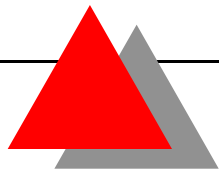




# **Square Placement Variants**

**An example of search tree analysis**

**H. Simonis  
COSYTEC SA**



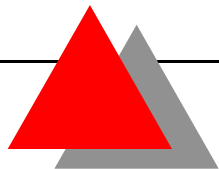


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## Overview

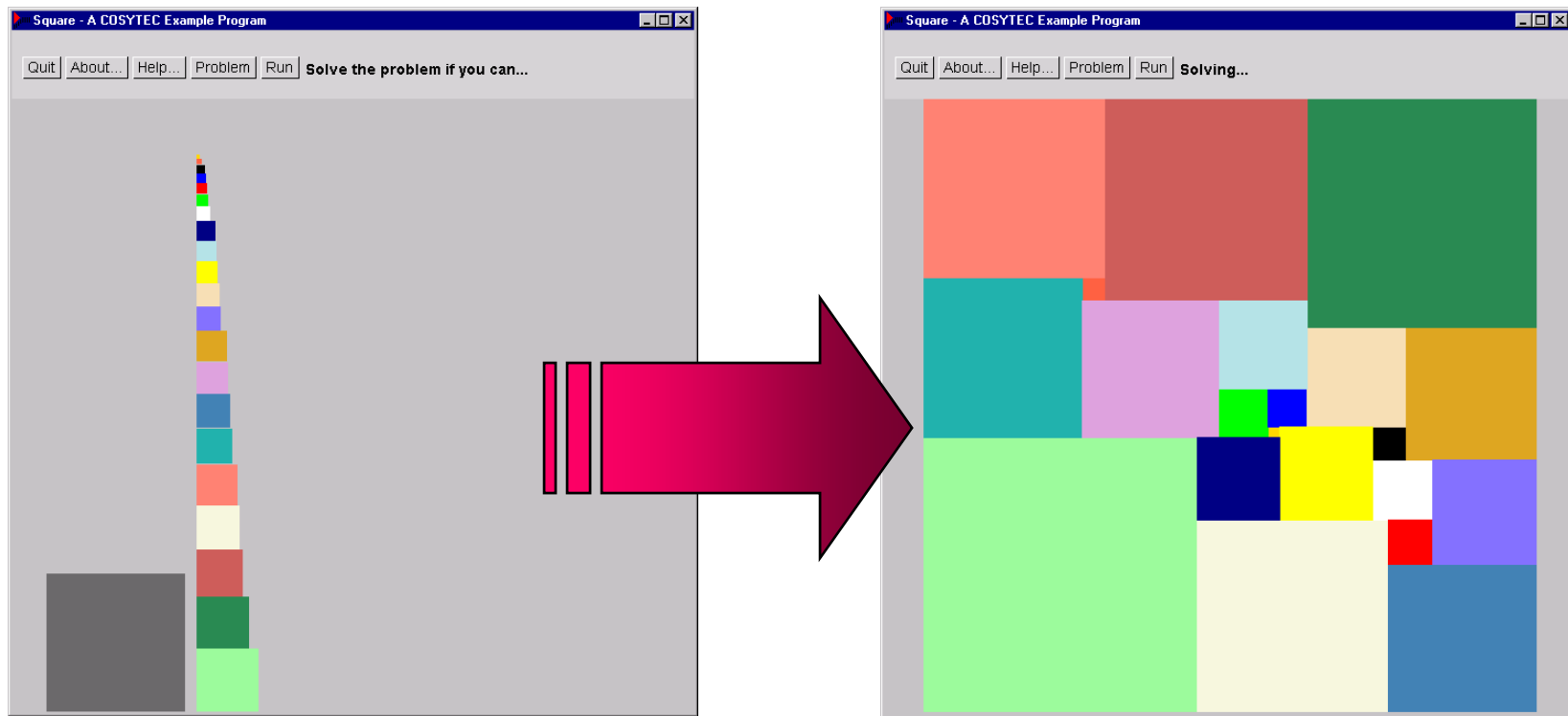
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- ◆ **Problem**
- ◆ **Different Strategies**
- ◆ **Search tree views**
- ◆ **Search tree comparison**
- ◆ **Failure causes**



## Problem

- ◆ Place 21 squares in square area
- ◆ Perfect placement problem





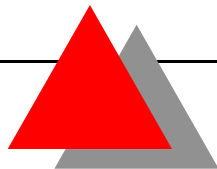
## Program

```
run(X,Y):-
  data(Nr, Data, W, H),
  create_vars(Data,X,Y,Rectangles,W,H, Vars),
  cumulative(X,Data,Data,unused,unused,H,W,[H,0,1]),
  cumulative(Y,Data,Data,unused,unused,W,H,[W,0,1]),
  diffn(Rectangles,unused,unused,[W,H]),
  labeling(Rectangles).

data(21, [50, 42, 37, 35, 33, 29, 27, 25, 24, 19, 18, 17, 16, 15, 11, 9, 8, 7, 6, 4, 2], 112, 112).

create_vars([],[],[],[],_,-, []).
create_vars([L|L1],[X|X1],[Y|Y1],[[X,Y,L,L]|S1],W,H, [X, Y | XsYs):-
  X :: 0..W,
  Y :: 0..H,
  create_vars(L1,X1,Y1,S1,W,H, XsYs).

labeling([]).
labeling([[X,Y,W,_]]):-
  indomain(X),
  indomain(Y).
labeling([[X,Y,W,_],[X1,Y1,W1,_]|R]]):-
  indomain(X),
  indomain(Y),
  indomain(X1,max),
  indomain(Y1,max),
  labeling(R).
```



