

# Benchmarks for Weighted Tree Automata

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April 12, 2019

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## 1 What fits in 16GB RAM

Finding the number of states that copar can solve in 16GB RAM for a few different types of WTAs.

### 1.1 Powerset

#### 1.1.1 GHC 8.6.4 with symbols 0,8 and zero-freq 0.7

```
./bench.py bisect ../../copar/bin/{random-wta,copar} --monoid powerset --symbols 0,8 --zero-frequency 0.7 --good 1400 --bad 1600 --start-states 1500
```

```
Trying 1500...  
Trying 1450...  
Trying 1475...  
Trying 1487...  
Trying 1481...  
Trying 1478...  
Trying 1479...  
First bad state count: 1479
```

#### 1. File Size

```
ls -sh bench/wta_powerset_0,8_0.7_1478*  
  
82M bench/wta_powerset_0,8_0.7_1478_0.coalgebra  
82M bench/wta_powerset_0,8_0.7_1478_1.coalgebra  
82M bench/wta_powerset_0,8_0.7_1478_2.coalgebra  
82M bench/wta_powerset_0,8_0.7_1478_3.coalgebra  
82M bench/wta_powerset_0,8_0.7_1478_4.coalgebra
```

#### 1.1.2 GHC 8.4.4 with symbols 0,8 and zero-freq 0.7

```
./bench.py bisect ../../copar/bin/{random-wta,copar} --monoid powerset --symbols 0,8 --zero-frequency 0.7 --start-states 1000
```

```
Trying 1000...  
Trying 2000...  
Trying 1500...  
Trying 1250...  
Trying 1375...  
Trying 1437...  
Trying 1468...  
Trying 1484...  
Trying 1476...  
Trying 1480...  
Trying 1478...  
Trying 1479...  
First bad state count: 1479
```

#### 1. File Size

```
ls -sh bench/wta_powerset_0,8_0.7_1478*  
  
82M bench/wta_powerset_0,8_0.7_1478_0.coalgebra  
82M bench/wta_powerset_0,8_0.7_1478_1.coalgebra  
82M bench/wta_powerset_0,8_0.7_1478_2.coalgebra  
82M bench/wta_powerset_0,8_0.7_1478_3.coalgebra  
82M bench/wta_powerset_0,8_0.7_1478_4.coalgebra
```

#### 2. Automaton size

```
python bench.py run ../../copar/bin/copar --monoid powerset --symbols 0,8 --zero-frequency 0.7 --states 1478 --indiv --header
```

i	states	edges	initial-partition-size	final-partition-size	explicit-final-partition-size	size1-skipped	overall-duration	parse-duration	algorithm-duration	initialize-duration	refine-duration
0	5243856	10484756	10	18	2	0	115.339077581	34.439478263	79.458232767	27.712258503	37.668249537
1	5245405	10487854	10	18	2	0	114.001430765	34.477874858	78.07613373	27.764347556	37.074617863
2	5243549	10484142	10	18	2	0	114.862812706	34.668409012	78.756016051	27.741448159	37.09480403
3	5241660	10480364	10	18	2	0	114.228588077	34.362576104	78.424601434	27.648526393	37.043127108
4	5243032	10483108	10	18	2	0	114.692551901	34.827430372	78.414037199	27.723198479	38.276163878

### 1.1.3 GHC 8.4.4 with symbols 1,0,4 and zero-freq 0.7

```
./bench.py bisect ../../copar/bin/{random-wta,copar} --monoid powerset --symbols 1,0,4 --zero-frequency 0.7
```

```
Trying 50...
Trying 100...
Trying 200...
Trying 150...
Trying 175...
Trying 162...
Trying 156...
Trying 153...
Trying 151...
Trying 152...
First bad state count: 152
```

#### 1. File Size

```
ls -sh bench/wta_powerset_1,0,4_0.7_152*
```

```
83M bench/wta_powerset_1,0,4_0.7_152_0.coalgebra
83M bench/wta_powerset_1,0,4_0.7_152_1.coalgebra
83M bench/wta_powerset_1,0,4_0.7_152_2.coalgebra
83M bench/wta_powerset_1,0,4_0.7_152_3.coalgebra
83M bench/wta_powerset_1,0,4_0.7_152_4.coalgebra
```

#### 2. Automaton Size

```
python bench.py run ../../copar/bin/copar --monoid powerset --symbols 1,0,4 --zero-frequency 0.7 --states 151 --indiv --header
```

i	states	edges	initial-partition-size	final-partition-size	explicit-final-partition-size	size1-skipped	overall-duration	parse-duration	algorithm-duration	initialize-duration	refine-duration
0	4131380	12393591	7	69	4	0	92.530296805	32.925871573	58.292789973	13.413784138	32.25285307
1	4131667	12394466	7	69	4	0	104.072447103	32.6810851	70.054731043	22.601698388	34.657530397
2	4130798	12391837	7	69	4	0	104.65358267	32.641475967	70.686110886	22.881971907	34.580390995
3	4131273	12393268	7	69	4	0	104.436764929	33.010643372	70.097279338	22.722527765	34.948100296
4	4131755	12394730	7	69	4	0	103.940596569	32.874641172	69.748179673	22.561661198	34.530464508

### 1.1.4 GHC 8.4.4 with symbols 4,3,2 and zero-freq 0.7

```
./bench.py bisect ../../copar/bin/{random-wta,copar} --monoid powerset --symbols 4,3,2 --zero-frequency 0.7
```

```
Trying 50...
Trying 100...
Trying 200...
Trying 150...
Trying 175...
Trying 187...
Trying 193...
Trying 190...
Trying 191...
First bad state count: 191
```

## 1. File Size

```
ls -sh bench/wta_powerset_4,3,2_0.7_190*
```

```
83M bench/wta_powerset_4,3,2_0.7_190_0.coalgebra
83M bench/wta_powerset_4,3,2_0.7_190_1.coalgebra
83M bench/wta_powerset_4,3,2_0.7_190_2.coalgebra
83M bench/wta_powerset_4,3,2_0.7_190_3.coalgebra
83M bench/wta_powerset_4,3,2_0.7_190_4.coalgebra
```

## 2. Automaton Size

```
python bench.py run ../../copar/bin/copar --monoid powerset --symbols 4,3,2 --zero-frequency 0.7 --states 190 --indiv --header
```

i	states	edges	initial-partition-size	final-partition-size	explicit-final-partition-size	size1-skipped	overall-duration	parse-duration	algorithm-duration	initialize-duration	refine-duration
0	4150153	12416791	11	72964	190	7474719	141.894074912	32.94816078	104.894412823	19.27142335	73.292672481
1	4149881	12415853	11	72964	190	7374059	143.936708293	32.959668876	106.847647981	19.335579933	74.389142529
2	4147912	12410153	11	72964	190	7530637	143.039477927	32.922891848	106.049882108	19.238034371	73.786648681
3	4149832	12415896	11	72964	190	7400820	141.899762867	32.763790399	105.08945468	19.081253852	73.103108932
4	4147931	12410198	11	72964	190	7356721	142.277553489	33.004372363	105.135364747	19.217062907	72.82642293

### 1.1.5 GHC 8.4.4 with symbols 0,0,0,0,0,3 and zero-freq 0.7

```
./bench.py bisect ../../copar/bin/{random-wta,copar} --monoid powerset --symbols 0,0,0,0,0,3 --zero-frequency 0.7 --start-states 2
```

```
Trying 2...
Trying 4...
Trying 8...
Trying 16...
Trying 12...
Trying 10...
Trying 11...
First bad state count: 12
```

