Case Study for Placement Solutions in ISPD11 and DAC12 Routability-Driven Placement Contests

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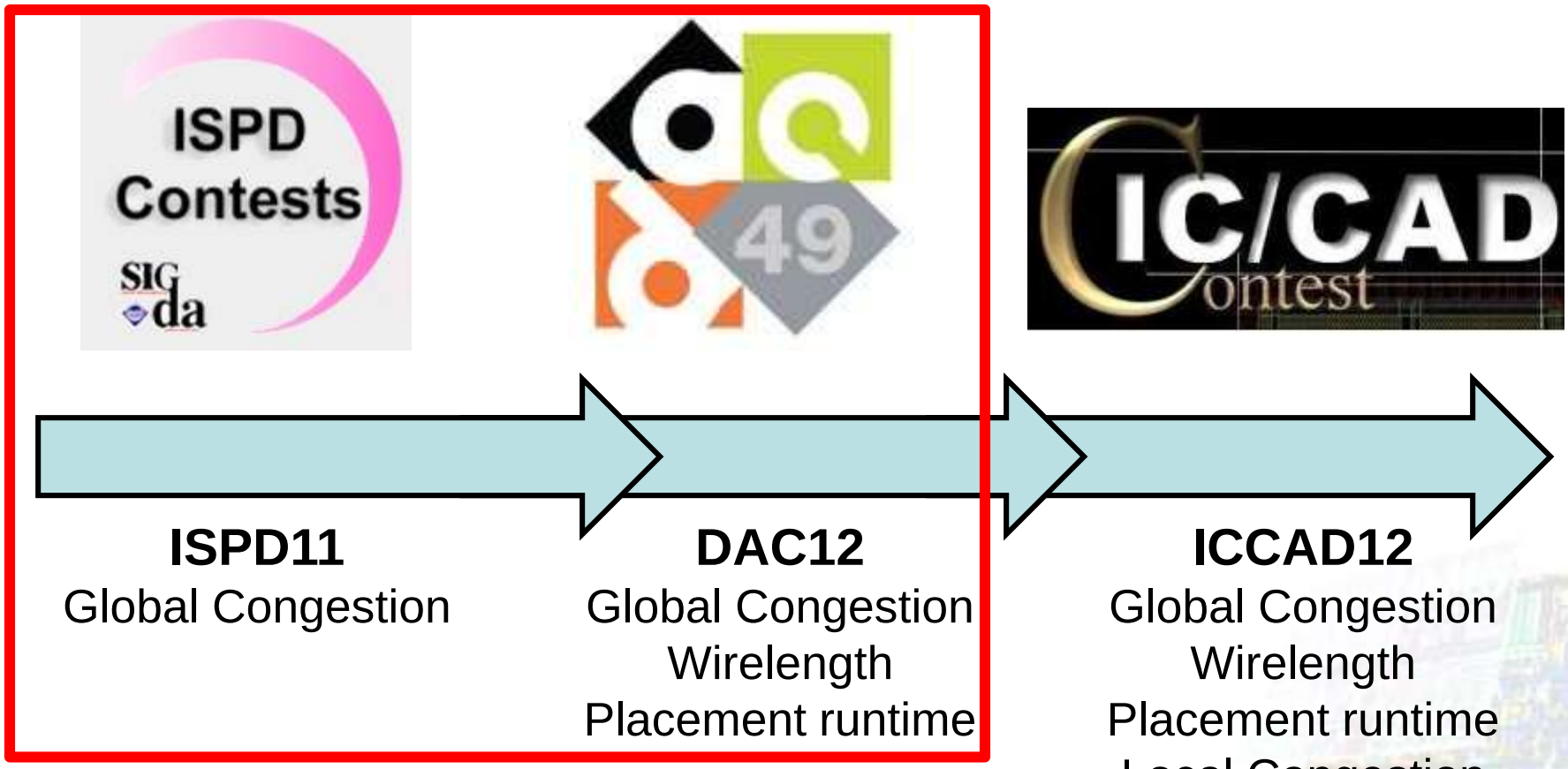
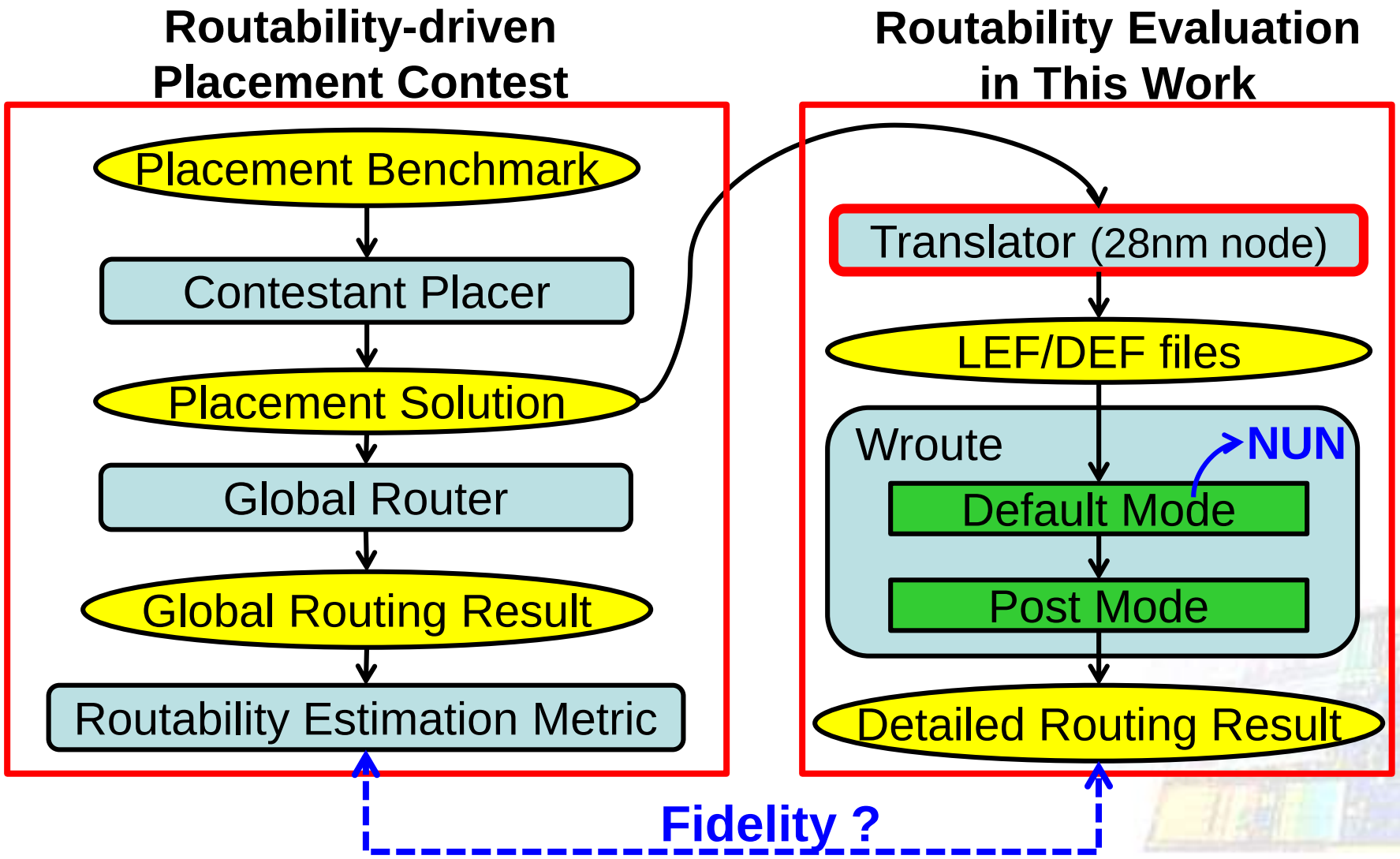
Routability-driven Placement Contest

