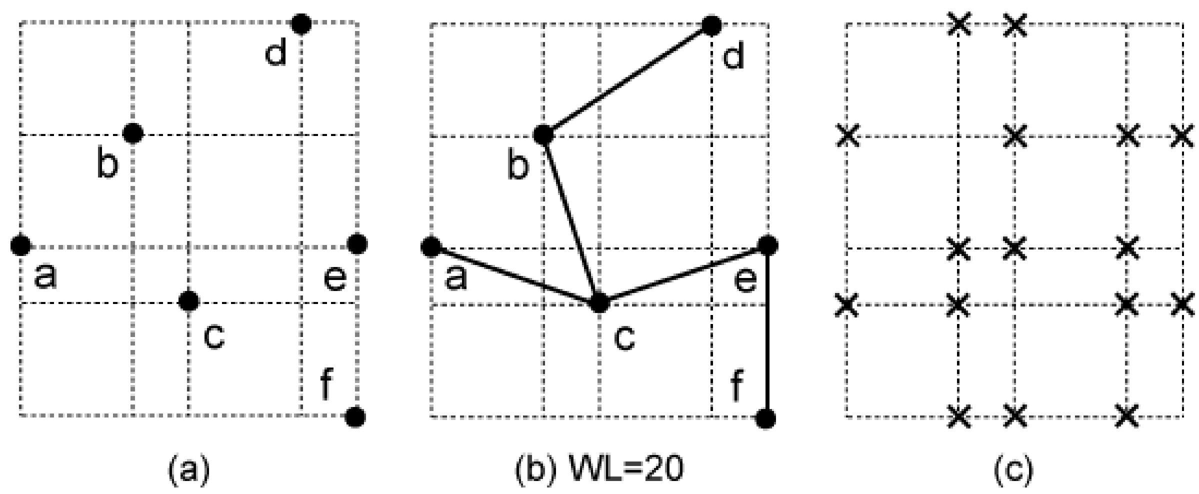
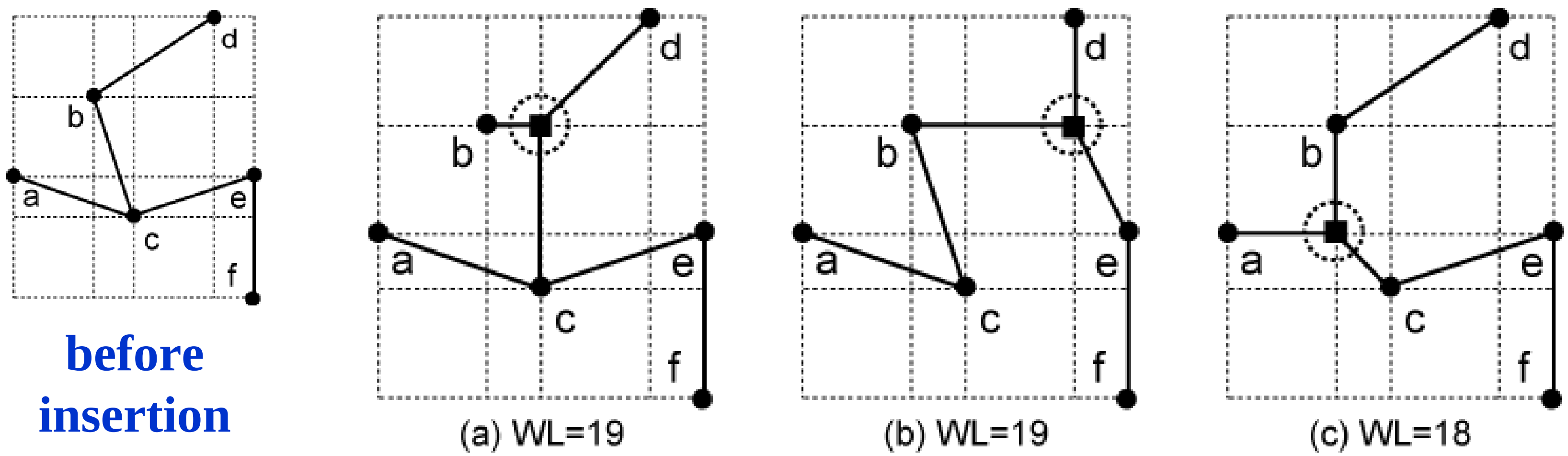
1-Steiner Routing by Kahng/Robins

