

# Parallel Sudoku Solver

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29		21		11	21	23	15		22	8		8		28	
18	3	18	15				16			18		6		23	
				13	19	19		9	30		14		20	15	
7		20	23			12			12	14	27			13	22
26				19	15	3	35				19				
12		28					18		42	30		16		8	31
	28		13		14						12		14		
16		9	23	24		13	31	14		17	21	5		14	16
	28			8				25	13				11		
10		5	34	23	21					10	28			21	
	14					13		7	19		11	23	30		10
26		18		27	10	29	24			10			27		
	13		4					12			14	20	23		12
27		24		6		14		17		26				19	
	15		26	25		15		31			24	18			6
				25					17			30			

# 1 A Sat Reduction

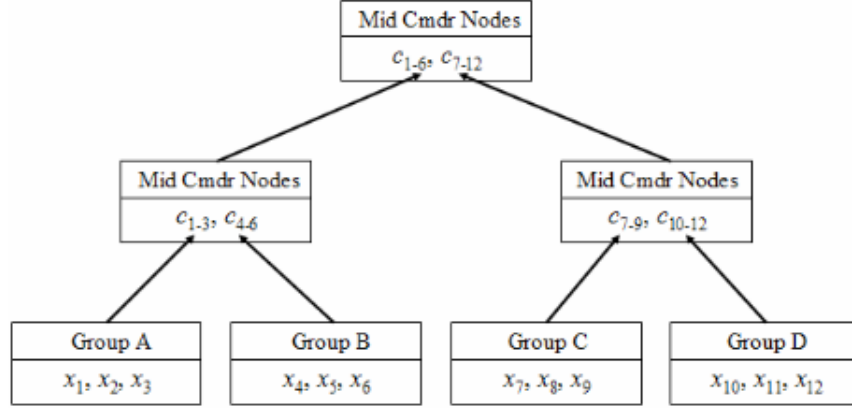


Figure 1: Graphical Depiction of Commander Variable Encoding

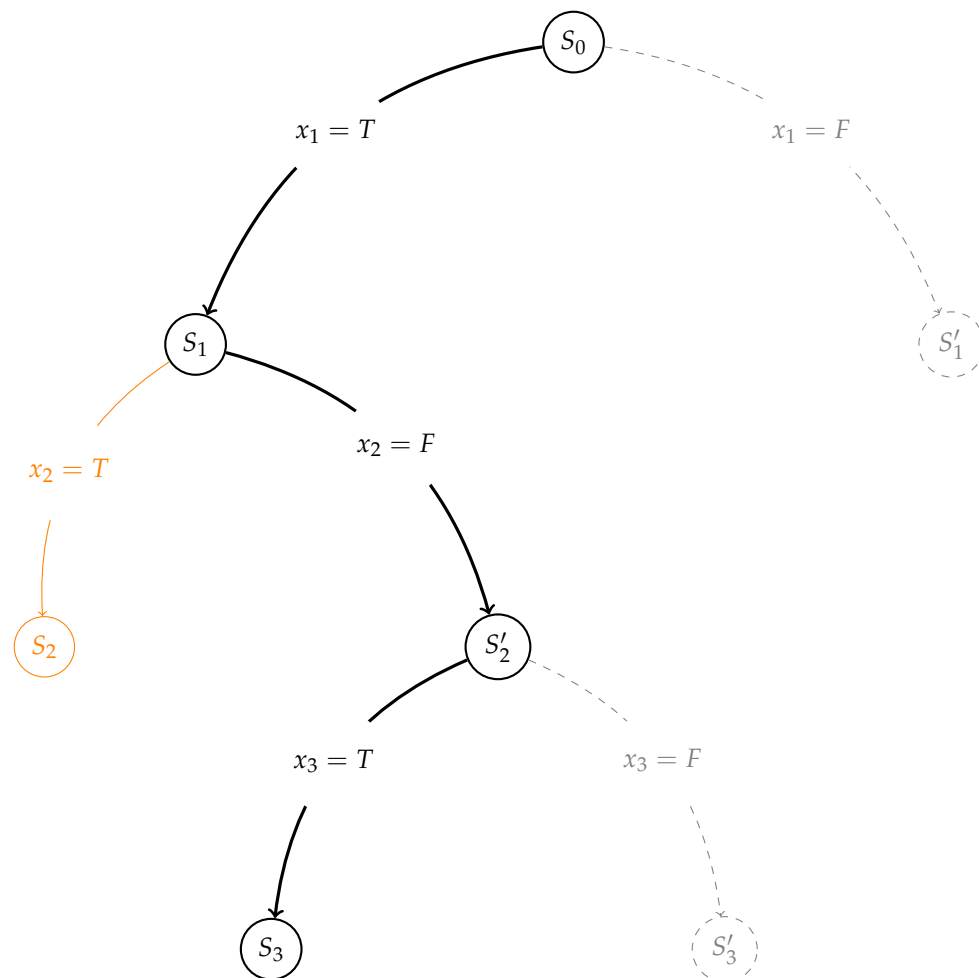
	$c_{25}$			$c_{26}$			$c_{27}$	
	$c_{22}$			$c_{23}$			$c_{24}$	
	$c_{19}$			$c_{20}$			$c_{21}$	
	$c_{16}$			$c_{17}$			$c_{18}$	
	$c_{13}$			$c_{14}$			$c_{15}$	
	$c_{10}$			$c_{11}$			$c_{12}$	
	$c_7$			$c_8$			$c_9$	
	$c_4$			$c_5$			$c_6$	
	$c_1$			$c_2$			$c_3$	