- Routability-driven Placement contests:



Simulation Environment

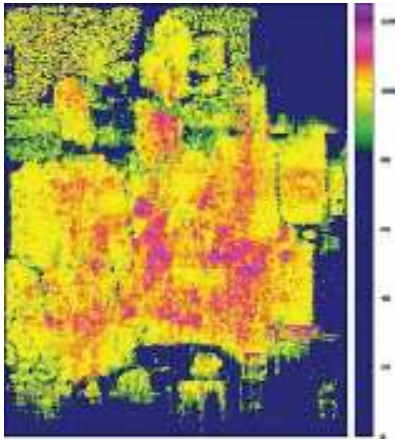


Routability Estimation Metrics

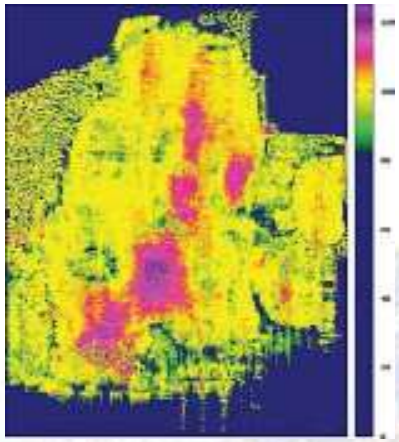
- ISPD placement contest
  - Invoked global router: coalesCgrip
  - Rank placement solutions by total overflow
- DAC placement contest
  - Invoked global router: NCTU-GR 2.0, BFG-R 2.0
  - Rank placement solutions by its score
  - Lower score means better routability

$$S(P) = HPWL(P) \times (1 + 0.03 \times PWC(G_P))$$

- P: Placement solution
- $HPWL(P)$: Half parameter wirelength
- $PWC(G_P)$: Congestion Metric



TOF=542786



TOF=513614

[1] N. Viswanathan et al, "The ISPD-2011 Routability-driven Placement Contest and Benchmark Suite", in Proc. ISPD, 2011.
[2] N. Viswanathan et al, "The DAC 2012 Routability-driven Placement contest and benchmark suite", in Pro. DAC, 2012.