- Perform 1-Steiner Routing by Kahng/Robins
  - Need an initial MST: wirelength is 20
  - 16 locations for Steiner points

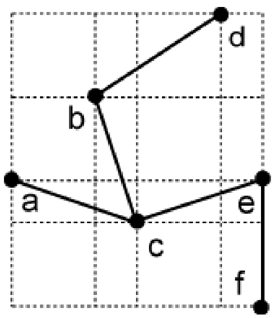


First 1-Steiner Point Insertion

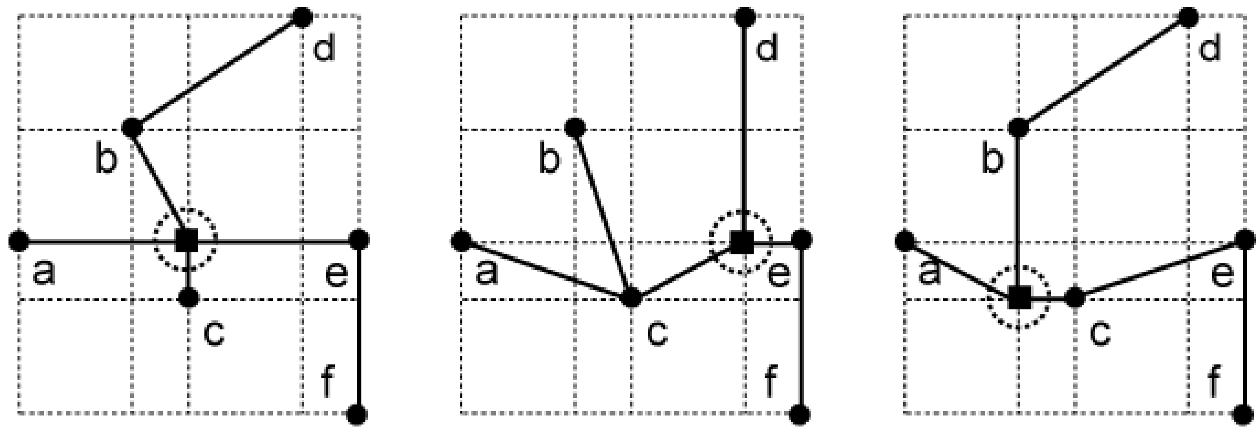
- There are six 1-Steiner points
  - Two best solutions: we choose (c) randomly



First 1-Steiner Point Insertion (cont)



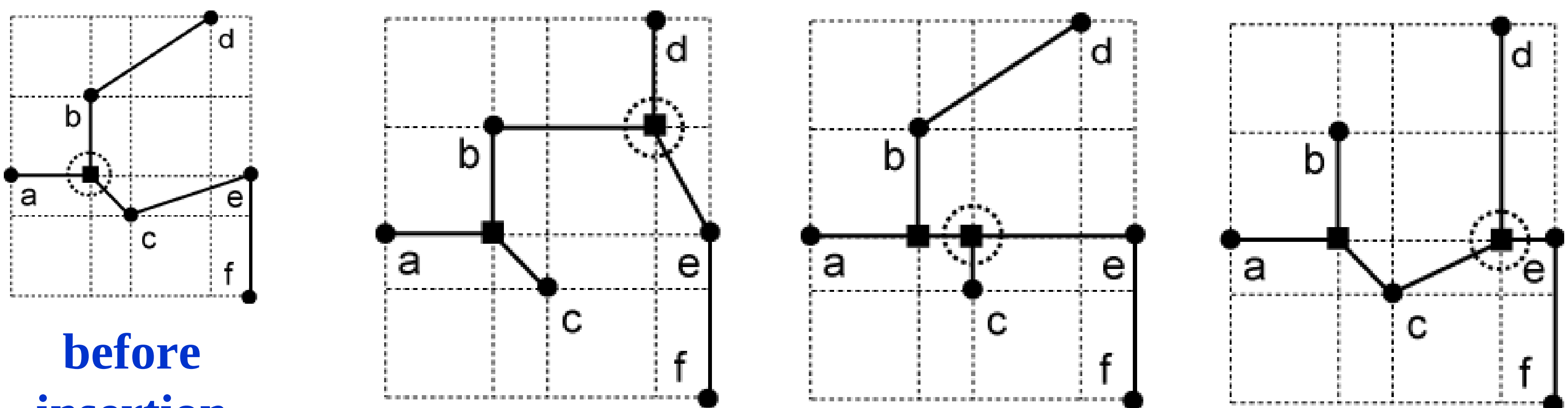
before insertion



(d) WL=18 (e) WL=19 (f) WL=19

Second 1-Steiner Point Insertion

- Need to break tie again
  - Note that (a) and (b) do not contain any more 1-Steiner point: so we choose (c)



