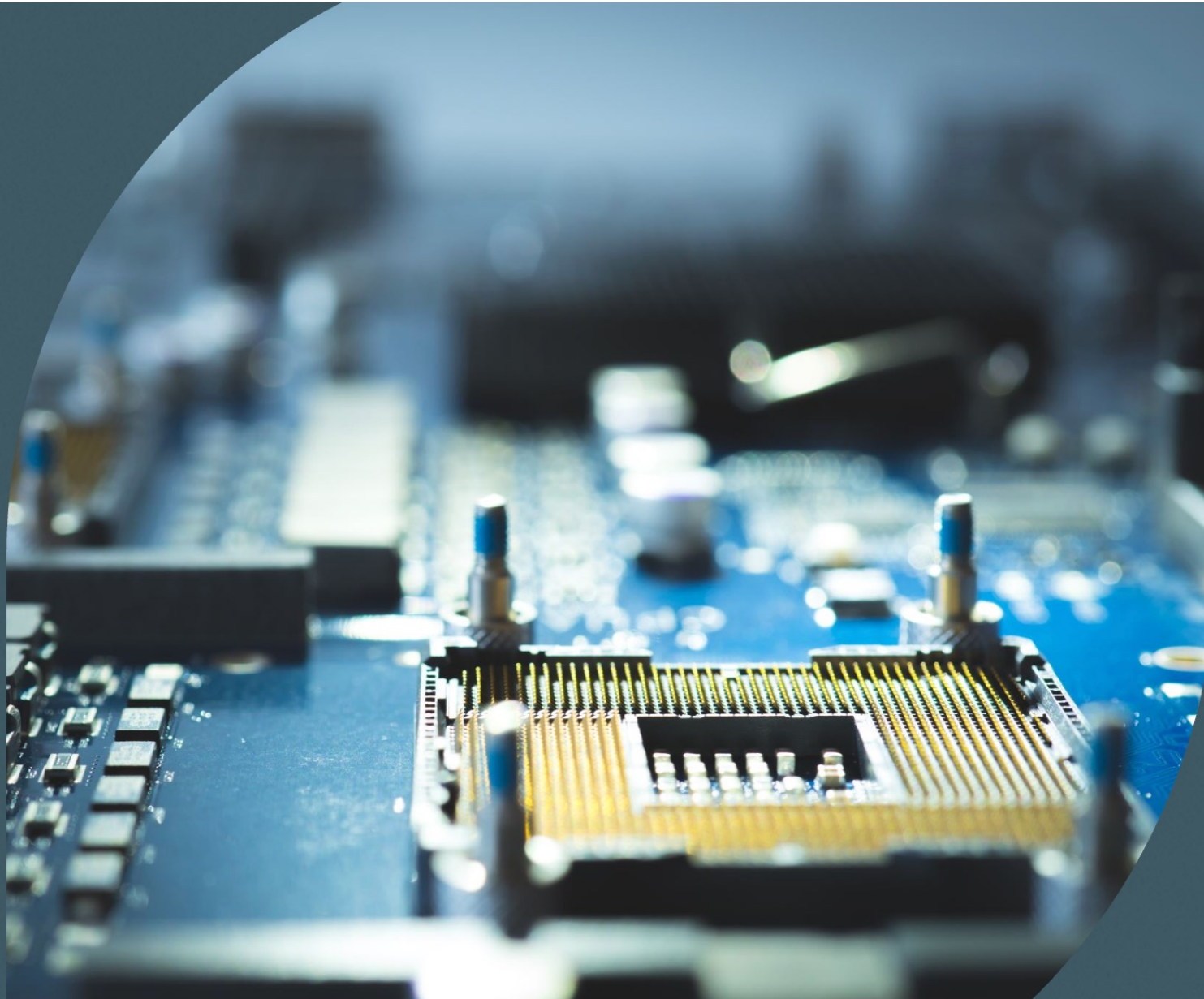


GPU Accelerated Routing

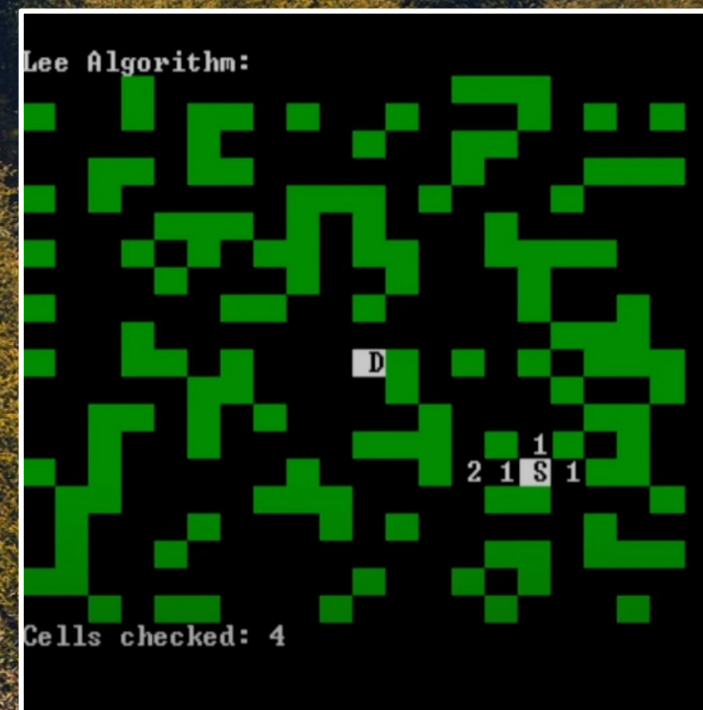