$$[\text{digitInCage}] \iff \bigwedge_{\text{cell} \in \text{cage}} [\text{digitInCell}] \quad (1)$$

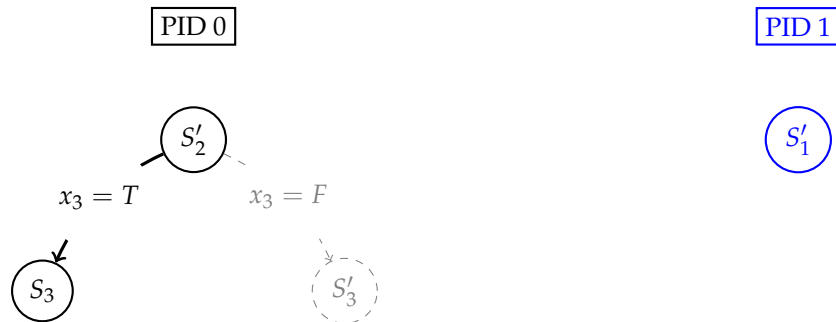
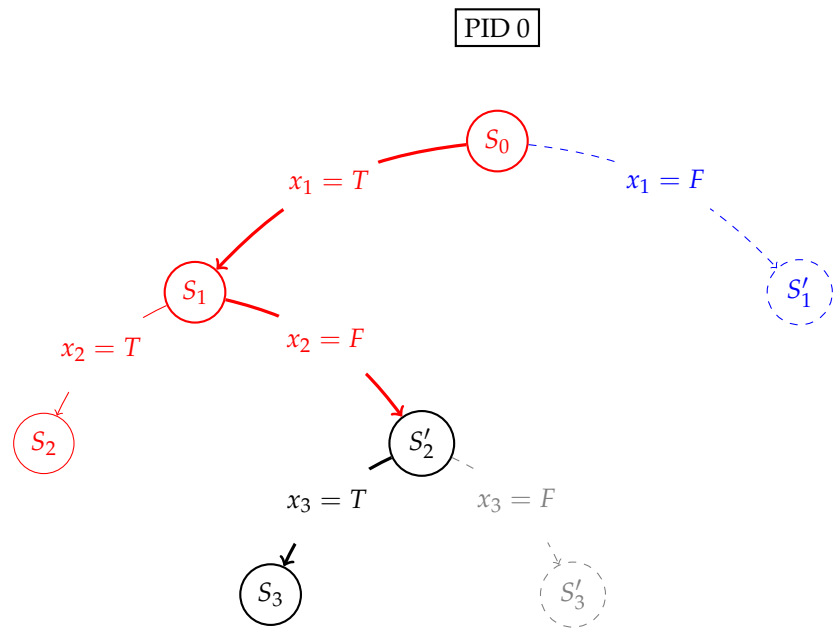
$$[\text{validPartition}] \iff \bigwedge_{\text{digit} \in \text{partition}} [\text{digitInCage}] \quad (2)$$

$$\bigvee_{\text{all partitions with valid sum}} [\text{validPartition}] \quad (3)$$