ISPD11 Placement Solutions

Evaluate ISPD11 placement solutions by ISPD11 metric

Table1

	Total Overflow reported by CGRIP (ISPD11 metric)				Ranking by Total Overflow			
	$Ripple_i$	mPL_i	$SimPLR_i$	$NTUplace_i$	$Ripple_i$	mPL_i	$SimPLR_i$	$NTUplace_i$
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	4
s2	1128906	1849664	2138796	1453774	1	3	4	2
s4	118850	[illegible]	[illegible]	256632	1	2	4	3
s5	143580	[illegible]	[illegible]	[illegible]	[illegible]	3	2	4
s10	1010058	1159416	1311688	616424	2	3	4	1
s12	542786	2272764	514614	3147446	2	3	1	4
s15	143580	171184	345284	767310	1	2	3	4
s18	514886	52498	72426	470266	4	1	2	3
Average					**1.750**	**2.500**	**2.625**	**3.125**
					1	2	3	4

Evaluate ISPD11 placement solutions by their global routing results of Wroute

Table2

	NUN reported by Wroute				Ranking by NUN			
	$Ripple_i$	mPL_i	$SimPLR_i$	$NTUplace_i$	$Ripple_i$	mPL_i	$SimPLR_i$	$NTUplace_i$
s1	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	3
s2	1086	3228	1353	1273	1	4	3	2
s4	632	2983	989	2568	1	4	[illegible]	3
s5	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	4	2	[illegible]
s10	657	689	535	505	3	4	2	1
s12	501	2147	681	3866	1	3	2	4
s15	985	1850	2086	3719	1	2	3	4
s18	2515	1834	1701	2571	3	2	1	4
Average					**1.625**	**3.375**	**2.000**	**3.000**
					1	4	2	3

Evaluate ISPD11 placement solutions by the detailed routing results of Wroute

Table3

	Routing Violations reported by Wroute				Ranking by Routing Violations			
	$Ripple_i$	mPL_i	$SimPLR_i$	$NTUplace_i$	$Ripple_i$	mPL_i	$SimPLR_i$	$NTUplace_i$
s1	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	4
s2	820	40967	79293	241252	1	2	3	4
s4	242	2148	27740	496819	1	2	[illegible]	4
s5	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	3	4	[illegible]
s10	837	31801	4643	[illegible]	1	4	2	3
s12	179	7181846	657749	14152052	1	3	2	4
s15	118	117	6033	133975	2	1	3	4
s18	64478	165549	9818	309269	2	3	1	4
Average					**1.375**	**2.625**	**2.375**	**3.625**
					1	3	2	4

DAC12 Placement Solutions

Evaluate DAC12 placement solutions by DAC12 metric

$$S(P) = HPWL(P) \times (1 + 0.03 \times PWC(G_P))$$

Table4

	DAC12 metric (10^7)				Ranking by DAC12 metric			
	$Ripple_d$	mPL_d	$SimPLR_d$	$NTUplace_d$	$Ripple_d$	mPL_d	$SimPLR_d$	$NTUplace_d$
s2	[illegible]	[illegible]	87.67	[illegible]	2	4	3	1
s3	44.28	46.08	40.75	37.6	3	4	2	1
s6	36.93	41.12	36.94	36.68	2	4	3	1
s7	47	[illegible]	[illegible]	[illegible]	2	3	4	1
s9	30	[illegible]	[illegible]	26.7	3	4	2	1
s11	36.27	44.66	38.51	34.73	2	4	3	1
s12	37.38	53.03	37.69	31.68	2	4	3	1
s14	23.89	[illegible]	25.68	22.96	2	4	3	1
s16	27.23	30.7	35.81	28.27	1	3	4	2
s19	16.95	22.78	16.63	15.33	3	4	2	1
Average					**2.2** 2	**3.8** 4	**2.9** 3	**1.1** 1

Evaluate DAC12 placement solutions by the global routing results of Wroute

Table5

	NUN reported by Wroute				Ranking by NUN			
	$Ripple_d$	mPL_d	$SimPLR_d$	$NTUplace_d$	$Ripple_d$	mPL_d	$SimPLR_d$	$NTUplace_d$
s2	1743	[illegible]	[illegible]	[illegible]	[illegible]	3	1	4
s3	566	649	487	1450	2	3	1	4
s6	267	892	443	921	1	3	2	4
s7	[illegible]	[illegible]	518	419	3	4	2	1
s9	[illegible]	[illegible]	[illegible]	[illegible]	1	2	3	4
s11	115	531	979	313	1	3	4	2
s12	167	994	715	120	2	4	3	1
s14	1220	1717	1459	2352	1	3	2	4
s16	129	127	434	78	3	2	4	1
s19	518	811	510	414	3	4	2	1
Average					**1.9** 1	**3.1** 4	**2.4** 2	**2.6** 3