## Different Strategies

### ◆ Constraint options

- **diffn only**
- **+cumulative limit**  
cumulative(X,Data,Data,unused,unused,H,unused,unused)
- **+cumulative overall end**  
cumulative(X,Data,Data,unused,unused,H,W,unused)
- **+ soft intermediate level**  
cumulative(X,Data,Data,unused,unused,H,W,[H,0])
- **+ forced intermediate level**  
cumulative(X,Data,Data,unused,unused,H,W,[H,0,1])
- **+ saturation for cumulative**
  - ◆ change of cumulative
- **+re-execution of all methods at all times**
  - ◆ change of cumulative

## Different Strategies (2)

### ◆ Search

- indomain alternating min/max
  - ◆ n-ary choice
- indomain1 alternating min/max
  - ◆ binary choice, select/remove value

indomain(X):-

dom(X,L),

member(X,L).

indomain1(X):-

domain\_info(X,Min,..),

indomain1(X,Min).

indomain1(X,X).

indomain1(X,Min):-

X #\= Min,

indomain1(X).

## Different Strategies (3)

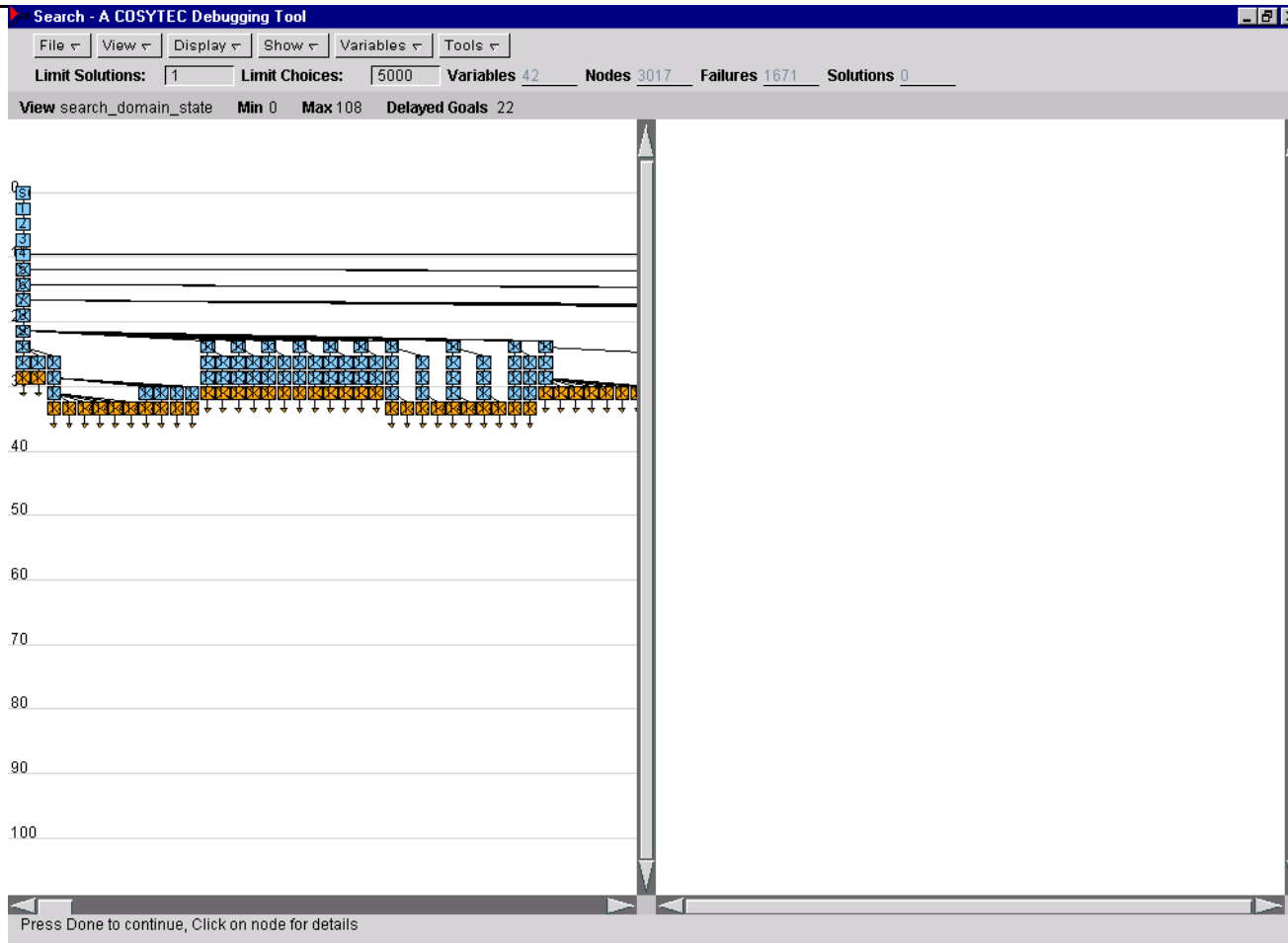
### ◆ Shaving

- test each variable to find which values are consistent with current state
- enough: test next variable in static variable ordering
- enough: shaving on min and max
- pointless?
  - ◆ does not control variable selection
  - ◆ does not count as backtracking step