## 2 Recursive Algorithm

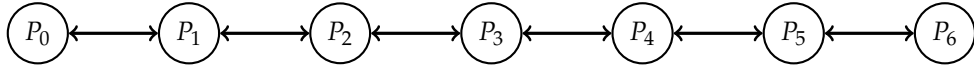


### 3 How to Steal Things

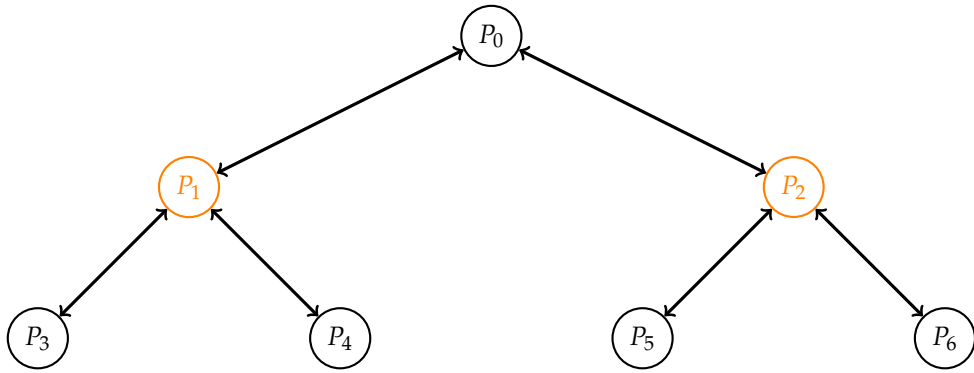


## 4 Public Speaking

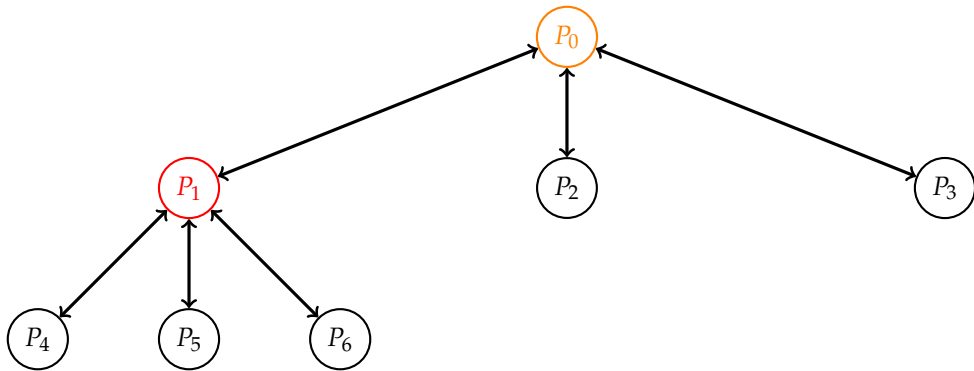
Branching factor 1 (low contention) (high latency)



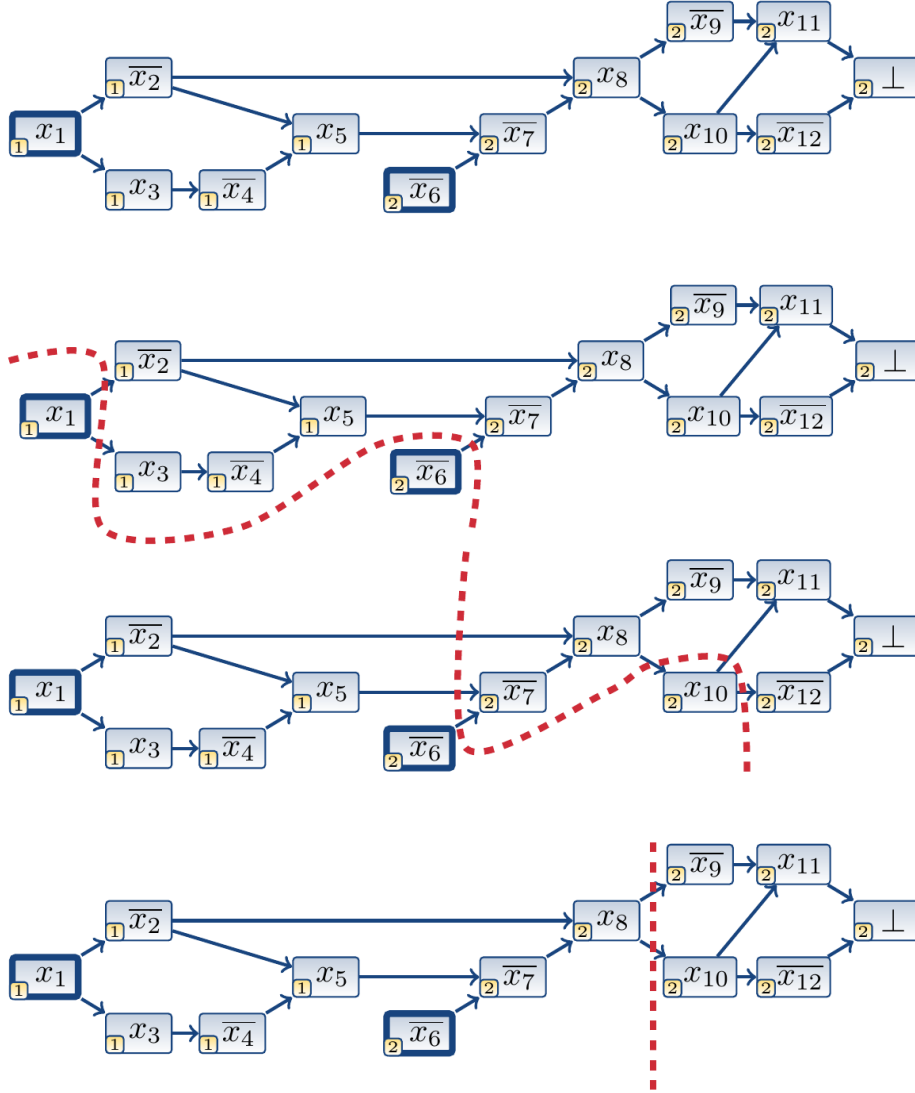
Branching factor 2 (okay contention) (okay latency)