## 1. File Size

```
ls -sh bench/wta_powerset_0,0,0,0,0,3_0.7_11*
```

```
47M bench/wta_powerset_0,0,0,0,0,3_0.7_11_0.coalgebra
47M bench/wta_powerset_0,0,0,0,0,3_0.7_11_1.coalgebra
47M bench/wta_powerset_0,0,0,0,0,3_0.7_11_2.coalgebra
47M bench/wta_powerset_0,0,0,0,0,3_0.7_11_3.coalgebra
47M bench/wta_powerset_0,0,0,0,0,3_0.7_11_4.coalgebra
```

## 2. Automaton Size

```
python bench.py run ../../copar/bin/copar --monoid powerset --symbols 0,0,0,0,0,3 --zero-frequency 0.7 --states 11 --indiv --header
```

i	states	edges	initial-partition-size	final-partition-size	explicit-final-partition-size	size1-skipped	overall-duration	parse-duration	algorithm-duration	initialize-duration	refine-duration
0	1593503	9560952	5	98	2	0	44.433319213	19.470309466	24.352231629	11.34834025	10.606600771
1	1594688	9568062	5	98	2	0	44.35660646	19.503070403	24.284648797	11.546398372	10.351405421
2	1595746	9574410	5	98	2	0	44.979436845	19.622696684	24.756055326	11.448256352	10.958179969
3	1594811	9568800	5	98	2	0	44.518512407	19.486959131	24.465812029	11.501689163	10.63837111
4	1595187	9571056	5	98	2	0	44.449440224	19.537019031	24.300846734	11.389487771	10.5363747

## 1.2 Z,max

### 1.2.1 GHC 8.4.4 with symbols 0,8 and zero-freq 0.7

```
./bench.py bisect ../../copar/bin/{random-wta,copar} --monoid 'Z,max' --symbols 0,8 --zero-frequency 0.7
```

```
Trying 50...
Trying 100...
Trying 200...
Trying 400...
Trying 800...
Trying 1600...
Trying 1200...
Trying 1400...
Trying 1500...
Trying 1450...
Trying 1475...
Trying 1462...
Trying 1456...
Trying 1453...
Trying 1451...
First bad state count: 1451
```

#### 1. File Size

```
ls -sh bench/wta_Z,max_0,8_0.7_1450*
```

```
182M bench/wta_Z,max_0,8_0.7_1450_0.coalgebra
182M bench/wta_Z,max_0,8_0.7_1450_1.coalgebra
182M bench/wta_Z,max_0,8_0.7_1450_2.coalgebra
182M bench/wta_Z,max_0,8_0.7_1450_3.coalgebra
182M bench/wta_Z,max_0,8_0.7_1450_4.coalgebra
```

#### 2. Automaton Size

```
python bench.py run ../../copar/bin/copar --monoid 'Z,max' --symbols 0,8 --zero-frequency 0.7 --states 1450 --indiv --header
```

i	states	edges	initial-partition-size	final-partition-size	explicit-final-partition-size	size1-skipped	overall-duration	parse-duration	algorithm-duration	initialize-duration	refine-duration
0	5047826	10092752	1458	13050	1450	9457197	127.724360284	43.258927035	81.171137974	26.874901612	40.422676395
1	5047514	10092128	1458	13050	1450	9456756	125.832804664	42.853972016	79.686342664	26.577174808	39.966384527
2	5049772	10096644	1458	13050	1450	9460968	126.336593045	42.68312591	80.349875424	26.745235991	40.031230363
3	5046916	10090932	1458	13050	1450	9455805	125.95962352	42.526542018	80.176310943	26.550162046	40.227319833
4	5049229	10095558	1458	13050	1450	9460347	126.718920083	42.559013501	80.863052096	26.756405734	40.145229524

### 1.2.2 GHC 8.4.4 with symbols 1,0,4 and zero-freq 0.7

```
./bench.py bisect ../../copar/bin/{random-wta,copar} --monoid 'Z,max' --symbols 1,0,4 --zero-frequency 0.7
```

```
Trying 50...
Trying 100...
Trying 200...
Trying 150...
Trying 175...
Trying 162...
Trying 156...
Trying 153...
Trying 151...
First bad state count: 151
```

```
ls -sh bench/wta_Z,max_1,0,4_0.7_150*
```

#### 1. File Size

```
162M bench/wta_Z,max_1,0,4_0.7_150_0.coalgebra
162M bench/wta_Z,max_1,0,4_0.7_150_1.coalgebra
162M bench/wta_Z,max_1,0,4_0.7_150_2.coalgebra
162M bench/wta_Z,max_1,0,4_0.7_150_3.coalgebra
162M bench/wta_Z,max_1,0,4_0.7_150_4.coalgebra
```

## 2. Automaton Size

```
python bench.py run ../../copar/bin/copar --monoid 'Z,max' --symbols 1,0,4 --zero-frequency 0.7 --states 150 --indiv --header
```

i	states	edges	initial-partition-size	final-partition-size	explicit-final-partition-size	size1-skipped	overall-duration	parse-duration	algorithm-duration	initialize-duration	refine-duration
0	4051480	12153896	155	90151	150	7087519	120.395749162	40.871788157	74.90886142	22.238988672	39.72932804
1	4050707	12151583	155	90151	150	7087488	120.463605814	40.81720097	75.096220332	22.78192433	39.512466086
2	4048842	12145992	155	90151	150	7083654	120.367574362	40.847872293	74.879748499	22.174812232	39.882652278
3	4052208	12156090	155	90151	150	7090069	120.237306821	40.747046417	74.945644255	22.185753095	39.520022235
4	4048823	12145929	155	90151	150	7084229	121.046334089	41.206127141	75.236966807	22.108849249	39.746848148

### 1.2.3 GHC 8.4.4 with symbols 4,3,2 and zero-freq 0.7

```
./bench.py bisect ../../copar/bin/{random-wta,copar} --monoid 'Z,max' --symbols 4,3,2 --zero-frequency 0.7 --start-states 100
```

```
Trying 100...
Trying 200...
Trying 150...
Trying 175...
Trying 187...
Trying 193...
Trying 190...
Trying 188...
Trying 189...
First bad state count: 189
```

## 1. File Size

```
ls -sh bench/wta_Z,max_4,3,2_0.7_188*
```

```
162M bench/wta_Z,max_4,3,2_0.7_188_0.coalgebra
162M bench/wta_Z,max_4,3,2_0.7_188_1.coalgebra
162M bench/wta_Z,max_4,3,2_0.7_188_2.coalgebra
162M bench/wta_Z,max_4,3,2_0.7_188_3.coalgebra
162M bench/wta_Z,max_4,3,2_0.7_188_4.coalgebra
```

## 2. Automaton Size

```
python bench.py run ../../copar/bin/copar --monoid 'Z,max' --symbols 4,3,2 --zero-frequency 0.7 --states 188 --indiv --header
```

i	states	edges	initial-partition-size	final-partition-size	explicit-final-partition-size	size1-skipped	overall-duration	parse-duration	algorithm-duration	initialize-duration	refine-duration
0	4020872	12029832	197	71444	188	6045852	115.942447016	40.75075879	71.271681594	18.625916768	39.91853539
1	4017121	12018620	197	71444	188	6040501	113.960683621	40.210261362	69.908854506	18.715510494	39.429755908
2	4017092	12018743	197	71444	188	6040038	114.417975118	40.056454421	70.449543532	18.443439893	39.714702929
3	4013171	12006729	197	71444	188	6034912	104.421419394	40.426583126	60.116296609	10.279226244	37.258447268
4	4018149	12021895	197	71444	188	6042204	104.595285757	40.484957759	60.29935373	10.313693438	37.315322541