*Shaving for all values in domain*

```
shaving(Variable,all):-  
  dom(Variable,Values),  
  findall(Variable,member(Variable,Values),[ValidValue|ValidValues]),  
  NewVariable :: [ValidValue|ValidValues],  
  Variable = NewVariable.
```

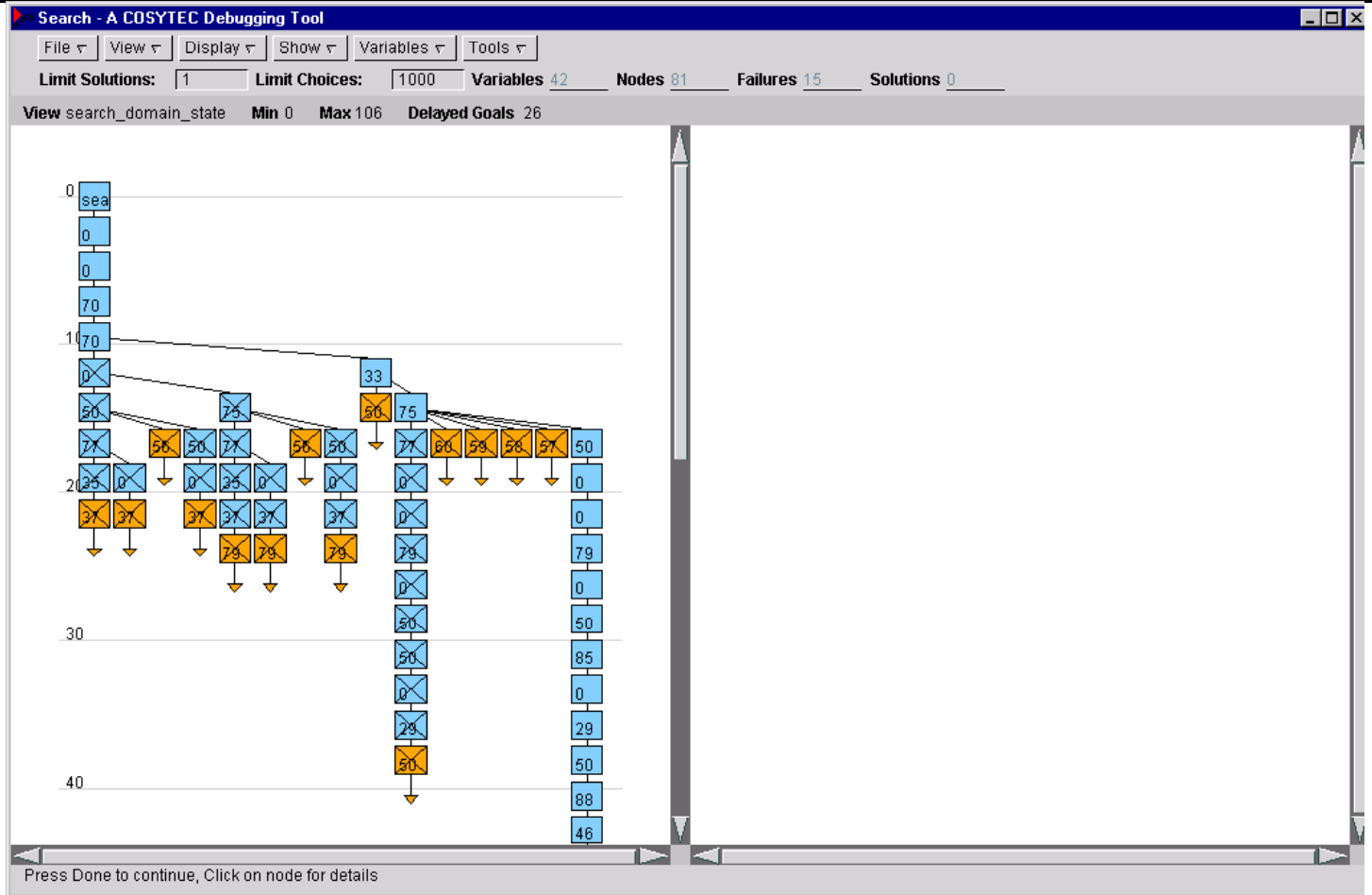
## diffn only (initial part only)