before insertion

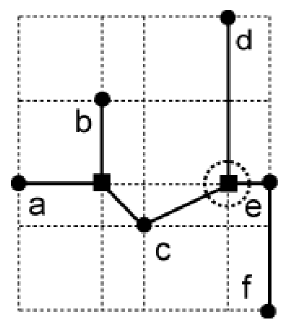
(a) WL=17

(b) WL=17

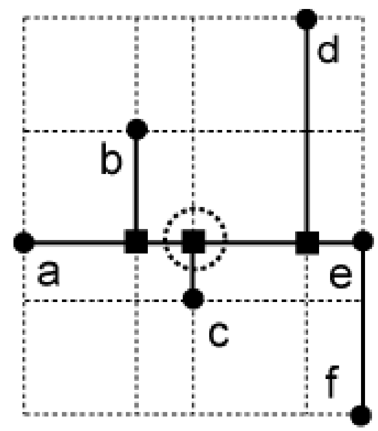
(c) WL=17

Third 1-Steiner Point Insertion

- Tree completed: all edges are rectilinearized
  - Overall wirelength reduction = 20 − 16 = 4



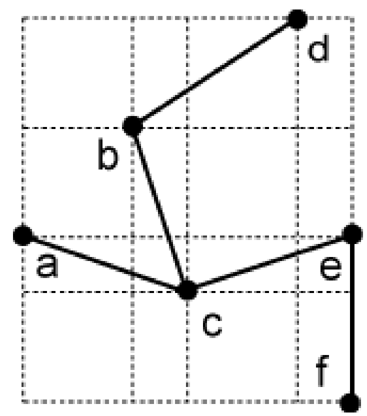
before insertion



WL=16

1-Steiner Routing by Borah/Owens/Irwin

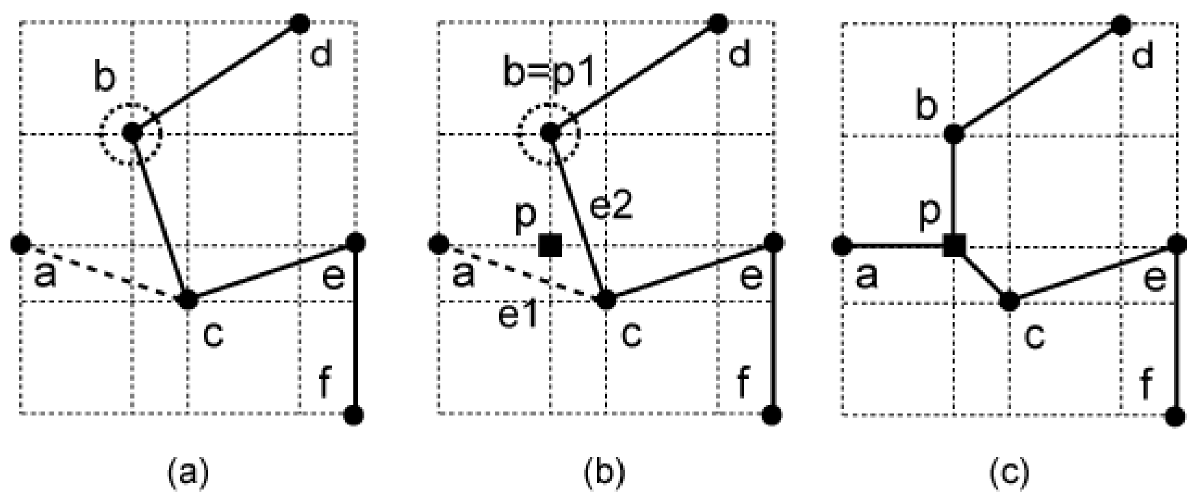
- Perform a single pass of Borah/Owens/Irwin
  - Initial MST has 5 edges with wirelength of 20
  - Need to compute the max-gain (node, edge) pair for each edge in this MST