### 1.2.4 GHC 8.4.4 with symbols 0,0,0,0,3 and zero-freq 0.7

```
./bench.py bisect ../../copar/bin/{random-wta,copar} --monoid 'Z,max' --symbols 0,0,0,0,3 --zero-frequency 0.7 --start-states 6
```

```
Trying 6...
Trying 12...
Trying 9...
Trying 10...
Trying 11...
First bad state count: 12
```

## 1. File Size

```
ls -sh bench/wta_Z,max_0,0,0,0,0,3_0.7_11*
```

```
79M bench/wta_Z,max_0,0,0,0,0,3_0.7_11_0.coalgebra
79M bench/wta_Z,max_0,0,0,0,0,3_0.7_11_1.coalgebra
79M bench/wta_Z,max_0,0,0,0,0,3_0.7_11_2.coalgebra
79M bench/wta_Z,max_0,0,0,0,0,3_0.7_11_3.coalgebra
79M bench/wta_Z,max_0,0,0,0,0,3_0.7_11_4.coalgebra
```

## 2. Automaton Size

```
python bench.py run ../../copar/bin/copar --monoid 'Z,max' --symbols 0,0,0,0,0,3 --zero-frequency 0.7 --states 11 --indiv --header
```

i	states	edges	initial-partition-size	final-partition-size	explicit-final-partition-size	size1-skipped	overall-duration	parse-duration	algorithm-duration	initialize-duration	refine-duration
0	1595450	9572634	14	473731	11	2679440	59.567674089	22.815217966	34.656233896	10.712862563	21.527223791
1	1596274	9577578	14	473599	11	2680789	59.667949978	22.964709813	34.595654672	10.671440318	21.504327033
2	1593533	9561132	14	473725	11	2676188	59.60896951	22.965296594	34.468009878	10.694780509	21.357284246
3	1593597	9561516	14	473516	11	2675256	59.618517937	22.900218752	34.517770264	10.699678956	21.404437124
4	1595682	9574026	14	473759	11	2679419	59.829033166	22.84743033	34.719394797	10.690592405	21.632768706

## 1.3 Word,or

### 1.3.1 GHC 8.4.4 with symbols 0,8 and zero-freq 0.7

```
./bench.py bisect ../../copar/bin/{random-wta,copar} --monoid 'Word,or' --symbols 0,8 --zero-frequency 0.7 --start-states 1000
```

```
Trying 1000...
Trying 2000...
Trying 1500...
Trying 1250...
Trying 1375...
Trying 1437...
Trying 1406...
Trying 1421...
Trying 1413...
Trying 1409...
Trying 1407...
Trying 1408...
First bad state count: 1409
```

## 1. File Size

```
ls -sh bench/wta_Word,or_0,8_0.7_1408*
```

```
164M bench/wta_Word,or_0,8_0.7_1408_0.coalgebra
164M bench/wta_Word,or_0,8_0.7_1408_1.coalgebra
165M bench/wta_Word,or_0,8_0.7_1408_2.coalgebra
165M bench/wta_Word,or_0,8_0.7_1408_3.coalgebra
165M bench/wta_Word,or_0,8_0.7_1408_4.coalgebra
```

## 2. Automaton Size

```
python bench.py run ../../copar/bin/copar --monoid 'Word,or' --symbols 0,8 --zero-frequency 0.7 --states 1408 --indiv --header
```

i	states	edges	initial-partition-size	final-partition-size	explicit-final-partition-size	size1-skipped	overall-duration	parse-duration	algorithm-duration	initialize-duration	refine-duration
0	4757493	9512170	1416	12672	1408	8913294	122.529064018	49.673619826	69.872621378	24.487186873	37.636595831
1	4757305	9511794	1416	12672	1408	8912679	121.871882143	49.468009438	69.396700752	24.548033181	37.526833514
2	4760364	9517912	1416	12672	1408	8918643	122.195401637	49.367139075	69.859922188	24.551202679	37.745627532
3	4760232	9517648	1416	12672	1408	8918564	121.744240716	49.628682967	69.111452032	24.573090085	37.819264634
4	4759753	9516690	1416	12672	1408	8917624	118.671354206	49.213411686	66.440058464	25.139216435	33.058420248

### 1.3.2 GHC 8.4.4 with symbols 1,0,4 and zero-freq 0.7

```
./bench.py bisect ../../copar/bin/{random-wta,copar} --monoid 'Word,or' --symbols 1,0,4 --zero-frequency 0.7 --start-states 120
```

```
Trying 120...
Trying 240...
Trying 180...
Trying 150...
Trying 135...
Trying 142...
Trying 146...
Trying 148...
Trying 149...
First bad state count: 149
```

#### 1. File Size

```
ls -sh bench/wta_Word,or_1,0,4_0.7_148*
```

```
151M bench/wta_Word,or_1,0,4_0.7_148_0.coalgebra
151M bench/wta_Word,or_1,0,4_0.7_148_1.coalgebra
151M bench/wta_Word,or_1,0,4_0.7_148_2.coalgebra
151M bench/wta_Word,or_1,0,4_0.7_148_3.coalgebra
151M bench/wta_Word,or_1,0,4_0.7_148_4.coalgebra
```

#### 2. Automaton Size

```
python bench.py run ../../copar/bin/copar --monoid 'Word,or' --symbols 1,0,4 --zero-frequency 0.7 --states 148 --indiv --header
```

i	states	edges	initial-partition-size	final-partition-size	explicit-final-partition-size	size1-skipped	overall-duration	parse-duration	algorithm-duration	initialize-duration	refine-duration
0	3889583	11668189	153	87765	148	6805177	117.573809962	44.159477335	69.176479615	20.97881901	36.97313268
1	3891836	11675004	153	87765	148	6809318	118.060187599	44.059742822	69.709799716	20.986764025	37.089169403
2	3889498	11667962	153	87765	148	6805428	117.680086041	43.801892931	69.639925802	20.888711457	36.894495934
3	3890675	11671481	153	87765	148	6807190	118.213230214	44.026034118	69.934017821	20.807216331	36.920223682
4	3889335	11667465	153	87765	148	6804884	118.020940476	44.097067581	69.813347698	20.923033139	36.907214948

### 1.3.3 GHC 8.4.4 with symbols 4,3,2 and zero-freq 0.7

```
./bench.py bisect ../../copar/bin/{random-wta,copar} --monoid 'Word,or' --symbols 4,3,2 --zero-frequency 0.7
```

```
Trying 50...
Trying 100...
Trying 200...
Trying 150...
Trying 175...
Trying 187...
Trying 181...
Trying 184...
Trying 185...
Trying 186...
First bad state count: 187
```

#### 1. File Size

```
ls -sh bench/wta_Word,or_4,3,2_0.7_186*
```

```
152M bench/wta_Word,or_4,3,2_0.7_186_0.coalgebra
152M bench/wta_Word,or_4,3,2_0.7_186_1.coalgebra
152M bench/wta_Word,or_4,3,2_0.7_186_2.coalgebra
152M bench/wta_Word,or_4,3,2_0.7_186_3.coalgebra
152M bench/wta_Word,or_4,3,2_0.7_186_4.coalgebra
```