Evaluate DAC placement solutions by the detailed routing results of Wroute

Table6

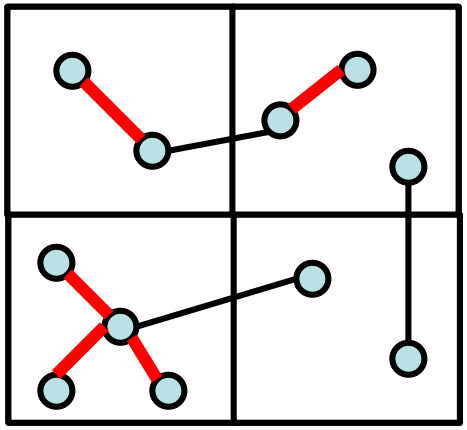
	Routing Violations reported by Wroute				Ranking by Routing Violations			
	$Ripple_d$	mPL_d	$SimPLR_d$	$NTUplace_d$	$Ripple_d$	mPL_d	$SimPLR_d$	$NTUplace_d$
s2	[illegible]	[illegible]	[illegible]	[illegible]	2	3	1	4
s3	243	231	194	988	3	2	1	4
s6	232	231	361	637	2	1	3	4
s7	[illegible]	[illegible]	[illegible]	[illegible]	3	2	4	1
s9	8136	68	22	89	4	2	1	3
s11	433	11009	1840	697	1	4	3	2
s12	155	343637	241	94	2	4	3	1
s14	19086	271799	224239	18446	2	4	3	1
s16	38	36	135	24	3	2	4	1
s19	110	276	72777	15114	1	2	4	3
Average					**2.3** 1	**2.6** 3	**2.7** 4	**2.4** 2

Big Mismatch

Effect of Local Routability

- Every DAC12 placement solution obtained by the top-4 placers has good **global routability**.
- **Local routability** becomes the primary issue to impact the routability of a placement solution.

Total Local Manhattan Wirelength (TLMW)



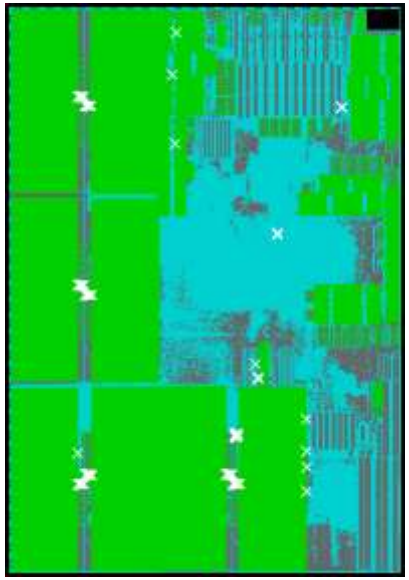
Global Routability

Local Routability

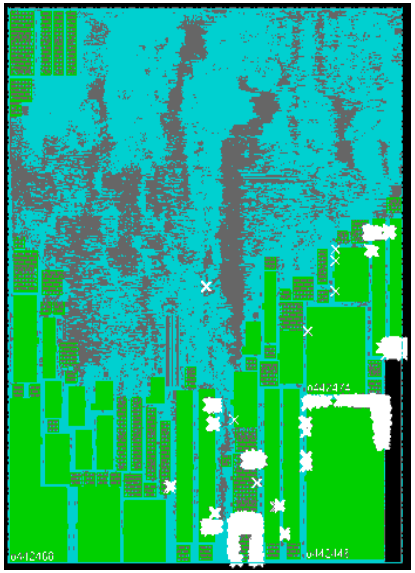
	$Ripple_d$	mPL_d	$SimPLR_d$	$NTUplace_d$
Ranking by DAC metric	2.2	3.8	2.9	1.1
Ranking by TLMW	3.0	1.1	2.2	3.7
Rank by routing violations	2.3	2.6	2.7	2.4

Blockage Impact

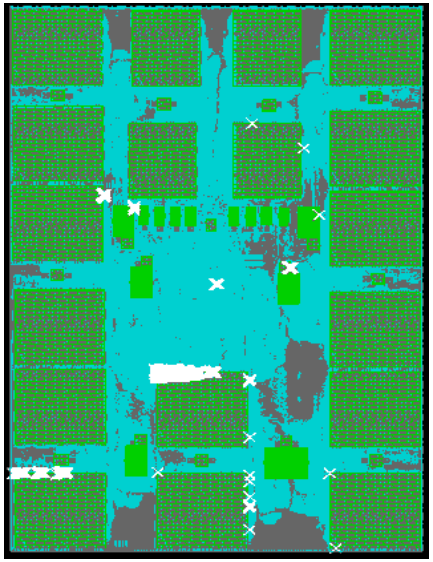
- According to observation, most routing violations are nears blockages.