Best Pair for (*a*,*c*)

We first let $p_1 = b$ and $e_1 = (a, c)$. Next, we compute the shortest Manhattan distance between p_1 and a "rectilinear layout" of e_1, which is 2 in this case. The node p is the nearest point on this rectilinear layout of e_1 to p_1. Next, we look for e_2, the longest edge on p_1-to-a path, which is $e_2 = (b, c)$. Thus,

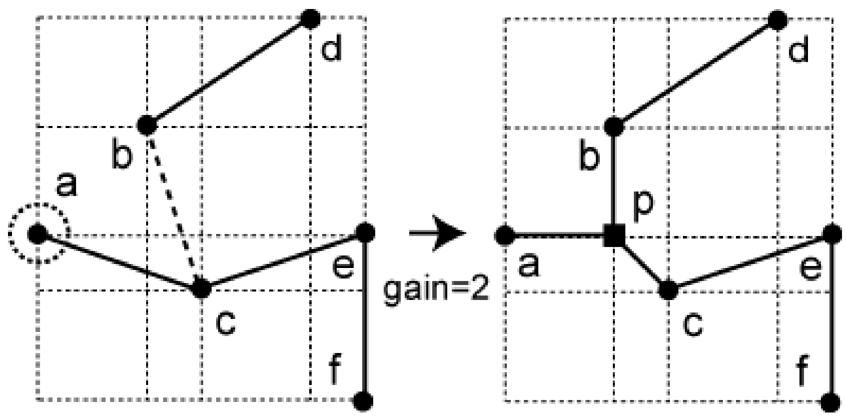
$$gain\{b, (a, c)\} = length(e_2) - length(p, p_1) = 4 - 2 = 2$$



Best Pair for (b,c)

- Three nodes can pair up with (b,c)

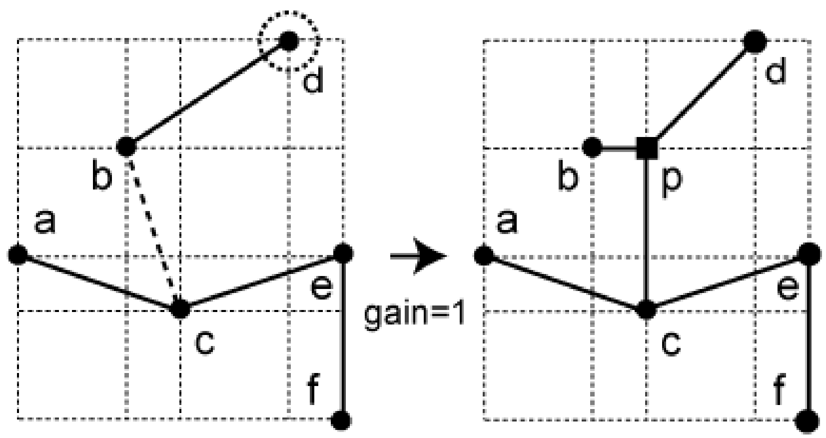
$$gain\{a,(b,c)\} = length(a,c) - length(p,a) = 4 - 2 = 2$$
$$gain\{d,(b,c)\} = length(b,d) - length(p,d) = 5 - 4 = 1$$
$$gain\{e,(b,c)\} = length(c,e) - length(p,e) = 4 - 3 = 1$$



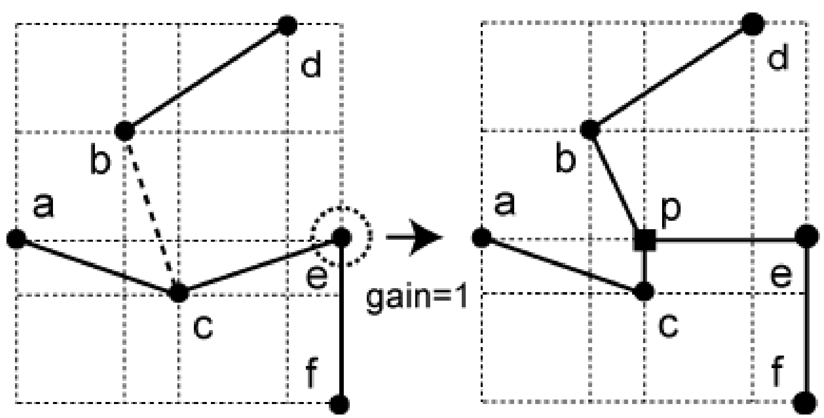
$l(a,c) - l(p,a) = 4 - 2$

Best Pair for (b,c) (cont)