## 2. Automaton Size

```
python bench.py run ../../copar/bin/copar --monoid 'Word,or' --symbols 4,3,2 --zero-frequency 0.7 --states 186 --indiv --header
```

i	states	edges	initial-partition-size	final-partition-size	explicit-final-partition-size	size1-skipped	overall-duration	parse-duration	algorithm-duration	initialize-duration	refine-duration
0	3890269	11638838	195	69940	186	5848699	114.733470175	43.499787726	67.5948969	17.660572753	37.835620352
1	3893818	11649123	195	69940	186	5854005	114.756947419	43.702682275	67.505722972	17.675712966	37.818639736
2	3893265	11647592	195	69940	186	5854134	115.418354168	43.606980048	68.133828807	17.837028275	37.992011256
3	3892206	11644421	195	69940	186	5852423	113.998060941	43.769845642	66.618120946	17.720427448	37.714434677
4	3892036	11643814	195	69940	186	5851296	115.965290499	44.138476758	68.234040288	17.763408679	38.356640369

### 1.3.4 GHC 8.4.4 with symbols 0,0,0,0,3 and zero-freq 0.7

```
./bench.py bisect ../../copar/bin/{random-wta,copar} --monoid 'Word,or' --symbols 0,0,0,0,3 --zero-frequency 0.7 --start-states 6
```

Trying 6...

Trying 12...

Trying 9...

Trying 10...

Trying 11...

First bad state count: 12

#### 1. File Size

```
ls -sh bench/wta_Word,or_0,0,0,0,3_0.7_11*
```

```
77M bench/wta_Word,or_0,0,0,0,3_0.7_11_0.coalgebra
```

```
77M bench/wta_Word,or_0,0,0,0,3_0.7_11_1.coalgebra
```

```
77M bench/wta_Word,or_0,0,0,0,3_0.7_11_2.coalgebra
```

```
77M bench/wta_Word,or_0,0,0,0,3_0.7_11_3.coalgebra
```

```
77M bench/wta_Word,or_0,0,0,0,3_0.7_11_4.coalgebra
```

## 2. Automaton Size

```
python bench.py run ../../copar/bin/copar --monoid 'Word,or' --symbols 0,0,0,0,3 --zero-frequency 0.7 --states 11 --indiv --header
```

i	states	edges	initial-partition-size	final-partition-size	explicit-final-partition-size	size1-skipped	overall-duration	parse-duration	algorithm-duration	initialize-duration	refine-duration
0	1594413	9566412	14	473587	11	2676959	61.53939505	24.79942316	34.477272309	10.822832613	21.313535924
1	1596360	9578094	14	473404	11	2681034	61.147599248	24.824030133	34.101896988	10.793184	20.989457877
2	1595591	9573480	14	473700	11	2679546	61.459443653	24.801616514	34.389540062	10.893824596	21.133849133
3	1593825	9562884	14	473580	11	2676789	61.147557505	24.98879381	33.942496577	10.818043846	20.839884809
4	1596528	9579102	14	473600	11	2681048	61.864094058	24.884111862	34.762990208	10.893522867	21.485077775

## 2 Same Question, but with limited transition count

### 2.1 Powerset

#### 2.1.1 GHC 8.4.4 with symbols 0,8 and transitions 500

```
./bench.py bisect ../../copar/bin/{random-wta,copar} --monoid powerset --symbols 0,8 --transitions 5000
```

Trying 1000...

Trying 2000...

Trying 1500...

Trying 1250...

Trying 1375...

Trying 1437...

Trying 1468...

Trying 1484...

Trying 1476...

Trying 1480...

Trying 1478...

Trying 1479...

First bad state count: 1479

## 1. File Size

```
ls -sh bench/wta_powerset_0,8_0.7_1478*
```

```
82M bench/wta_powerset_0,8_0.7_1478_0.coalgebra
82M bench/wta_powerset_0,8_0.7_1478_1.coalgebra
82M bench/wta_powerset_0,8_0.7_1478_2.coalgebra
82M bench/wta_powerset_0,8_0.7_1478_3.coalgebra
82M bench/wta_powerset_0,8_0.7_1478_4.coalgebra
```

## 2. Automaton size

```
python bench.py run ../../copar/bin/copar --monoid powerset --symbols 0,8 --zero-frequency 0.7 --states 1478 --indiv --header
```

i	states	edges	initial-partition-size	final-partition-size	explicit-final-partition-size	size1-skipped	overall-duration	parse-duration	algorithm-duration	initialize-duration	refine-duration
0	5243856	10484756	10	18	2	0	115.339077581	34.439478263	79.458232767	27.712258503	37.668249537
1	5245405	10487854	10	18	2	0	114.001430765	34.477874858	78.07613373	27.764347556	37.074617863
2	5243549	10484142	10	18	2	0	114.862812706	34.668409012	78.756016051	27.741448159	37.09480403
3	5241660	10480364	10	18	2	0	114.228588077	34.362576104	78.424601434	27.648526393	37.043127108
4	5243032	10483108	10	18	2	0	114.692551901	34.827430372	78.414037199	27.723198479	38.276163878

### 2.1.2 GHC 8.4.4 with symbols 0,8 and out-degree 1000

```
./bench.py bisect ../../copar/bin/random-wta ../../copar/bin/copar --monoid powerset --symbols 0,8 --out-degree 1000 --good 1000
```

```
Trying 1001...
Trying 2002...
Trying 4004...
Trying 8008...
Trying 6006...
Trying 7007...
Trying 7507...
Trying 7257...
Trying 7382...
Trying 7444...
Trying 7413...
Trying 7428...
Trying 7420...
Trying 7416...
Trying 7414...
Trying 7415...
First bad state count: 7416
```

## 1. File Size

```
ls -sh bench/wta_powerset_0,8_t7415000__7415*
```

```
120M bench/wta_powerset_0,8_t7415000__7415_0.coalgebra
120M bench/wta_powerset_0,8_t7415000__7415_1.coalgebra
120M bench/wta_powerset_0,8_t7415000__7415_2.coalgebra
120M bench/wta_powerset_0,8_t7415000__7415_3.coalgebra
120M bench/wta_powerset_0,8_t7415000__7415_4.coalgebra
```

## 2. Automaton Size

```
python bench.py run ../../copar/bin/copar --monoid powerset --symbols 0,8 --transitions 7415000 --states 7415 --indiv --header
```

i	states	edges	initial-partition-size	final-partition-size	explicit-final-partition-size	size1-skipped	overall-duration	parse-duration	algorithm-duration	initialize-duration	refine-duration
0	7422415	14830000	10	18	2	0	157.872966092	51.221314999	104.615248956	33.7012898	58.664739269
1	7422415	14830000	10	18	2	0	157.428380106	51.433510926	103.926494829	33.216537153	58.775334589
2	7422415	14830000	10	18	2	0	156.808413994	51.343226544	103.40051371	32.969125294	58.865798525
3	7422415	14830000	10	18	2	0	157.791363724	51.873644617	103.855838314	33.05713406	58.931293578
4	7422415	14830000	10	18	2	0	157.126256596	51.400301031	103.666329167	32.976280595	58.830566981

### 3 Next Try

We now use the following parameters:

**Signature**  $4 \times X^k$   $k \in \{0, \dots, 5\}$

**GHC** 8.4.4

#### 3.1 Powerset

##### 3.1.1 $4 \times X$ mit out-degree 500

```
./bench.py bisect ../../copar/bin/random-wta ../../copar/bin/copar --monoid powerset --symbols 0,4 --out-degree 500 --good 8000 --start-states 12000 --bad 16000
```

```
Trying 12000...
Trying 14000...
Trying 15000...
Trying 14500...
Trying 14250...
Trying 14375...
Trying 14312...
Trying 14281...
Trying 14296...
Trying 14288...
Trying 14284...
Trying 14282...
First bad state count: 14282
```