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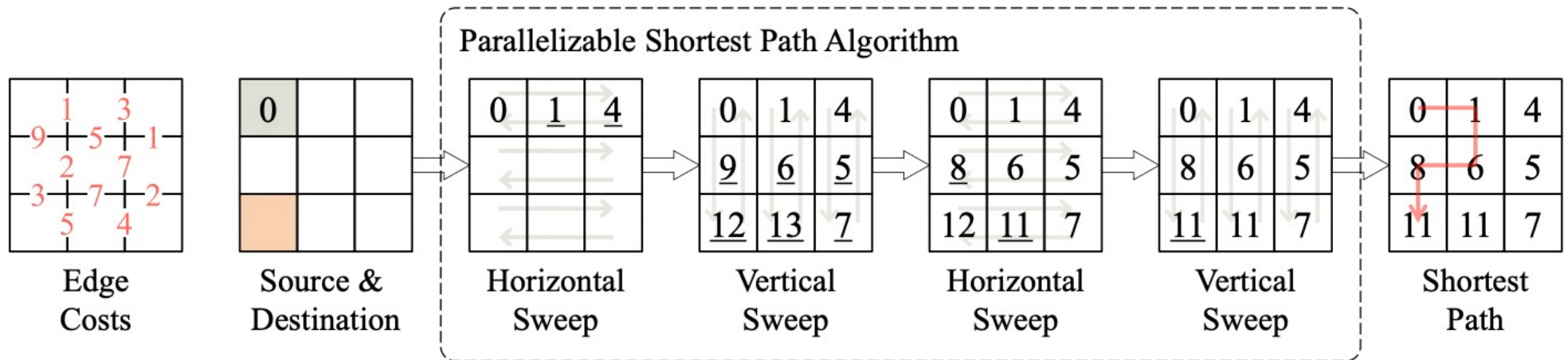
March 30, 2022