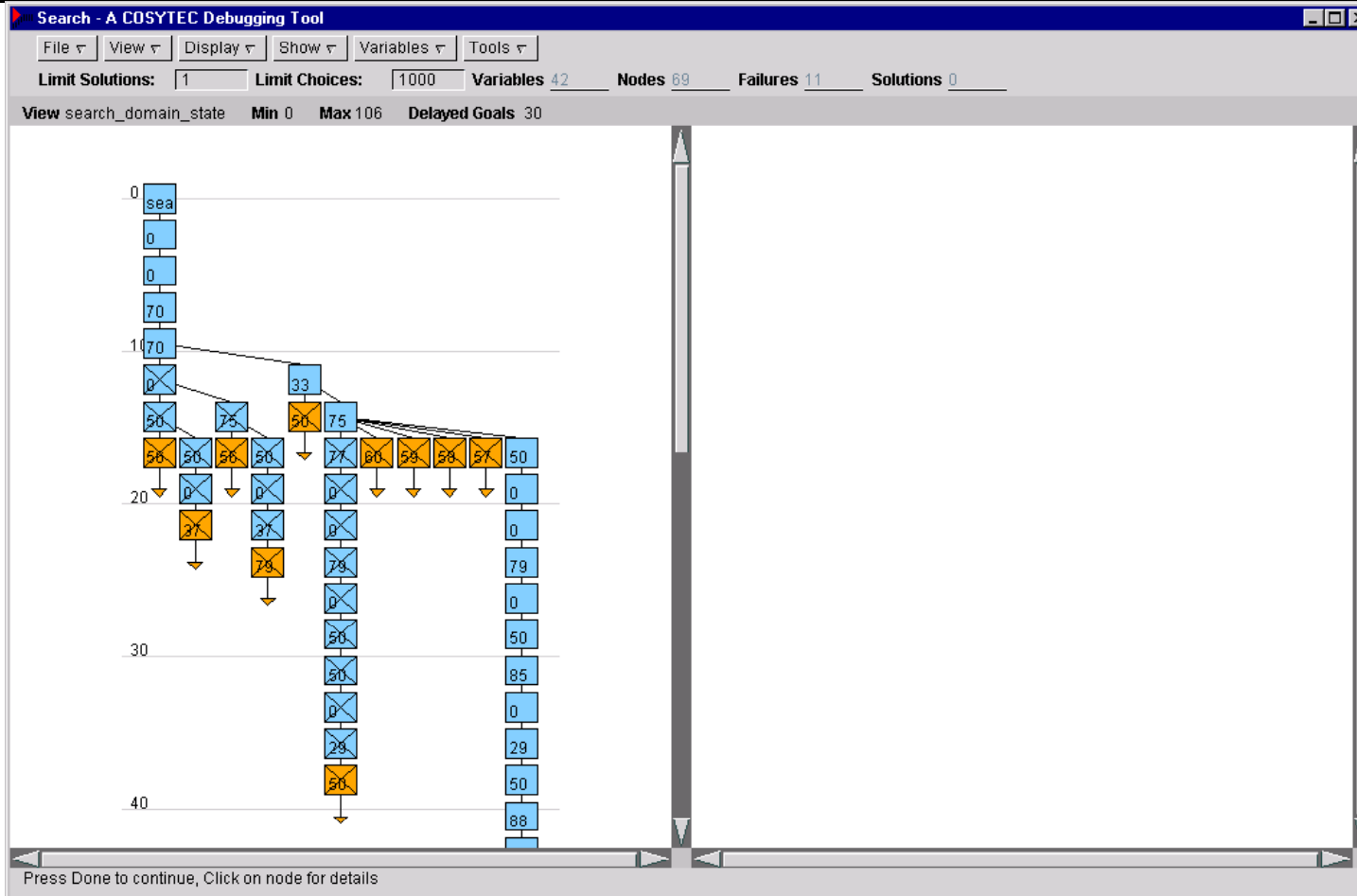




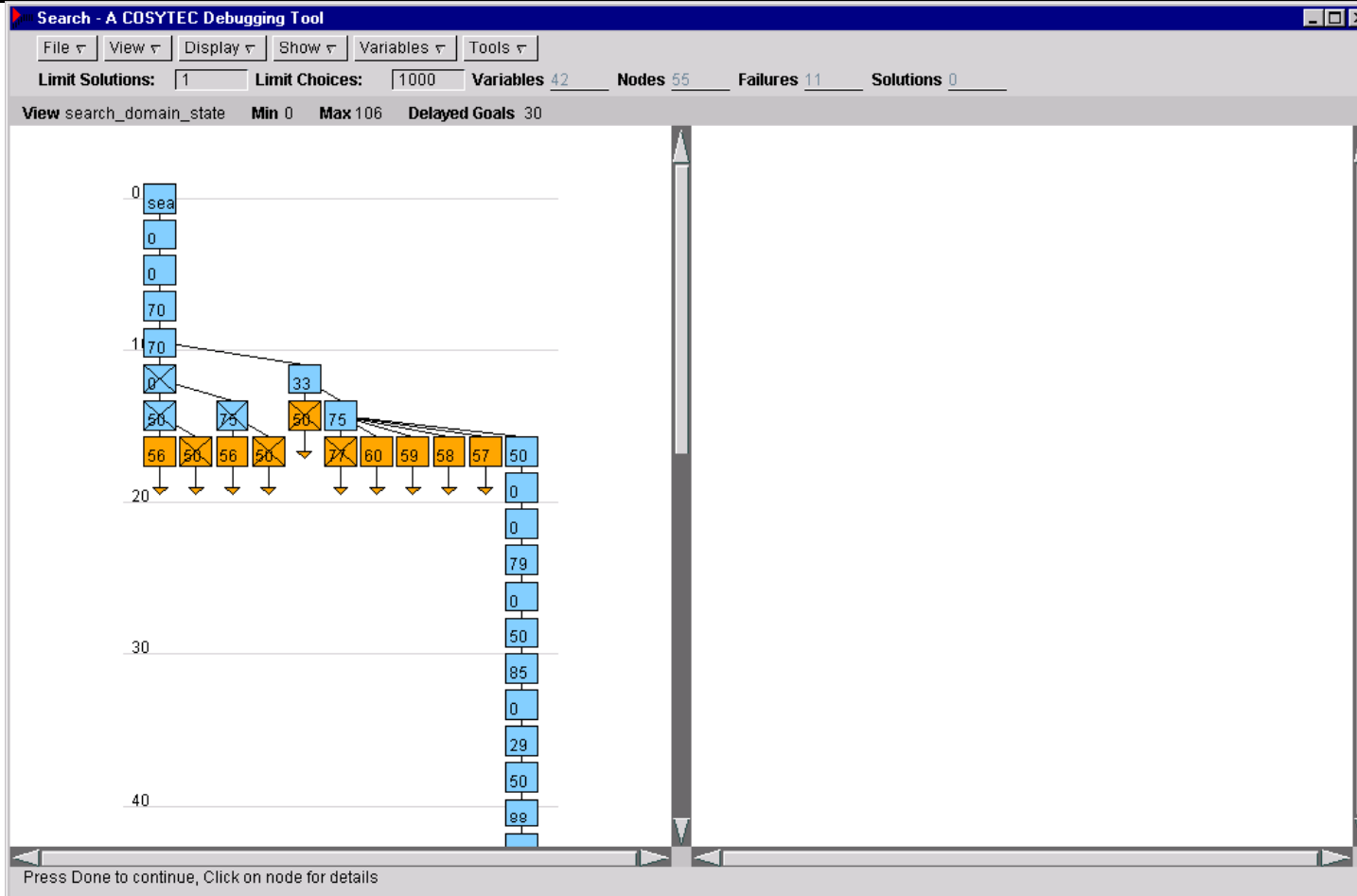
## forced intermediate



## saturation cumulative



all methods, all times





## indomain1

Search - A COSYTEC Debugging Tool

File View Display Show Variables Tools