##### 1. File Size

```
ls -sh bench/wta_powerset_0,4*_14281_* | tr " ," ",."
```

```
118M bench/wta_powerset0.4t7140500_142810.coalgebra
118M bench/wta_powerset0.4t7140500_142811.coalgebra
118M bench/wta_powerset0.4t7140500_142812.coalgebra
118M bench/wta_powerset0.4t7140500_142813.coalgebra
118M bench/wta_powerset0.4t7140500_142814.coalgebra
```

##### 2. Automaton Size

```
./bench.py generate ../../copar/bin/random-wta --monoid powerset --symbols 0,4 --out-degree 500 --states 14281
./bench.py run ../../copar/bin/copar --monoid powerset --symbols 0,4 --out-degree 500 --states 14281 --indiv --header
```

i	states	edges	initial-partition-size	final-partition-size	explicit-final-partition-size	size1-skipped	overall-duration	parse-duration	algorithm-duration	initialize-duration	refine-duration
0	7154781	14281000	6	10	2	0	155.635043092	50.511676534	103.239235361	30.135940008	61.445316625
1	7154781	14281000	6	10	2	0	155.345664537	50.391815858	103.046448356	29.52881681	61.823502784
2	7154781	14281000	6	10	2	0	154.746389702	50.356318464	102.487287332	29.561887582	61.245616512
3	7154781	14281000	6	10	2	0	156.681042711	50.477922803	104.306181251	30.132009036	62.231759233
4	7154781	14281000	6	10	2	0	156.206931801	50.552217812	103.775304876	30.106012782	61.793692847

##### 3.1.2 $4 \times X$ mit out-degree 20

```
./bench.py bisect ../../copar/bin/random-wta ../../copar/bin/copar --monoid powerset --symbols 0,4 --out-degree 20 --good 8000 --start-states 14281
```

```
Trying 14281...
Trying 28562...
Trying 57124...
Trying 114248...
Trying 228496...
Trying 456992...
Trying 342744...
Trying 399868...
```

```

Trying 371306...
Trying 357025...
Trying 349884...
Trying 353454...
Trying 355239...
Trying 356132...
Trying 355685...
Trying 355462...
Trying 355573...
Trying 355629...
Trying 355657...
Trying 355671...
Trying 355678...
Trying 355681...
Trying 355683...
Trying 355684...
First bad state count: 355685

```

1. File Size
2. Automaton Size

```

./bench.py generate ../../copar/bin/random-wta --monoid powerset --symbols 0,4 --out-degree 20 --states 355684
./bench.py run ../../copar/bin/copar --monoid powerset --symbols 0,4 --out-degree 20 --states 355684 --indiv --header

```

i	states	edges	initial-partition-size	final-partition-size	explicit-final-partition-size	size1-skipped	overall-duration	parse-duration	algorithm-duration	initialize-duration	refine-duration
0	7469364	14227360	6	1768728	355684	10883373	344.399732107	61.942569869	262.572157652	32.047148894	209.333188906
1	7469364	14227360	6	1768935	355684	10883077	340.732038227	60.912573518	260.176273796	31.928906963	208.837646082
2	7469364	14227360	6	1768908	355684	10885631	340.838739608	61.120402905	260.008098908	31.951679391	208.775189688
3	7469364	14227360	6	1768880	355684	10880372	340.237713603	61.448840572	259.027481579	31.936433445	207.318948419
4	7469364	14227360	6	1768875	355684	10886155	342.792217839	61.487509806	261.434824046	32.045849362	209.995181997

### 3.1.3 4xX mit out-degree 50

```

./bench.py bisect ../../copar/bin/random-wta ../../copar/bin/copar --monoid powerset --symbols 0,4 --out-degree 50 --good 130000 --bad 140000

```

```

Trying 135000...
Trying 132500...
Trying 131250...
Trying 131875...
Trying 132187...
Trying 132031...
Trying 132109...
Trying 132148...
Trying 132167...
Trying 132177...
Trying 132182...
Trying 132179...
Trying 132178...
First bad state count: 132179

```

1. File Size

```

ls -sh bench/wta_powerset_0,4*_132178_* | tr " ," ". ."

```

```

117M bench/wta_powerset0.4t6608900_1321780.coalgebra
117M bench/wta_powerset0.4t6608900_1321781.coalgebra
117M bench/wta_powerset0.4t6608900_1321782.coalgebra
117M bench/wta_powerset0.4t6608900_1321783.coalgebra
117M bench/wta_powerset0.4t6608900_1321784.coalgebra

```

2. Automaton Size

```
./bench.py generate ../../copar/bin/random-wta --monoid powerset --symbols 0,4 --out-degree 50 --states 132177
./bench.py run ../../copar/bin/copar --monoid powerset --symbols 0,4 --out-degree 50 --states 132177 --indiv --header
```

i	states	edges	initial-partition-size	final-partition-size	explicit-final-partition-size	size1-skipped	overall-duration	parse-duration	algorithm-duration	initialize-duration	refine-duration
0	6741027	13217700	6	660882	132177	9323005	265.849947508	53.024255888	200.012469965	32.711091055	156.049078211
1	6741027	13217700	6	660884	132177	9336757	266.027492928	53.656205959	199.630533624	33.784156055	154.30670604
2	6741027	13217700	6	660885	132177	9295860	266.131064164	53.031692734	200.333990554	33.839128343	154.752397766
3	6741027	13217700	6	660882	132177	9287608	266.57863175	53.338030998	200.492577153	33.341400299	155.694877544
4	6741027	13217700	6	660884	132177	9347998	265.39360727	52.816564437	199.812521066	33.25935421	155.166041015

### 3.1.4 4xX<sup>2</sup> mit out-degree 50

```
./bench.py bisect ../../copar/bin/random-wta ../../copar/bin/copar --monoid powerset --symbols 0,0,4 --out-degree 50 --start-states 80000
```

```
Trying 80000...
Trying 160000...
Trying 120000...
Trying 100000...
Trying 90000...
Trying 95000...
Trying 97500...
Trying 98750...
Trying 98125...
Trying 98437...
Trying 98593...
Trying 98671...
Trying 98632...
Trying 98651...
Trying 98661...
Trying 98666...
Trying 98668...
Trying 98669...
Trying 98670...
First bad state count: 98671
```

#### 1. File Size

```
ls -sh bench/wta_powerset_0,0,4*_98670_* | tr " ," ". "
```

```
123M bench/wta_powerset0.0.4t4933500_986700.coalgebra
123M bench/wta_powerset0.0.4t4933500_986701.coalgebra
123M bench/wta_powerset0.0.4t4933500_986702.coalgebra
123M bench/wta_powerset0.0.4t4933500_986703.coalgebra
123M bench/wta_powerset0.0.4t4933500_986704.coalgebra
```