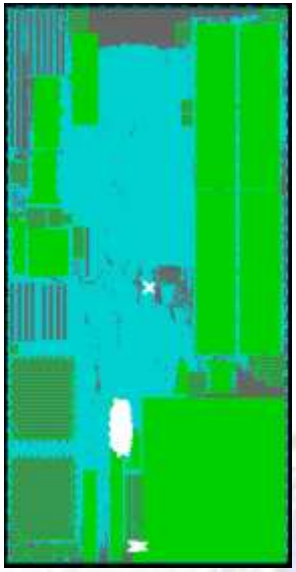
SimPLR$_i$ (s2)



Ripple$_i$ (s18)



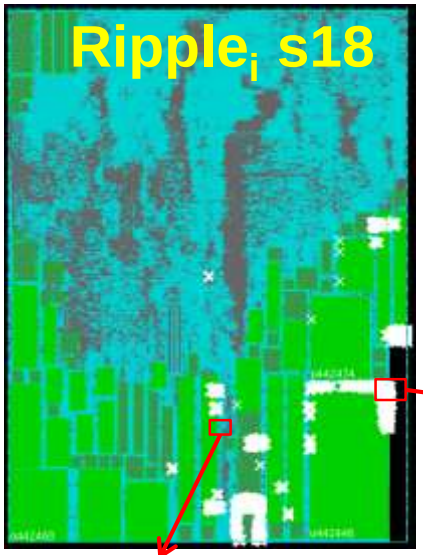
mPL$_i$ (s10)

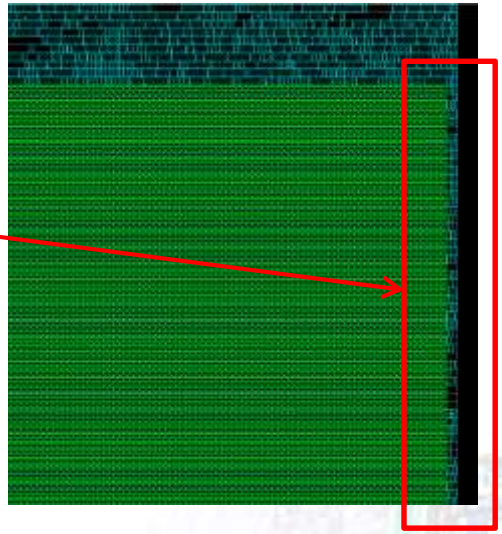


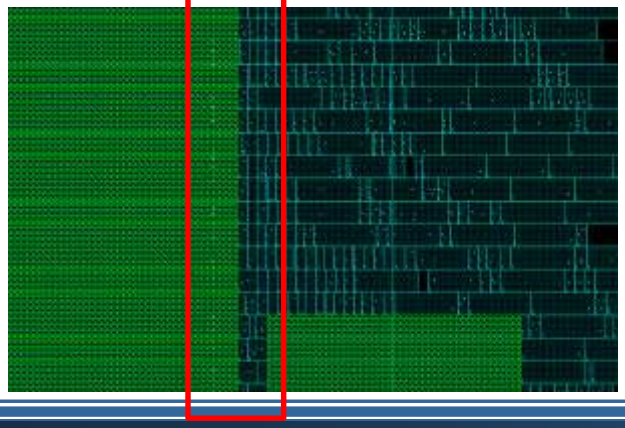
NTUplace$_d$ (s19)

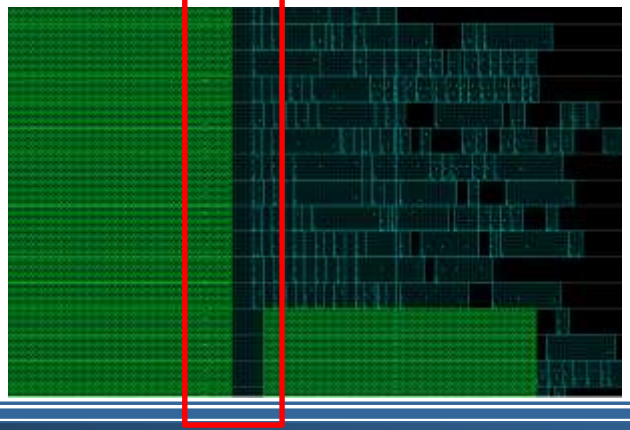
Deeply look violations

- Placing cells too close blockages causes violations.