- All three pairs have the same gain
  - Break ties randomly



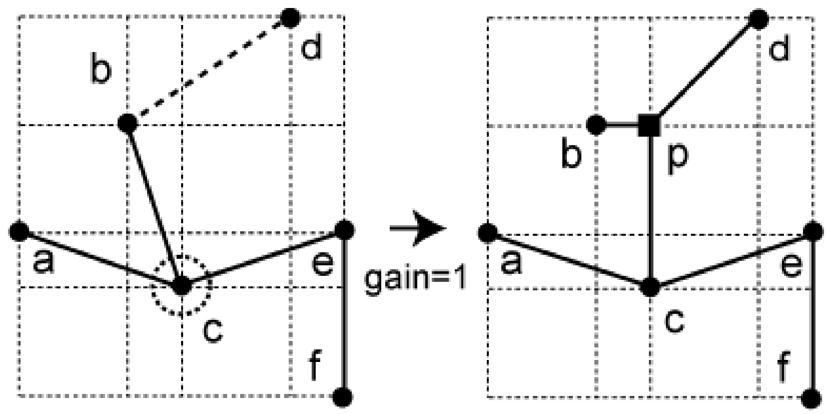
$l(b,d) - l(p,d) = 5 - 4$



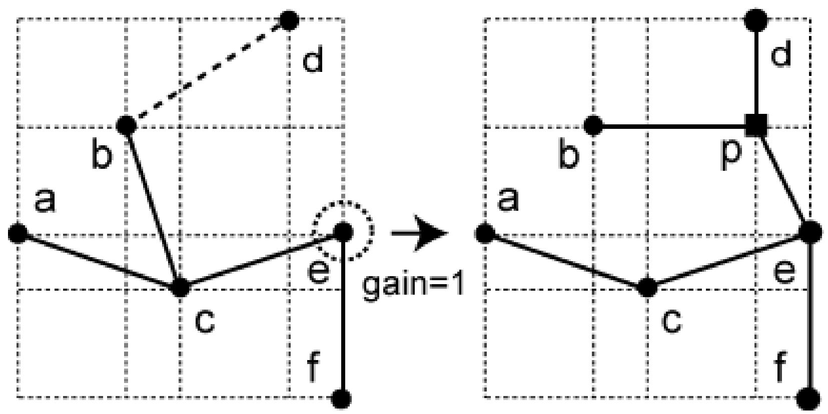
$l(c,e) - l(p,e) = 4 - 3$

Best Pair for (b,d)