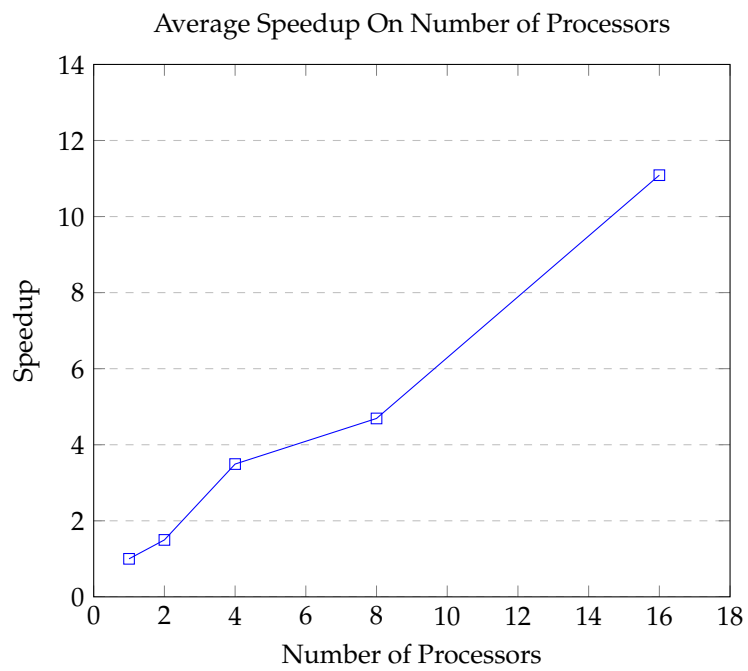
Branching factor 3 (high contention) (low latency)



## 5 Conflict Resolution



## 6 Performance!



Puzzle Number	$n = 1$	$n = 2$	$n = 4$	$n = 8$	$n = 16$
0	29.0	89.8	16.9	1.90	1.00
1	12.69	7.81	1.35	1.70	0.89
2	23.66	14.5	6.88	3.85	2.96
3	4.01	2.45	1.90	2.41	0.77

## 7 How Perf-ect?

```
Performance counter stats for 'mpirun -n 1 ./main -f inputs/ktest8.txt -r 1':

    139,136,416      cache-misses          #    5.321 % of all cache refs
    2,614,914,105    cache-references

    11.400383799 seconds time elapsed

    11.062300000 seconds user
    0.050201000 seconds sys
```

Figure 2: Perf stat on  $n = 1$  for cache-references and cache-misses.

```
Samples: 20K of event 'cache-misses', Event count (approx.): 125580024
Overhead Command Shared Object Symbol
20.60% main libc.so.6 [.] _int_free
15.35% main libc.so.6 [.] _int_malloc
11.34% main libc.so.6 [.] malloc
8.02% main main [.] Cnf::propagate_assignment
5.32% main main [.] Clauses::change_clause_size
5.17% main main [.] Cnf::undo_local_edits
5.15% main main [.] Clauses::drop_clause
4.60% main libc.so.6 [.] cfree@GLIBC_2.2.5
```

Figure 3: Perf report on  $n = 1$  for cache-misses

```
Performance counter stats for 'mpirun -n 8 ./main -f inputs/ktest8.txt -r 1':

    684,901,460      cache-misses          #   50.312 % of all cache refs
    1,361,317,023    cache-references

    1.840858557 seconds time elapsed

    11.396627000 seconds user
    0.225572000 seconds sys
```

Figure 4: Perf stat on  $n = 8$  for cache-references and cache-misses.

```
Samples: 53K of event 'cache-misses', Event count (approx.): 896398337
Overhead Command Shared Object Symbol
18.18% main libc.so.6 [.] _int_free
12.94% main libc.so.6 [.] _int_malloc
10.24% main main [.] Cnf::propagate_assignment
9.61% main libc.so.6 [.] malloc
7.55% main main [.] Clauses::change_clause_size
6.49% main main [.] Clauses::drop_clause
5.65% main main [.] Cnf::undo_local_edits
3.93% main main [.] Clauses::re_add_clause
```

Figure 5: Perf report on  $n = 8$  for cache-misses