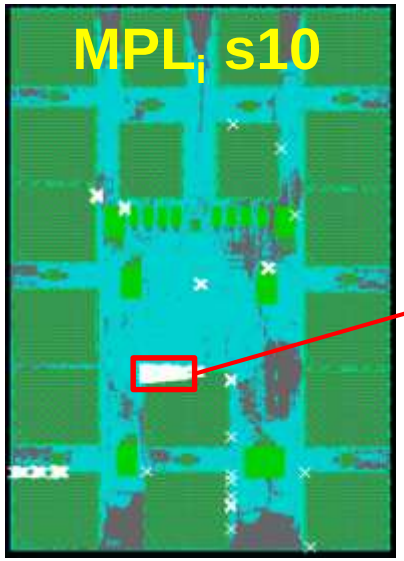


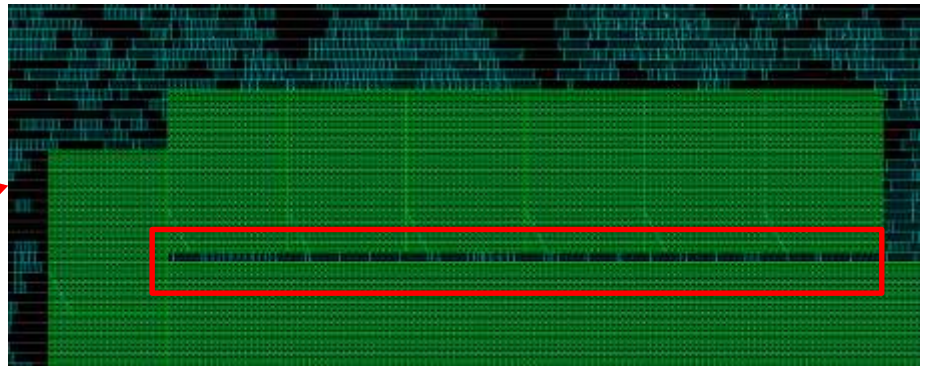


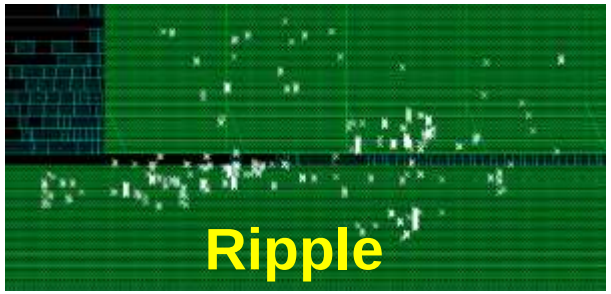


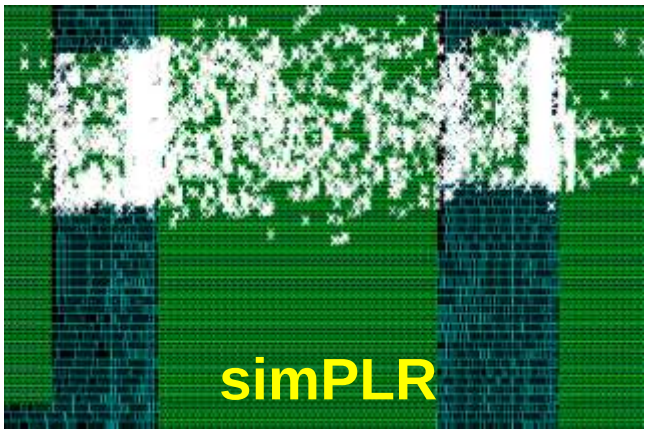
Deeply look violations

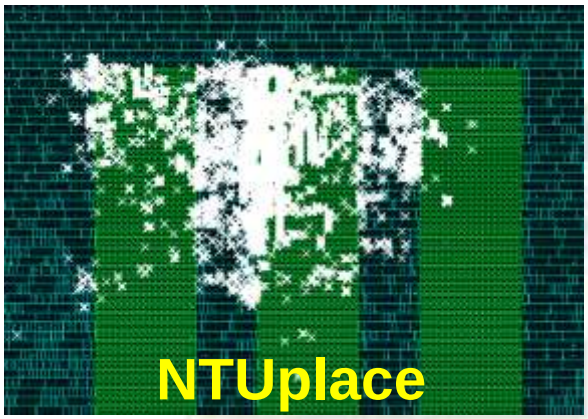
- Placing cells in the narrow easily causes violations.











