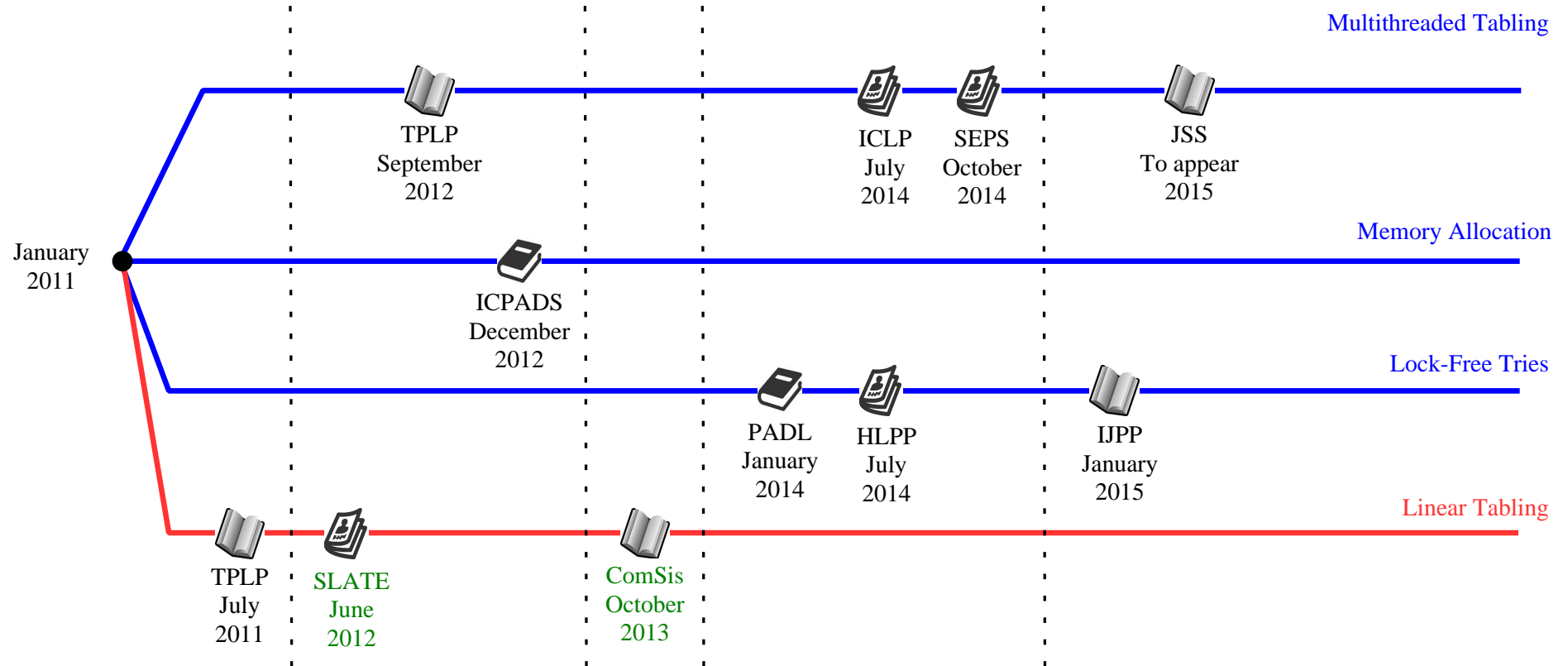# Private Answer Chaining - Internals

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Experimental Results - Worst Case Scenarios

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

Conclusions and Further Work

use this with mode-directed tabling

Research Outline

Multithreaded Tabling

TPLP
September
2012

ICLP
July
2014

SEPS
October
2014

JSS
To appear
2015

Memory Allocation

ICPADS
December
2012

Lock-Free Tries

PADL
January
2014

HLPP
July
2014

IJPP
January
2015

Linear Tabling

January
2011

TPLP
July
2011

SLATE
June
2012

ComSis
October
2013

Work related:

3 Journals

2 Book Series

3 Workshop Proceedings
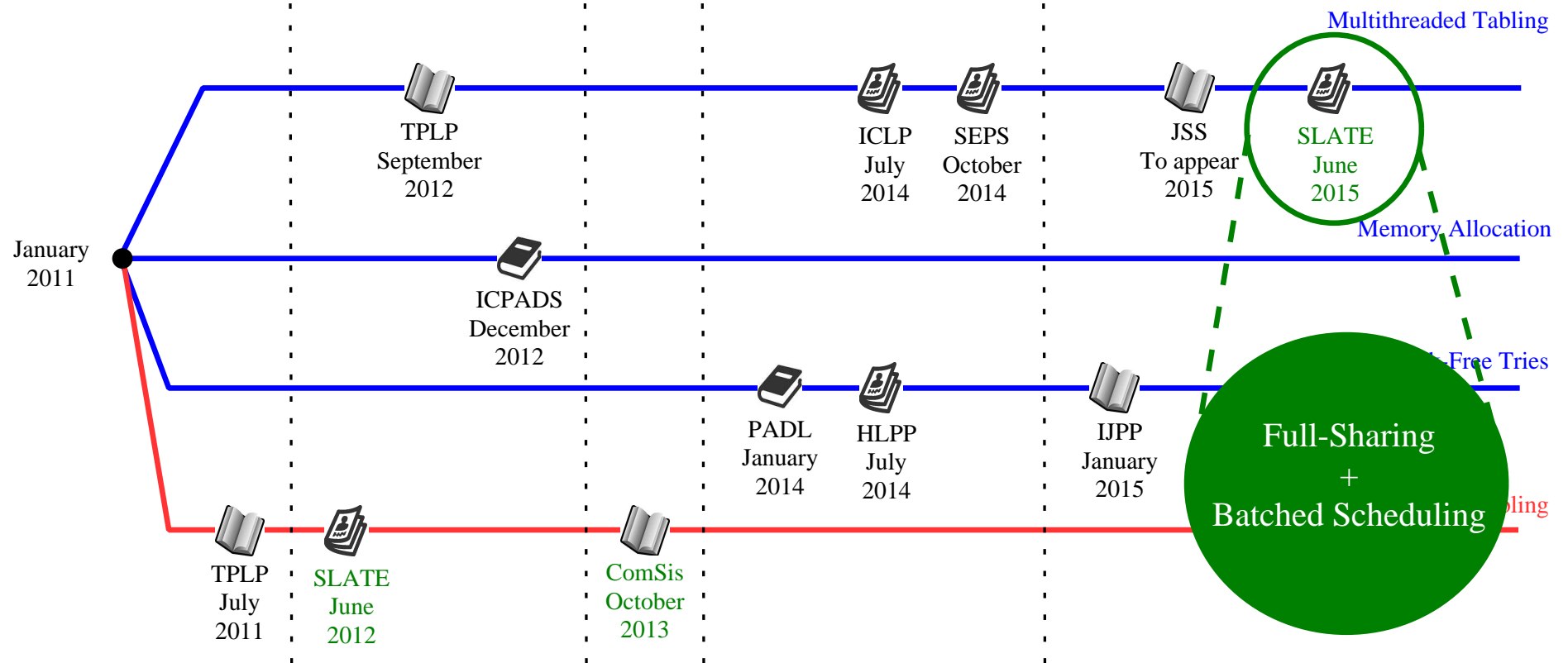
Others:

2 Journals

0 Book Series

1 Workshop Proceeding

Research Outline

Work related:

📖 3 Journals

📕 2 Book Series

📄 4 Workshop Proceedings

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Thank You !!!