- Two nodes can pair up with (b,d)
  - both pairs have the same gain



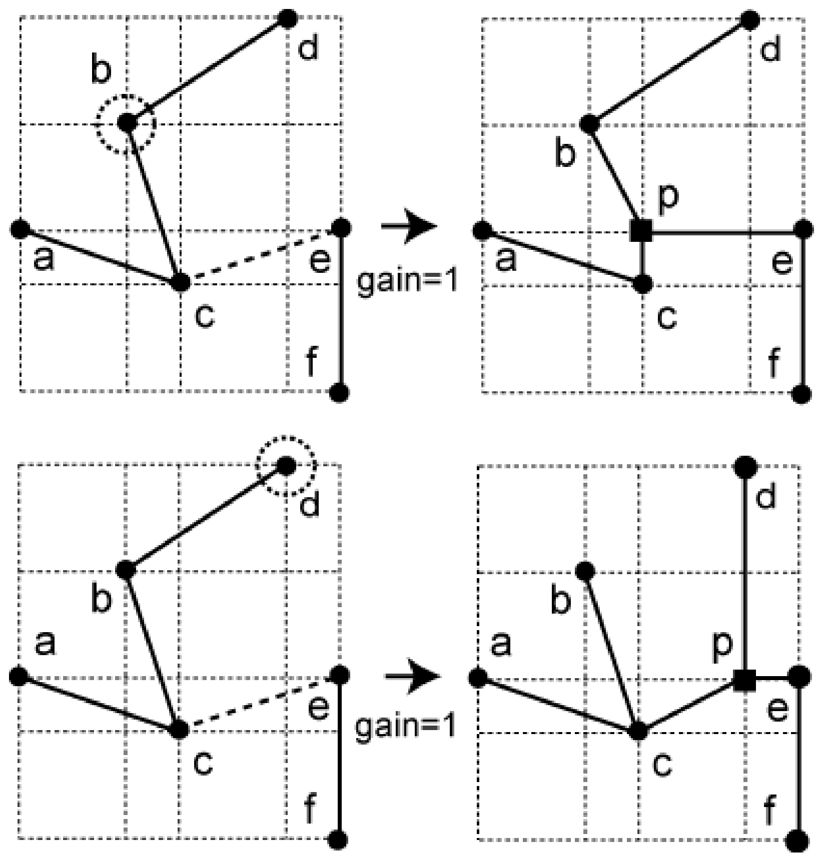
$l(b,c) - l(p,c) = 4 - 3$



$l(b,c) - l(p,e) = 4 - 3$

Best Pair for (c,e)

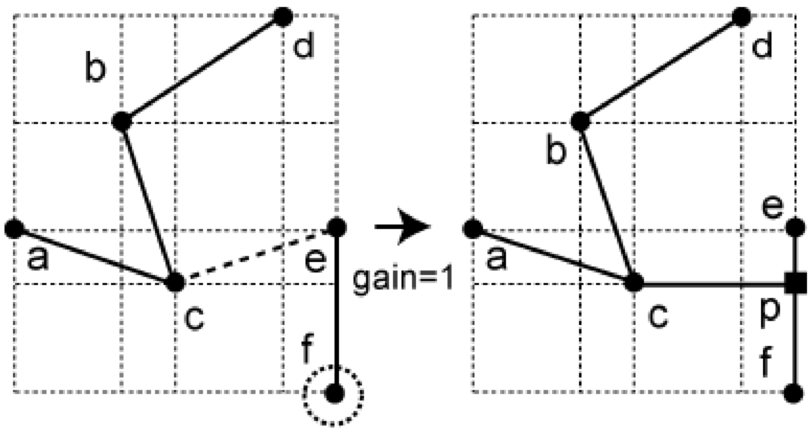
- Three nodes can pair up with (c,e)



$l(b,c) - l(p,b) = 4 - 3$

$l(b,d) - l(p,d) = 5 - 4$

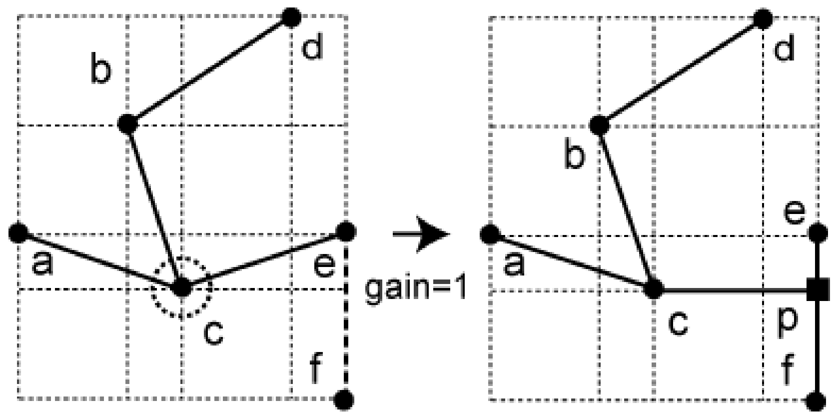
Best Pair for (c,e) (cont)



$l(e,f) - l(p,f) = 3 - 2$

Best Pair for (*e*,*f*)