#### 2. Automaton Size

```
./bench.py generate ../../copar/bin/random-wta --monoid powerset --symbols 0,0,4 --out-degree 50 --states 98670
./bench.py run ../../copar/bin/copar --monoid powerset --symbols 0,0,4 --out-degree 50 --states 98670 --indiv --header
```

i	states	edges	initial-partition-size	final-partition-size	explicit-final-partition-size	size1-skipped	overall-duration	parse-duration	algorithm-duration	initialize-duration	refine-duration
0	5032170	14800500	6	5031861	98670	11563672	318.18771425	46.231443471	259.512847417	31.400595851	212.323222545
1	5032170	14800500	6	5031879	98670	11565958	318.887658897	46.483533968	259.856085361	31.407316023	212.38857748
2	5032170	14800500	6	5031848	98670	11565284	318.529242826	46.499900763	259.501330137	31.347128979	210.955648567
3	5032170	14800500	6	5031845	98670	11558234	317.809993575	46.522121526	258.840719384	31.371523591	211.925301877
4	5032170	14800500	6	5031882	98670	11551538	316.309936896	46.212332602	257.508264904	31.362333309	210.039264838

### 3.1.5 $4xX^3$ mit out-degree 50

```
./bench.py bisect ../../copar/bin/random-wta ../../copar/bin/copar --monoid powerset --symbols 0,0,0,4 --out-degree 50 --start-states 60000
```

```
Trying 60000...
Trying 120000...
Trying 90000...
Trying 75000...
Trying 82500...
Trying 86250...
Trying 84375...
Trying 85312...
Trying 84843...
Trying 85077...
Trying 84960...
Trying 85018...
Trying 84989...
Trying 85003...
Trying 85010...
Trying 85014...
Trying 85016...
Trying 85017...
First bad state count: 85018
```

#### 1. File Size

```
ls -sh bench/wta_powerset_0,0,0,4*_85017_* | tr " ," ",."
```

```
138M  bench/wta_powerset0.0.0.4t4250850_850170.coalgebra
```

#### 2. Automaton Size

```
./bench.py generate ../../copar/bin/random-wta --monoid powerset --symbols 0,0,0,4 --out-degree 50 --states 85016
./bench.py run ../../copar/bin/copar --monoid powerset --symbols 0,0,0,4 --out-degree 50 --states 85016 --indiv --header
```

i	states	edges	initial-partition-size	final-partition-size	explicit-final-partition-size	size1-skipped	overall-duration	parse-duration	algorithm-duration	initialize-duration	refine-duration
0	4335816	17003200	6	4335816	85016	11932210	261.096600392	47.614392976	203.643561011	20.446586332	167.587154416

### 3.1.6 $4xX^4$ mit out-degree 50

```
./bench.py bisect ../../copar/bin/random-wta ../../copar/bin/copar --monoid powerset --symbols 0,0,0,0,4 --out-degree 50 --start-states 48000
```

```
Trying 48000...
Trying 96000...
Trying 72000...
Trying 60000...
Trying 54000...
Trying 57000...
Trying 58500...
Trying 59250...
Trying 59625...
Trying 59437...
Trying 59531...
Trying 59578...
Trying 59601...
Trying 59589...
Trying 59595...
Trying 59598...
Trying 59596...
First bad state count: 59596
```

#### 1. File Size

```
ls -sh bench/wta_powerset_0,0,0,0,4*_59596_* | tr " ," ",."
```

119M bench/wta\_powerset0.0.0.0.4t2979800\_595960.coalgebra

## 2. Automaton Size

```
./bench.py generate ../../copar/bin/random-wta --monoid powerset --symbols 0,0,0,0,4 --out-degree 50 --states 59596
./bench.py run ../../copar/bin/copar --monoid powerset --symbols 0,0,0,0,4 --out-degree 50 --states 59596 --indiv --header
```

i	states	edges	initial-partition-size	final-partition-size	explicit-final-partition-size	size1-skipped	overall-duration	parse-duration	algorithm-duration	initialize-duration	refine-duration
0	3039396	14899000	6	3039396	59596	13024716	200.034099951	41.065064963	152.485306449	25.383501709	121.316305478

### 3.1.7 4xX<sup>5</sup> mit out-degree 50

```
./bench.py bisect ../../copar/bin/random-wta ../../copar/bin/copar --monoid powerset --symbols 0,0,0,0,0,4 --out-degree 50 --start-states 40000
```

```
Trying 40000...
Trying 80000...
Trying 60000...
Trying 50000...
Trying 45000...
Trying 47500...
Trying 48750...
Trying 49375...
Trying 49687...
Trying 49531...
Trying 49453...
Trying 49414...
Trying 49394...
Trying 49384...
Trying 49379...
Trying 49377...
Trying 49376...
First bad state count: 49376
```

## 1. File Size

```
ls -sh bench/wta_powerset_0,0,0,0,0,4*_49375_* | tr " ," ",."
```

116M bench/wta\_powerset0.0.0.0.0.4t2468750\_493750.coalgebra

## 2. Automaton Size

```
./bench.py generate ../../copar/bin/random-wta --monoid powerset --symbols 0,0,0,0,0,4 --out-degree 50 --states 49375
./bench.py run ../../copar/bin/copar --monoid powerset --symbols 0,0,0,0,0,4 --out-degree 50 --states 49375 --indiv --header
```

i	states	edges	initial-partition-size	final-partition-size	explicit-final-partition-size	size1-skipped	overall-duration	parse-duration	algorithm-duration	initialize-duration	refine-duration
0	2518125	14812500	6	2518125	49375	13940781	164.986249384	38.769441334	119.843574846	24.415685672	90.703821725

## 3.2 Z,max

### 3.2.1 4xX mit out-degree 50 und different-values 50

```
./bench.py bisect ../../copar/bin/random-wta ../../copar/bin/copar --monoid Z,max --symbols 0,4 --out-degree 50 --good 100000 --bad 130000 --different-values 50
```

```
Trying 115000...
Trying 107500...
Trying 111250...
Trying 113125...
Trying 114062...
Trying 114531...
```

```
Trying 114765...
Trying 114882...
Trying 114941...
Trying 114911...
Trying 114896...
Trying 114889...
Trying 114885...
Trying 114887...
Trying 114888...
First bad state count: 114889
```

#### 1. File Size

```
ls -sh bench/wta_Z,max_0,4*_114888_* | tr " ," ",."
```

```
122M  bench/wtaZ,max0.4t5744400501148880.coalgebra
```

#### 2. Automaton Size

```
./bench.py generate ../../copar/bin/random-wta --monoid Z,max --symbols 0,4 --out-degree 50 --different-values 50 --states 114888
./bench.py run ../../copar/bin/copar --monoid Z,max --symbols 0,4 --out-degree 50 --different-values 50 --states 114888 --indiv --header
```

i	states	edges	initial-partition-size	final-partition-size	explicit-final-partition-size	size1-skipped	overall-duration	parse-duration	algorithm-duration	initialize-duration	refine-duration
0	5859288	11488800	416	574439	114888	6911761	181.011843864	58.957254337	111.080014285	34.573326846	66.278452727

### 3.2.2 $4xX^2$ mit out-degree 50 und different-values 50

```
./bench.py bisect ../../copar/bin/random-wta ../../copar/bin/copar --monoid Z,max --symbols 0,0,4 --out-degree 50 --good 50000 --bad 100000 --different-values 50
```

```
Trying 75000...
Trying 87500...
Trying 93750...
Trying 96875...
Trying 95312...
Trying 94531...
Trying 94921...
Trying 95116...
Trying 95214...
Trying 95263...
Trying 95287...
Trying 95299...
Trying 95293...
Trying 95290...
Trying 95288...
First bad state count: 95288
```

#### 1. File Size

```
ls -sh bench/wta_Z,max_0,0,4*_95287_* | tr " ," ",."
```

```
136M  bench/wtaZ,max0.0.4t476435050952870.coalgebra
```