Limit Solutions: 1 Limit Choices: 1000 Variables 42 Nodes 50 Failures 5 Solutions 0

View search\_domain\_state Min 0 Max 106 Delayed Goals 30

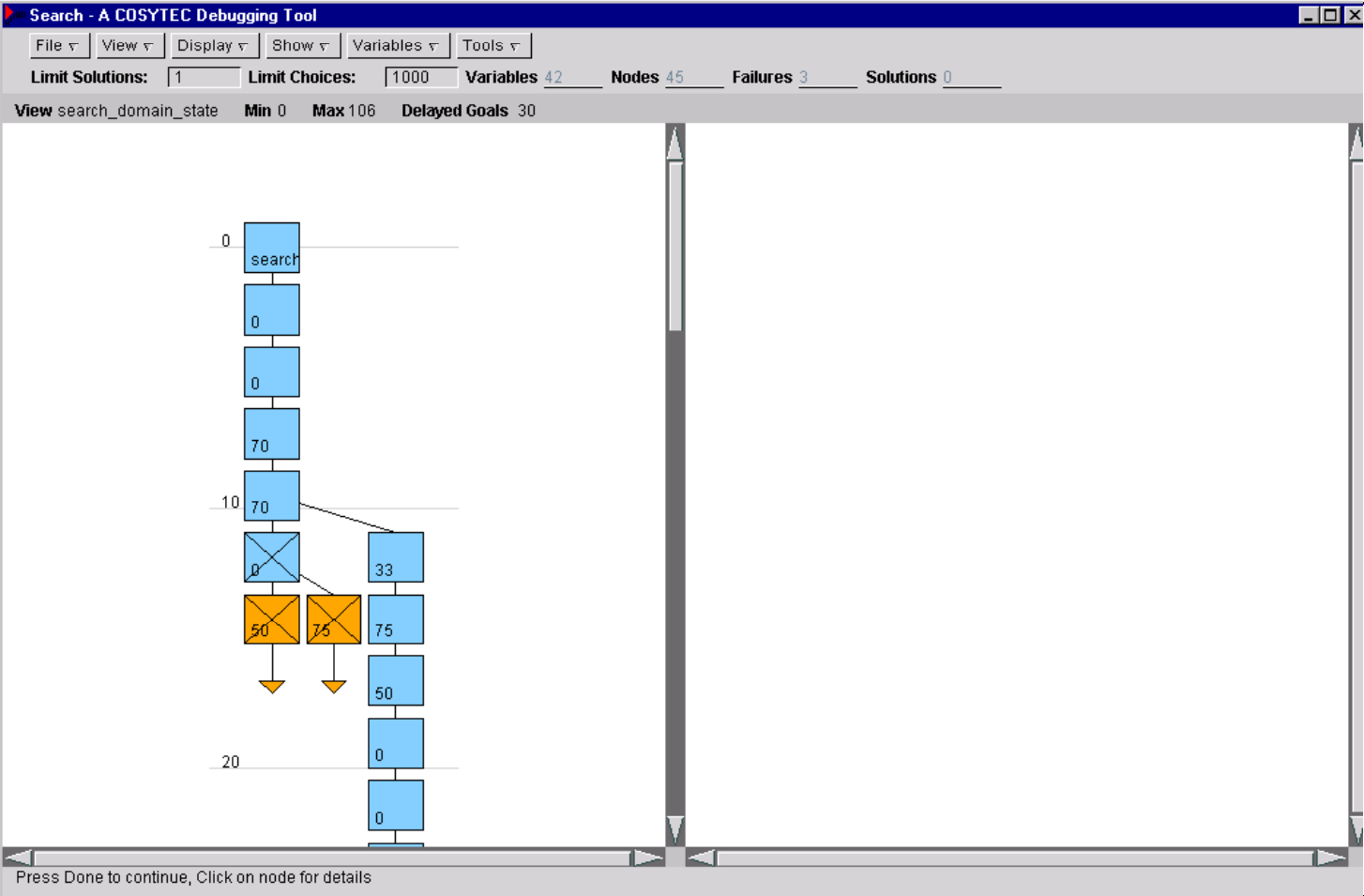
0 sea  
0  
0  
70  
1 70  
0 33  
50 75 50  
2 0 50 75 50  
0  
79  
0  
30 50  
85  
0  
29  
40 50  
00