Conclusions

- Feed the placement solutions of ISPD and DAC contests into Wroute to observe their detailed routing results
- Indicate the limitations of the contest metrics in predicting the local routability
- Take a closer look at where the routing violations occur

- Backup

ISPD Ripple v.s. DAC Ripple

- Evaluate **$Ripple_i$** and **$Ripple_d$** by **NCTU-GR 2.0**

	$Ripple_i$					$Ripple_d$				
	MOF	TOF	WL(10^5)	Via(10^5)	R_{NCTU}	MOF	TOF	WL(10^5)	Via(10^5)	R_{NCTU}
s1	0	0	97.73	46.17	133.58	0	0	94.73	46.85	180.1
s2	8	1802	248.49	65.32	4828.22	0	0	220.06	61.33	1137.73
s4	4	296	74.33	33.2	730.9	0	0	69.52	32.19	238.51
s5	2	4	128.66	46.94	724.46	0	0	121.15	45.71	588.25
s10	8	37212	217.09	71.46	42144.4	2	34	194.96	65.45	6685.29
s12	0	0	144.82	89.7	1552.61	0	0	131.11	82.68	861.86
s15	0	0	116.53	61.61	828.39	0	0	97.95	56.3	191.22
s18	16	108218	91.77	47.11	8813.48	0	0	65.13	36.64	233.67
$Ratio_{ind}$	**1**	**1**	**1**	**1**	**1**			**0.8860**	**0.9280**	**0.4617**
$Ratio_{sum}$	**1**	**1**	**1**	**1**	**1**	**0.0526**	**0.0002**	**0.8890**	**0.9260**	**0.1693**

- Evaluate **$Ripple_i$** and **$Ripple_d$** by **Wroute**

	$Ripple_i$					$Ripple_d$				
	NUM	Violation	WL(10^6)	Via(10^6)	R_{Wroute}	NUM	Violation	WL(10^6)	Via(10^6)	R_{Wroute}
s1	2070	99	337.00	10.23	09:58:37	830	45	331.31	10.25	09:29:02
s2	1086	820	788.32	12.75	14:40:57	1066	4989	719.11	12.61	18:05:02
s4	632	242	275.02	6.87	06:07:22	378	238	260.48	6.76	06:28:59
s5	1761	805	419.71	9.23	11:23:19	1248	506	395.49	8.98	10:59:48
s10	657	837	678.77	13.72	15:26:41	416	398	637.42	13.51	15:37:18
s12	501	179	552.46	18.24	11:23:43	992	78519	500.92	17.93	19:50:53
s15	985	118	447.10	13.7	09:12:07	270	195	372.82	12.92	08:02:07
s18	2515	64478	320.31	7.99	20:41:57	1311	31435	245.67	7.4	19:06:16
$Ratio_{ind}$	**1**	**1**	**1**	**1**	**1**	**0.7620**	**56.1770**	**0.9040**	**0.9730**	**1.0950**
$Ratio_{sum}$	**1**	**1**	**1**	**1**	**1**	**0.6380**	**1.7210**	**0.9070**	**0.9740**	**1.0880**