#### 2. Automaton Size

```
./bench.py generate ../../copar/bin/random-wta --monoid Z,max --symbols 0,0,4 --out-degree 50 --different-values 50 --states 95287
./bench.py run ../../copar/bin/copar --monoid Z,max --symbols 0,0,4 --out-degree 50 --different-values 50 --states 95287 --indiv --header
```

i	states	edges	initial-partition-size	final-partition-size	explicit-final-partition-size	size1-skipped	overall-duration	parse-duration	algorithm-duration	initialize-duration	refine-duration
0	4859637	14293050	404	4859343	95287	7100778	222.092892824	54.223932252	154.676164911	30.811423501	108.364036654

### 3.2.3 $4xX^3$ mit out-degree und different-values 50

```
./bench.py bisect ../../copar/bin/random-wta ../../copar/bin/copar --monoid Z,max --symbols 0,0,0,4 --out-degree 50 --good 58471 --bad 73000 --different-values 50
```

```
Trying 65735...
Trying 69367...
Trying 71183...
Trying 70275...
Trying 70729...
Trying 70502...
Trying 70615...
Trying 70672...
Trying 70643...
Trying 70657...
Trying 70664...
Trying 70660...
Trying 70662...
Trying 70661...
First bad state count: 70661
```

#### 1. File Size

```
ls -sh bench/wta_Z,max_0,0,0,4*_70660_* | tr " ," ",."
```

```
127M  bench/wtaZ,max0.0.0.4t353300050706600.coalgebra
```

#### 2. Automaton Size

```
./bench.py generate ../../copar/bin/random-wta --monoid Z,max --symbols 0,0,0,4 --out-degree 50 --different-values 50 --states 70660
./bench.py run ../../copar/bin/copar --monoid Z,max --symbols 0,0,0,4 --out-degree 50 --different-values 50 --states 70660 --indiv --header
```

i	states	edges	initial-partition-size	final-partition-size	explicit-final-partition-size	size1-skipped	overall-duration	parse-duration	algorithm-duration	initialize-duration	refine-duration
0	3603660	14132000	397	3603660	70660	9226293	172.420794076	49.287429	115.080725376	25.88631871	82.245759651

### 3.2.4 $4xX^4$ mit out-degree und different-values 50

```
./bench.py bisect ../../copar/bin/random-wta ../../copar/bin/copar --monoid Z,max --symbols 0,0,0,0,4 --out-degree 50 --good 55181 --bad 73000 --different-values 50
```

```
Trying 64090...
Trying 59635...
Trying 61862...
Trying 62976...
Trying 62419...
Trying 62697...
Trying 62558...
Trying 62627...
Trying 62662...
Trying 62679...
Trying 62670...
Trying 62666...
Trying 62664...
Trying 62665...
First bad state count: 62666
```

#### 1. File Size

```
ls -sh bench/wta_Z,max_0,0,0,0,4*_62665_* | tr " ," ",."
```

```
136M  bench/wtaZ,max0.0.0.0.4t313325050626650.coalgebra
```

#### 2. Automaton Size

```
./bench.py generate ../../copar/bin/random-wta --monoid Z,max --symbols 0,0,0,0,4 --out-degree 50 --different-values 50 --states 62665
./bench.py run ../../copar/bin/copar --monoid Z,max --symbols 0,0,0,0,4 --out-degree 50 --different-values 50 --states 62665 --indiv --header
```

i	states	edges	initial-partition-size	final-partition-size	explicit-final-partition-size	size1-skipped	overall-duration	parse-duration	algorithm-duration	initialize-duration	refine-duration
0	3195915	15666250	397	3195915	62665	11627719	154.99753875	48.473165	98.758726744	26.2347205	66.312403669

### 3.2.5 4xX<sup>5</sup> mit out-degree und different-values 50

```
./bench.py bisect ../../copar/bin/random-wta ../../copar/bin/copar --monoid Z,max --symbols 0,0,0,0,0,4 --out-degree 50 --good 31000 --bad 55000 --different-values 50
```

```
Trying 43000...
Trying 49000...
Trying 52000...
Trying 50500...
Trying 49750...
Trying 50125...
Trying 49937...
Trying 49843...
Trying 49890...
Trying 49913...
Trying 49925...
Trying 49931...
Trying 49928...
Trying 49926...
Trying 49927...
First bad state count: 49927
```

#### 1. File Size

```
ls -sh bench/wta_Z,max_0,0,0,0,0,4*_49926_* | tr " ," ",."
```

```
127M  bench/wta_Z,max_0,0,0,0,0,4t249630050499260.coalgebra
```

#### 2. Automaton Size

```
./bench.py generate ../../copar/bin/random-wta --monoid Z,max --symbols 0,0,0,0,0,4 --out-degree 50 --different-values 50 --states 49926
./bench.py run ../../copar/bin/copar --monoid Z,max --symbols 0,0,0,0,0,4 --out-degree 50 --different-values 50 --states 49926 --indiv --header
```

i	states	edges	initial-partition-size	final-partition-size	explicit-final-partition-size	size1-skipped	overall-duration	parse-duration	algorithm-duration	initialize-duration	refine-duration
0	2546226	14977800	376	2546226	49926	11841832	129.05925319	44.887706321	78.246885415	20.851582498	52.50648174

## 3.3 Word,or

### 3.3.1 4xX mit out-degree und different-values 50

```
./bench.py bisect ../../copar/bin/random-wta ../../copar/bin/copar --monoid Word,or --symbols 0,4 --out-degree 50 --good 100000 --bad 130000 --different-values 50
```

```
Trying 115000...
Trying 107500...
Trying 111250...
Trying 113125...
Trying 114062...
Trying 113593...
Trying 113827...
Trying 113944...
Trying 114003...
Trying 113973...
Trying 113958...
Trying 113951...
Trying 113954...
Trying 113956...
Trying 113957...
First bad state count: 113958
```

#### 1. File Size

```
ls -sh bench/wta_Word,or_0,4*_113957_* | tr " ," ",."
```

## 2. Automaton Size

```
./bench.py generate ../../copar/bin/random-wta --monoid Word,or --symbols 0,4 --out-degree 50 --different-values 50 --states 113957
./bench.py run ../../copar/bin/copar --monoid Word,or --symbols 0,4 --out-degree 50 --different-values 50 --states 113957 --indiv --header
```

i	states	edges	initial-partition-size	final-partition-size	explicit-final-partition-size	size1-skipped	overall-duration	parse-duration	algorithm-duration	initialize-duration	refine-duration
0	5811807	11395700	54	569783	113957	11076343	223.763784071	61.587433127	152.359932717	32.126284469	109.721586786

3.3.2  $4xX^2$  mit out-degree und different-values 50

```
./bench.py bisect ../../copar/bin/random-wta ../../copar/bin/copar --monoid Word,or --symbols 0,0,4 --out-degree 50 --bad 93001 --good 80000 --different-values 50
```

```
Trying 86500...
Trying 89750...
Trying 91375...
Trying 92188...
Trying 92594...
Trying 92391...
Trying 92492...
Trying 92441...
Trying 92416...
Trying 92428...
Trying 92434...
Trying 92437...
Trying 92435...
First bad state count: 92435
```