Press Done to continue, Click on node for details





## shaving



## Comparing two search methods

- ◆ Often interested in comparison of two methods
- ◆ Difficult to achieve with two programs
  - two machines?
- ◆ Change search tree call

OLD:

```
search_start(Vars,labeling(Vars))
```

NEW:

```
search_start(Vars,try(Vars))
```

```
try(Vars):-
```

```
    once(labeling1(Vars)),
```

```
    fail.
```

```
try(Vars):-
```

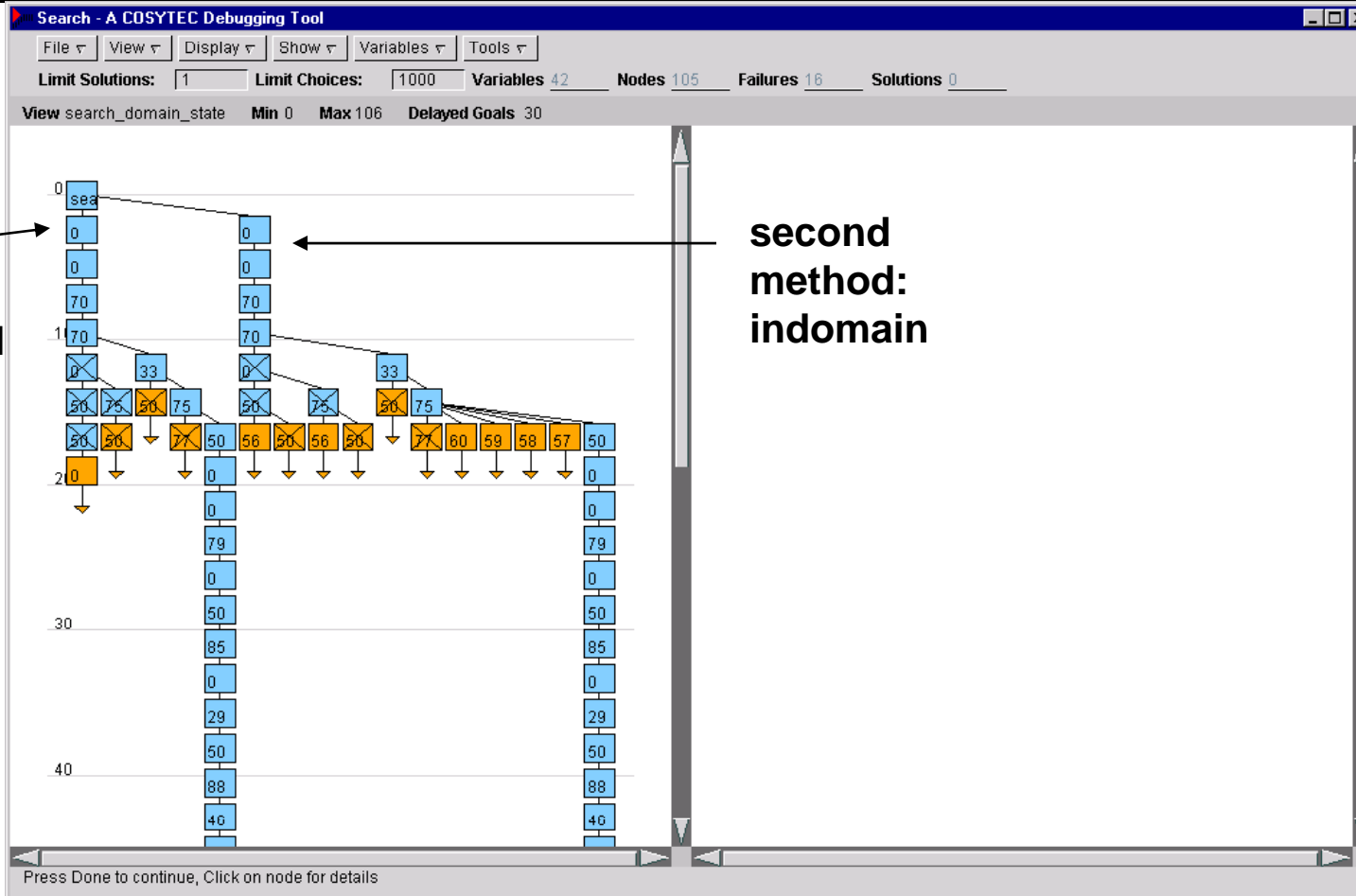
```
    once(labeling2(Vars)),
```

```
    fail.
```