MAZE ROUTING



Maze Routing on GPU



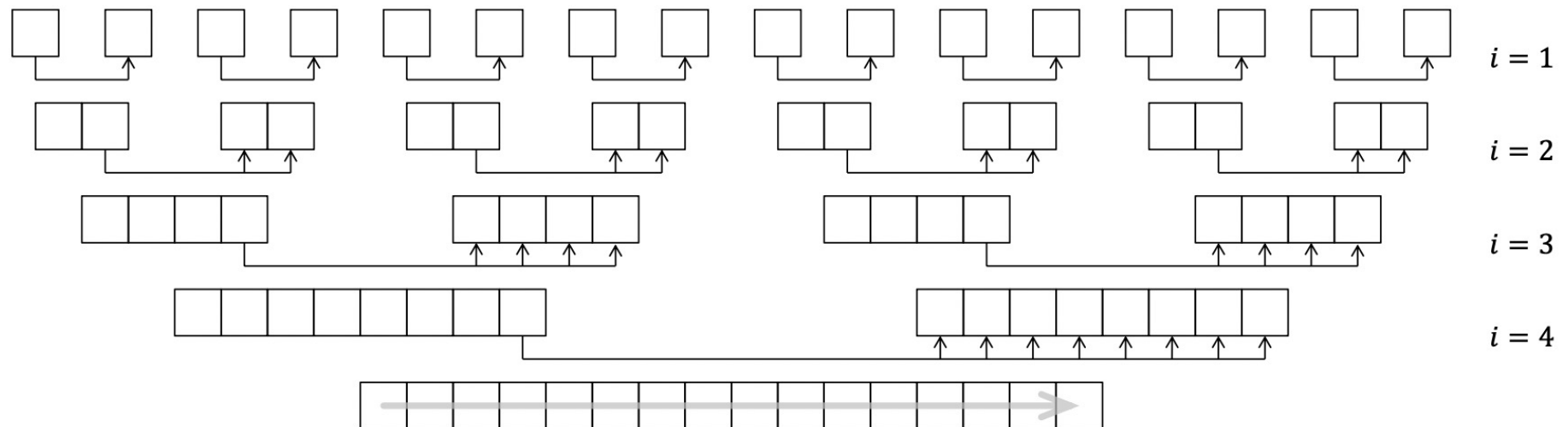
d_i : current shortest distance to G-cell i

c_i : wire cost between G-cell $i - 1$ and G-cell i

$$d_i^* = \min_{0 \leq j \leq i} \left(d_j + \sum_{k=j+1}^i c_k \right)$$

Parallel Sweep with Conditional Partial Sum

- ▶ Total work $O(n \log_2 n)$
- ▶ Running time $O(\log_2 n)$



Reformulation as a Work-Efficient Method

- ▶ Notations

- ▶ d_i : current shortest distance
- ▶ c_i : wire cost
- ▶ $s_i = \sum_{j=0}^i c_j$
- ▶ Original formulation