- Can merge with *c* only

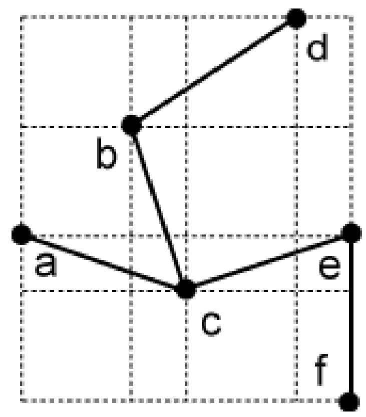


$l(c,e) - l(p,c) = 4 - 3$

Summary

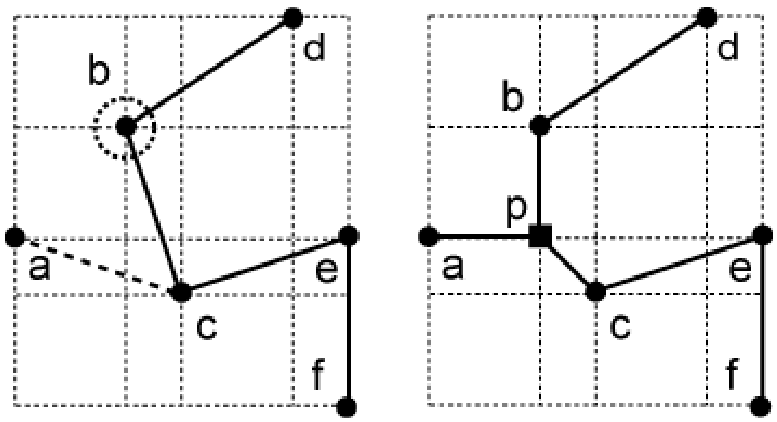
- Max-gain pair table
  - Sort based on gain value

pair	gain	e_1	e_2
$\{b, (a, c)\}$	2	(a, c)	(b, c)
$\{a, (b, c)\}$	2	(b, c)	(a, c)
$\{c, (b, d)\}$	1	(b, d)	(b, c)
$\{b, (c, e)\}$	1	(c, e)	(b, c)
$\{c, (e, f)\}$	1	(e, f)	(c, e)



First 1-Steiner Point Insertion

- Choose $\{b, (a,c)\}$ (max-gain pair)
  - Mark $e_1 = (a,c)$, $e_2 = (b,c)$
  - Skip $\{a, (b,c)\}$, $\{c, (b,d)\}$, $\{b, (c,e)\}$ since their e_1/e_2 are already marked
  - Wirelength reduces from 20 to 18

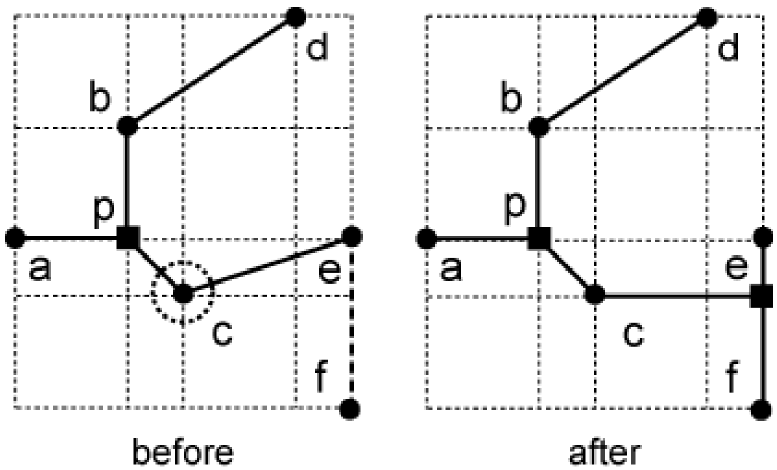


before after

pair	gain	e_1	e_2
$\{b, (a, c)\}$	2	(a, c)	(b, c)
$\{a, (b, c)\}$	2	(b, c)	(a, c)
$\{c, (b, d)\}$	1	(b, d)	(b, c)
$\{b, (c, e)\}$	1	(c, e)	(b, c)
$\{c, (e, f)\}$	1	(e, f)	(c, e)

Second 1-Steiner Point Insertion

- Choose {*c*, (*e*,*f*)} (last one remaining)
  - Wirelength reduces from 18 to 17



pair	gain	e_1	e_2
$\{b, (a, c)\}$	2	(a, c)	(b, c)
$\{a, (b, c)\}$	2	(b, c)	(a, c)
$\{c, (b, d)\}$	1	(b, d)	(b, c)
$\{b, (c, e)\}$	1	(c, e)	(b, c)
$\{c, (e, f)\}$	1	(e, f)	(c, e)

Comparison

- Kahng/Robins vs Borah/Owens/Irwin
  - Khang/Robins has better wirelength (16 vs 17) but is slower