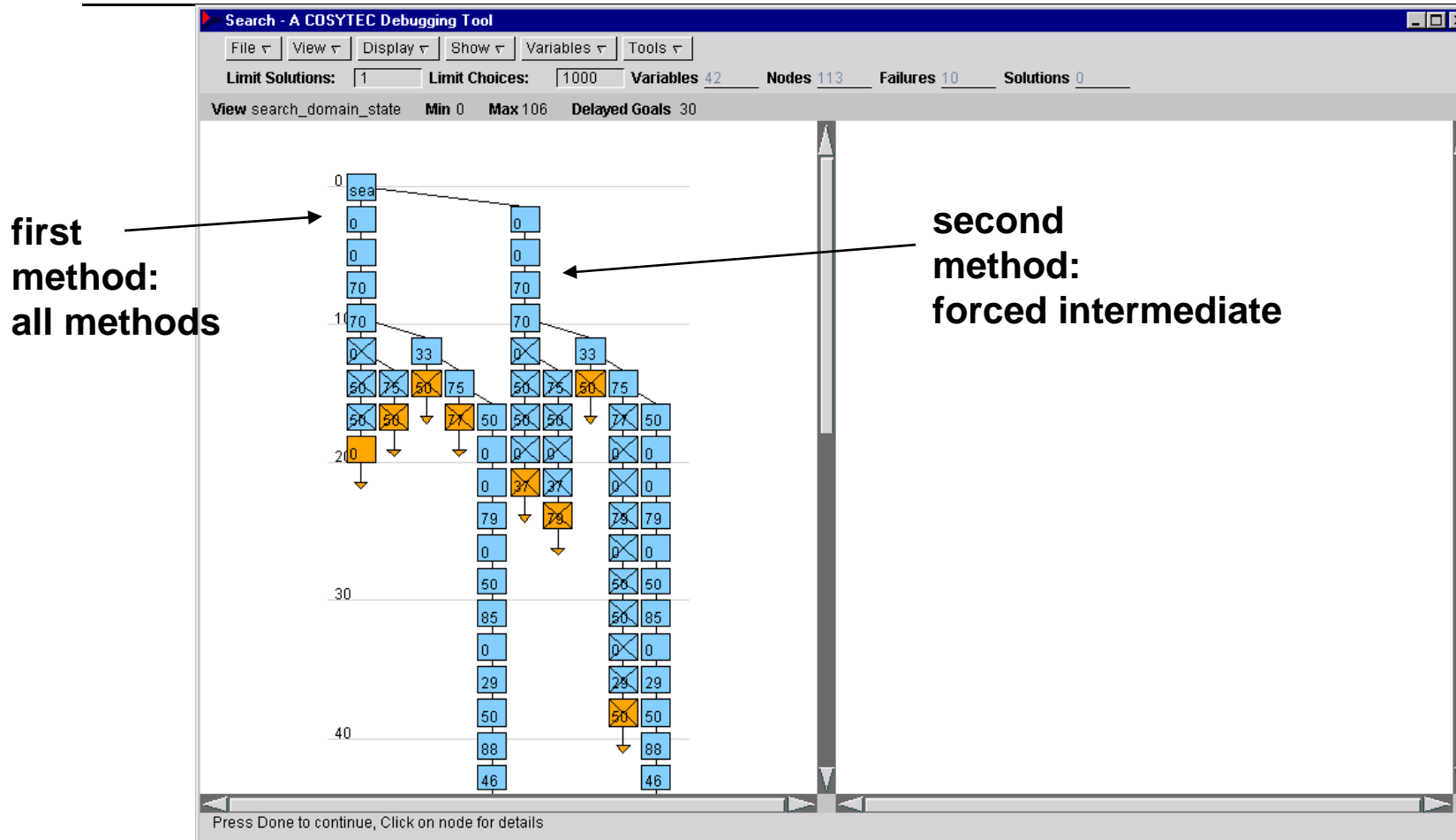
## Compare indomain1 - indomain

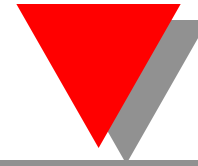
first method:  
indomain1

second method:  
indomain



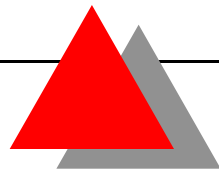
## Compare cumulative - all methods, all times; indomain1