$$d_i^* = \min_{0 \leq j \leq i} \left(d_j + \sum_{k=j+1}^i c_k \right)$$

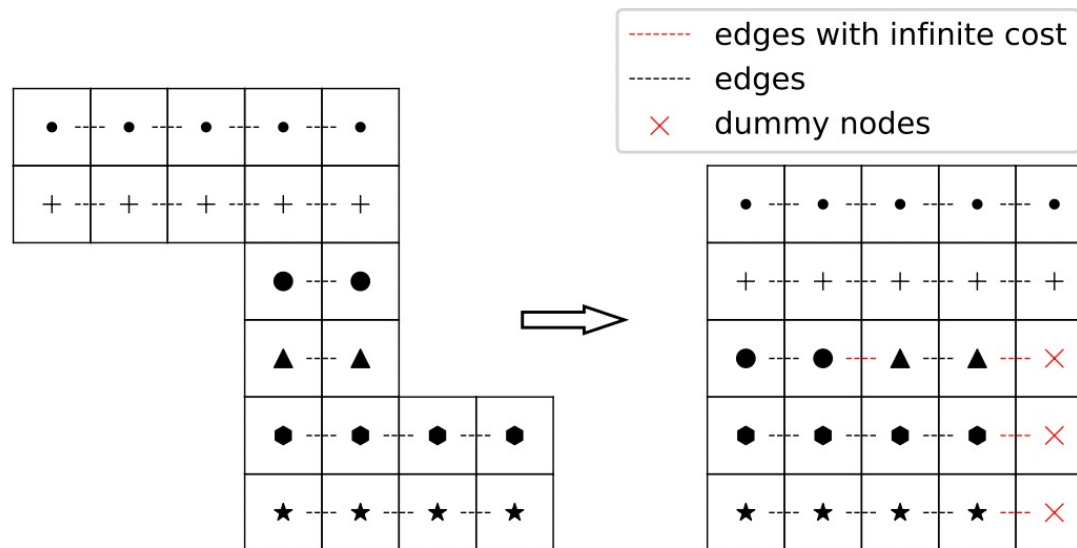
- ▶ New formulation

$$d_i^* - s_i = \min_{0 \leq j \leq i} (d_j - s_j)$$

- ▶ This new formulation is a prefix sum problem and a prefix min problem.

Irregular Routing Regions

- ▶ Solution: routing track extraction and placement
 - ▶ Rectilinear Regions to Rectangular ones
 - ▶ Dummy nodes & infinite cost



Speedup of 2D Maze Routing

- ▶ Sequential maze routing is implemented with priority queues.
- ▶ 11 alternations of sweeps in GAMER
- ▶ Directional change cost: 50
- ▶ Congestion cost:
 - ▶ 91% : $\{1, 2, 3\}$
 - ▶ 1% : $3 + 2^1$
 - ▶ 1% : $3 + 2^2$
 - ▶ ...
 - ▶ 1% : $3 + 2^9$

Grid Graph Size	#Pins	Runtime (s)		Speedup
		GAMER	Maze Routing	
256×256	4	0.07	1.29	17.36×
256×256	8	0.14	2.51	17.71×
256×256	16	0.29	4.93	17.25×
512×512	4	0.16	5.57	33.92×
512×512	8	0.25	11.44	45.14×
512×512	16	0.40	24.60	61.53×
1024×1024	4	0.34	30.40	90.02×
1024×1024	8	0.65	74.51	115.05×
1024×1024	16	1.25	152.52	121.78×

Apply in CUGR

Benchmarks	Coarse-Grained Time (s)			Fine-Grained Time (s)			Total Time (s)			Quality Score	
	CUGR	GAMER	Speedup	CUGR	GAMER	Speedup	CUGR	GAMER	Speedup	CUGR	GAMER
ispd18_test5	29.15	1.08	26.98	1.91	1.17	1.63	73.08	47.70	1.53	16104127	16146848
ispd18_test8	185.21	6.83	27.13	8.22	5.58	1.47	282.90	99.72	2.84	37937622	37982628
ispd18_test10	257.22	8.98	28.66	18.41	5.17	3.56	373.25	118.59	3.15	40593601	40942190
ispd19_test7	488.70	11.45	42.67	11.63	7.84	1.48	652.42	170.61	3.82	88481579	86843860
ispd19_test8	207.28	9.22	22.48	7.07	9.02	0.78	431.06	226.44	1.90	128287651	127394338
ispd19_test9	308.81	11.72	26.34	7.29	7.09	1.03	620.88	326.84	1.90	201500802	199734785
ispd18_test5_metal5	41.96	7.49	5.60	20.36	6.70	3.04	93.48	40.49	2.31	16206355	16258160
ispd18_test8_metal5	147.38	22.09	6.67	60.89	14.61	4.17	289.95	100.72	2.88	37313105	37334467
ispd18_test10_metal5	226.19	27.18	8.32	76.63	15.68	4.89	399.13	114.33	3.49	46068410	45991227
ispd19_test7_metal5	297.36	15.72	18.92	30.29	12.89	2.35	434.59	136.02	3.20	82368279	81140446
ispd19_test8_metal5	442.85	29.04	15.25	61.31	22.34	2.74	670.22	224.17	2.99	126219722	126706049
ispd19_test9_metal5	427.64	46.91	9.12	72.96	18.48	3.95	732.86	304.05	2.41	197686583	196779131
Average	19.85×			2.59×			2.70×			84897320	84437844



More GPU
Acceleration
in Routing?