## 1. File Size

```
ls -sh bench/wta_Word,or_0,0,4*_92434_* | tr " ," ".,"
```

## 2. Automaton Size

```
./bench.py generate ../../copar/bin/random-wta --monoid Word,or --symbols 0,0,4 --out-degree 50 --different-values 50 --states 92434
./bench.py run ../../copar/bin/copar --monoid Word,or --symbols 0,0,4 --out-degree 50 --different-values 50 --states 92434 --indiv --header
```

i	states	edges	initial-partition-size	final-partition-size	explicit-final-partition-size	size1-skipped	overall-duration	parse-duration	algorithm-duration	initialize-duration	refine-duration
0	4714134	13865100	54	4713833	92434	13286924	258.308924373	55.730150301	184.86496102	31.15297126	144.089898137

3.3.3  $4xX^3$  mit out-degree und different-values 50

```
./bench.py bisect ../../copar/bin/random-wta ../../copar/bin/copar --monoid Word,or --symbols 0,0,0,4 --out-degree 50 --good 67000 --bad 73000 --different-values 50
```

```
Trying 70000...
Trying 68500...
Trying 69250...
Trying 69625...
Trying 69437...
Trying 69531...
Trying 69578...
Trying 69601...
Trying 69613...
Trying 69619...
Trying 69622...
Trying 69623...
Trying 69624...
First bad state count: 69624
```

## 1. File Size

```
ls -sh bench/wta_Word,or_0,0,0,4*_69623_* | tr " ," ",."
```

132M bench/wtaWord,or0.0.0.4t348115050696230.coalgebra

## 2. Automaton Size

```
./bench.py generate ../../copar/bin/random-wta --monoid Word,or --symbols 0,0,0,4 --out-degree 50 --different-values 50 --states 69623
./bench.py run ../../copar/bin/copar --monoid Word,or --symbols 0,0,0,4 --out-degree 50 --different-values 50 --states 69623 --indiv --header
```

i	states	edges	initial-partition-size	final-partition-size	explicit-final-partition-size	size1-skipped	overall-duration	parse-duration	algorithm-duration	initialize-duration	refine-duration
0	3550773	13924600	54	3550773	69623	13715478	217.684389256	49.986173123	159.050504019	25.229488197	127.060520493

### 3.3.4 $4xX^4$ mit out-degree und different-values 50

```
./bench.py bisect ../../copar/bin/random-wta ../../copar/bin/copar --monoid Word,or --symbols 0,0,0,0,4 --out-degree 50 --bad 60001 --good 55000 --different-values 50
```

```
Trying 57500...
Trying 56250...
Trying 56875...
Trying 57187...
Trying 57343...
Trying 57265...
Trying 57304...
Trying 57323...
Trying 57313...
Trying 57318...
Trying 57320...
Trying 57319...
First bad state count: 57320
```

## 1. File Size

```
ls -sh bench/wta_Word,or_0,0,0,0,4*_57319_* | tr " ," ",."
```

130M bench/wtaWord,or0.0.0.0.4t286595050573190.coalgebra

## 2. Automaton Size

```
./bench.py generate ../../copar/bin/random-wta --monoid Word,or --symbols 0,0,0,0,4 --out-degree 50 --different-values 50 --states 57319
./bench.py run ../../copar/bin/copar --monoid Word,or --symbols 0,0,0,0,4 --out-degree 50 --different-values 50 --states 57319 --indiv --header
```

i	states	edges	initial-partition-size	final-partition-size	explicit-final-partition-size	size1-skipped	overall-duration	parse-duration	algorithm-duration	initialize-duration	refine-duration
0	2923269	14329750	54	2923269	57319	15469967	199.956928585	47.318311842	146.418279061	25.807646931	115.015762137

### 3.3.5 $4xX^5$ mit out-degree und different-values 50

```
./bench.py bisect ../../copar/bin/random-wta ../../copar/bin/copar --monoid Word,or --symbols 0,0,0,0,0,4 --out-degree 50 --good 48000 --bad 52000 --different-values 50
```

```
Trying 50000...
Trying 49000...
Trying 48500...
Trying 48750...
Trying 48875...
Trying 48937...
Trying 48968...
Trying 48952...
Trying 48960...
Trying 48964...
Trying 48962...
Trying 48963...
First bad state count: 48964
```

## 1. File Size

```
ls -sh bench/wta_Word,or_0,0,0,0,0,4*_48963_* | tr " ," ",."
```

129M bench/wtaWord,or0.0.0.0.0.4t244815050489630.coalgebra

## 2. Automaton Size

Aus irgendeinem Grund läuft jetzt 48963 auch schon ins memory limit, deswegen 48962

```
./bench.py generate ../../copar/bin/random-wta --monoid Word,or --symbols 0,0,0,0,0,4 --out-degree 50 --different-values 50 --states 48962
./bench.py run ../../copar/bin/copar --monoid Word,or --symbols 0,0,0,0,0,4 --out-degree 50 --different-values 50 --states 48962 --indiv --header
```

i	states	edges	initial-partition-size	final-partition-size	explicit-final-partition-size	size1-skipped	overall-duration	parse-duration	algorithm-duration	initialize-duration	refine-duration
0	2497062	14688600	54	2497062	48962	18284567	167.692238761	45.179623229	117.531354091	20.079035336	92.723851956

## 3.4 Summary

### 3.4.1 4xX

Monoid	States	States+Interm.	Edges	File Size	init part	final part	t <sub>p</sub>	t <sub>i</sub>	t <sub>r</sub>
powerset	132177	6741027	13217700	117 M	6	132177	53.024256	32.711091	156.04908
Z,max	114888	5859288	11488800	122 M	416	114888	58.957254	34.573327	66.278453
Word,or	113957	5811807	11395700	131 M	54	113957	61.587433	32.126284	109.72159

### 3.4.2 4xX<sup>2</sup>

Monoid	States	States+Interm.	Edges	File Size	init part	final part	t <sub>p</sub>	t <sub>i</sub>	t <sub>r</sub>
powerset	98670	5032170	14800500	123 M	6	98670	46.231443	31.400596	212.32322
Z,max	95287	4859637	14293050	136 M	404	95287	54.223932	30.811424	108.36404
Word,or	92434	4714134	13865100	141 M	54	92434	55.730150	31.152971	144.08990

### 3.4.3 4xx<sup>3</sup>

Monoid	States	States+Interm.	Edges	File Size	init part	final part	t <sub>p</sub>	t <sub>i</sub>	t <sub>r</sub>
powerset	85016	4335816	17003200	138 M	6	85016	47.614393	20.446586	167.58715
Z,max	70660	3603660	14132000	127 M	397	70660	49.287429	25.886319	82.245760
Word,or	69623	3550773	13924600	132 M	54	69623	49.986173	25.229488	127.06052

### 3.4.4 4xx<sup>4</sup>

Monoid	States	States+Interm.	Edges	File Size	init part	final part	t <sub>p</sub>	t <sub>i</sub>	t <sub>r</sub>
powerset	59596	3039396	14899000	119 M	6	59596	41.065065	25.383502	121.31631
Z,max	62665	3195915	15666250	136 M	397	62665	48.473165	26.234721	66.312404
Word,or	57319	2923269	14329750	130 M	54	57319	47.318312	25.807647	115.01576

### 3.4.5 4xx<sup>5</sup>

Monoid	States	States+Interm.	Edges	File Size	init part	final part	t <sub>p</sub>	t <sub>i</sub>	t <sub>r</sub>
powerset	49375	2518125	14812500	116 M	6	49375	38.769441	24.415686	90.703822
Z,max	49926	2546226	14977800	127 M	376	49926	44.887706	20.851582	52.506482
Word,or	48962	2497062	14688600	129 M	54	48962	45.179623	20.079035	92.723852