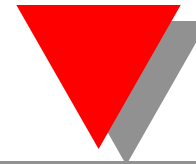




## Backtracking count

Methods	Backtrack	Time	Backtrack	Time
Diffn only	2975	22653	2993 (?)	18757
Cumulative limit	2261	21521	2259	17836
Cumulative limit+end	55	1292	48	1392
Cumulative intermediate	55	1272	48	1342
Forced intermediate	39	1402	35	1392
Saturation cumul	27	1072	21	961
All methods, all times	7	5197	7	5799
Shaving	3	6709	3	6911





## Failure Events

Constraint	Context	All methods	Cumul saturation	Force intermediate	Cumul limit+end	Diff only
cumulative	avoid small hole before	295	108	104	104	0
cumulative	avoid small hole after	176	104	102	102	0
diffn	temoin overflow	54	104	183	191	29489
diffn	hole overflow	31	95	117	280	12133
cumulative	max intersect prune	30	35	32	32	0
cumulative	smallest high task prune	22	4	2	0	0
diffn	dom-arbitre	17	42	51	59	4871
cumulative	cant fill enough deepest hole	17	22	21	0	0
diffn	cum arbitre (fail k-conflict)	9	7	17	17	180
cumulative	oblig.part intersect	6	1	0	0	0
diffn	disj arbitre (fail)	5	15	12	13	249
diffn	cum arbitre (prune)	4	4	0	0	0
diffn	cum arbitre (fail)	2	6	12	12	182
cumulative	top of interval fail	2	5	5	4	0
cumulative	prune origin (global frontier)	2	2	2	2	0
cumulative	residual high max cover fail	1	1	2	2	0

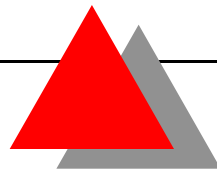




## Failure Events (2)

cumulative	Cant reach intermediate level	0	7	7	1	0
cumulative	Cum arbitre (fail)	0	1	1	0	0
Diffn	overlapping	0	0	8	9	243
diffn	Disj arbitre (before-after)	0	0	1	1	0
Cumulative	First interval fail	0	0	1	0	0
diffn	Eval earliest end	0	0	0	0	359
diffn	Min ori prune	0	0	0	0	217
diffn	Hole include big size	0	0	0	0	7
diffn	Disj arbitre fail (marge)	0	0	0	0	6
diffn	Max ori prune	0	0	0	0	3
diffn	Hole overflow2	0	0	0	0	2
diffn	Disj partititon	0	0	0	0	2
total	-	673	563	680	829	47943

not shown for shaving, as shaving failures can not be separated



## Newprop tool

The screenshot shows the 'Prop - A COSYTEC Debugging Tool' window. At the top, there are several checkboxes: 'Get Propagation Events', 'Aggregate Type' (yes/no), 'Pred' (yes/no), 'Cnr' (yes/no), and 'Context' (yes/no). Below this is a table with the following columns: Type, Pred, Cnr, Context, and Count. The table contains 20 rows of data. Annotations with arrows point to various parts of the interface:

- type of event**: points to the 'Type' column.
- constraint name**: points to the 'Context' column.
- constraint number**: points to the 'Cnr' column.
- context**: points to the 'Pred' column.
- count of events**: points to the 'Count' column.
- aggregate choices**: points to the 'Aggregate Type' checkbox.

Type	Pred	Cnr	Context	Count
Fail	cumulative	122	cum arbitre (fail)	1
Fail	cumulative	130	cum arbitre (fail k-conflict)	1
Fail	cumulative	122	prune origin (2 adjacent)	2
Fail	cumulative	148	prune origin (global frontier)	2
Fail	cumulative	218	residual high max cover fail	2
Fail	diffr	118	cum arbitre (prune)	4
Fail	cumulative	218	oblig.part intersect	5
Fail	diffr	118	disj arbitre (fail)	6
Fail	cumulative	37	top of interval fail	8
Fail	diffr	118	cum arbitre (fail k-conflict)	10
Fail	diffr	13	cum arbitre (fail)	11
Fail	cumulative	1	smallest high task prune	19
Fail	cumulative	37	cant fill enough deepest hole	21
Fail	diffr	118	dom-arbitre	22
Fail	cumulative	77	max intersect prune	29
Fail	diffr	128	hole overflow	59
Fail	diffr	43	temoin overflow	89
Fail	cumulative	1	avoid small hole after	175
Fail	cumulative	1	avoid small hole before	229

## Conclusion

- ◆ **Example of problem analysis with search tree tool**
- ◆ **Comparison of strategies inside tool**
- ◆ **Backtracking count vs failure count**
- ◆ **Failure events**
  - variety of methods
  - change of methods with small change of programs
- ◆ **Newprop tool**
  - listing of all propagation events
  - aggregation
  - internal use only
  - for tool developer
- ◆ **Significant improvement of program by small modification**