Detailed Routing Results

- ISPD11 Contest Benchmarks

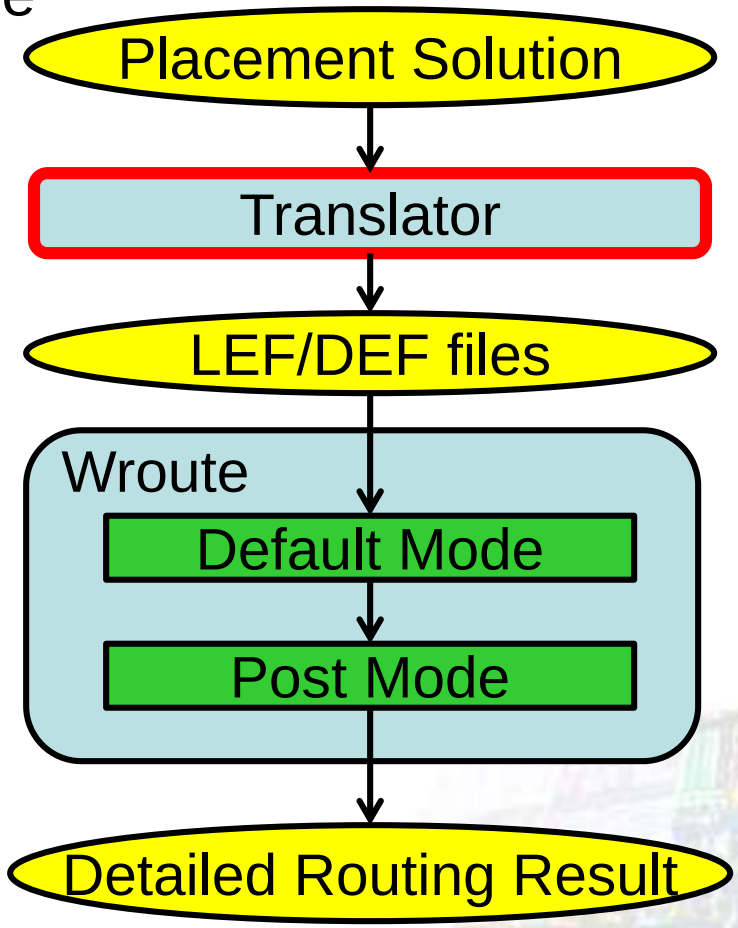
	Ripple$_i$			mPL$_i$			SimPLR$_i$			NTUplace$_i$		
	WL(10^7)	Via(10^6)	Runtime	WL(10^7)	Via(10^6)	Runtime	WL(10^7)	Via(10^6)	Runtime	WL(10^7)	Via(10^6)	Runtime
s1	33.70	10.23	09:58:37	35.04	10.81	11:29:32	34.05	10.24	08:17:36	36.71	11.19	16:45:59
s2	78.83	12.75	14:40:57	76.53	14.32	41:15:07	78.43	13.46	24:53:58	80.35	14.10	49:02:39
s4	27.50	6.87	06:07:22	27.35	7.46	11:15:59	31.69	7.28	13:20:42	25.92	7.32	48:30:12
s5	41.97	9.23	11:23:19	44.33	10.29	46:30:12	42.84	9.51	29:51:25	49.70	10.32	18:06:48
s10	67.88	13.72	15:26:41	68.82	14.86	22:25:37	67.59	13.71	17:30:56	65.66	14.83	28:59:10
s12	55.25	18.24	11:23:43	53.47	21.73	51:28:56	50.98	18.66	31:18:03	47.53	22.96	52:05:18
s15	44.71	13.70	09:12:07	40.46	13.78	09:16:59	43.75	13.89	14:32:30	40.13	13.91	29:07:13
s18	32.03	7.99	20:41:57	22.60	7.39	21:09:52	27.54	7.81	12:09:08	21.37	7.57	26:11:38
Ratio$_{ind}$	**1**	**1**	**1**	**0.957**	**1.073**	**2.236**	**0.992**	**1.020**	**1.672**	**0.953**	**1.085**	**3.176**
Ratio$_{sum}$	**1**	**1**	**1**	**0.965**	**1.085**	**2.172**	**0.987**	**1.020**	**1.536**	**0.962**	**1.102**	**2.718**

- DAC12 Contest Benchmarks

	Ripple$_d$			mPL$_d$			SimPLR$_d$			NTUplace$_d$		
	WL(10^7)	Via(10^6)	Runtime	WL(10^7)	Via(10^6)	Runtime	WL(10^7)	Via(10^6)	Runtime	WL(10^7)	Via(10^6)	Runtime
s2	72.77	12.67	32:26:26	80.08	13.40	40:44:26	69.67	12.47	14:37:14	67.80	12.28	48:33:08
s3	43.55	11.58	10:47:19	44.93	11.56	10:32:16	45.59	11.71	10:26:24	39.99	11.05	13:06:50
s6	40.96	11.77	10:35:16	45.42	12.22	10:13:03	41.54	11.80	10:26:33	39.17	11.49	11:02:01
s7	53.83	17.77	13:28:38	55.55	18.44	14:13:09	55.44	18.15	15:40:00	48.31	16.93	13:17:31
s9	32.46	10.03	09:21:58	34.22	10.32	08:34:57	31.09	9.94	08:53:54	29.19	9.62	08:49:18
s11	40.22	10.48	11:14:55	47.48	11.31	22:16:53	39.27	10.49	15:41:12	38.63	10.19	11:52:41
s12	47.13	17.91	12:05:03	47.58	19.18	48:49:04	46.98	17.80	12:04:46	42.73	17.01	11:26:41
s14	27.79	7.59	11:16:24	31.10	7.96	36:07:43	28.65	7.71	24:24:14	26.81	7.46	21:57:51
s16	29.17	7.92	06:13:12	31.90	8.00	07:11:05	30.31	7.97	06:42:16	29.19	7.72	06:59:38
s19	19.35	6.21	05:37:44	20.74	6.43	05:57:55	18.72	6.12	17:55:16	18.11	5.99	16:42:50
Ratio$_{ind}$	**1**	**1**	**1**	**1.080**	**1.040**	**1.661**	**1.002**	**1.001**	**1.334**	**0.937**	**0.966**	**1.373**
Ratio$_{sum}$	**1**	**1**	**1**	**1.078**	**1.043**	**1.662**	**1.000**	**1.002**	**1.112**	**0.933**	**0.963**	**1.331**

Simulation Environment

- Original benchmarks are unroutable to Wroute, so the proposed translator slightly modifies the benchmarks.



- Refer to 28*nm* technology node
  - Minimum wire width – 42 *nm*
  - Minimum spacing rule – 42 *nm*
  - Via size – 56 *nm* × 56 *nm*
  - Layers 1-4: 1X minimum wire width
  - Layers 5-7: 2X minimum wire width
  - Layers 8-9: 4X minimum wire width