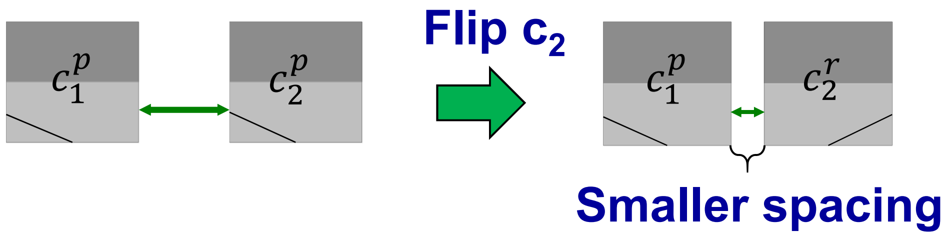
Appendix C: Cell Compaction with Flipping

- Tseng, Chang, and Liu, "Minimum-implant-area-aware detailed placement with spacing constraints," DAC-2016
- Different cell boundaries need different minimum spacing
  - Optimize cell orientations to get smaller chip area



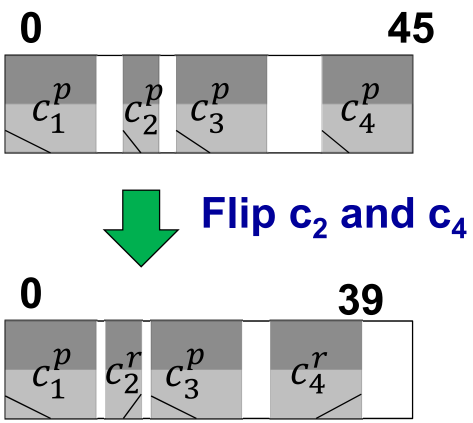
- Consider the cells in a single row with a fixed cell order
  - Exhibit optimal substructure → Dynamic programming (DP)

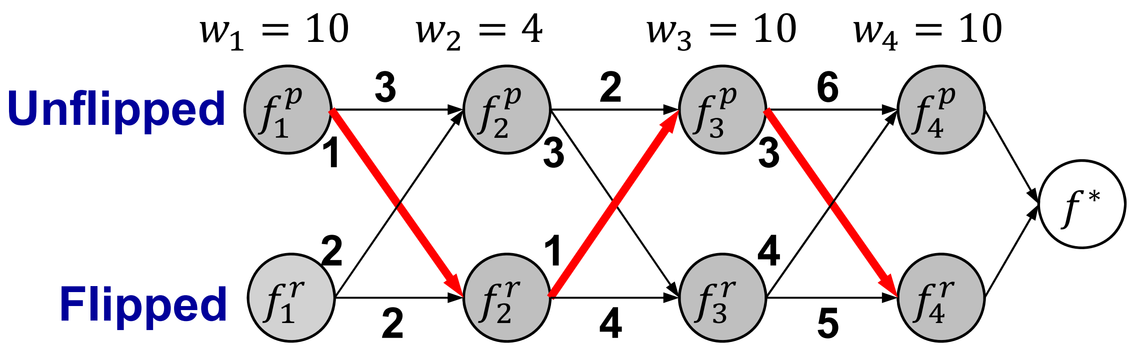
$$T(f_i^\alpha) = \begin{cases} x_i, & if\ i = 1 \\ w_{i-1} + \min_{\beta \in \{p,r\}} \left\{ T\left(f_{i-1}^{\beta}\right) + \phi_{c_{i-1}^{\beta}, c_i^{\alpha}} \right\}, & if\ i > 1 \end{cases}$$

$$T(f^*) = w_{n_{s_j}} + \min\left\{ T\left(f_{n_{s_j}}^{p}\right), T\left(f_{n_{s_j}}^{r}\right) \right\}$$

T: cost function (row length)
n_{s_j}: #cells in row *j*
ϕ: minimum spacing
f: nodes of cell flipping graph
f^*: node of optimal solution
$\{p, r\}$: the two orientations
$\alpha \in \{p, r\}$

Example of DP-Based Cell Flipping





Cell flipping graph

$$T(f_i^\alpha) = \begin{cases} x_i, & if\ i = 1 \\ w_{i-1} + \min\limits_{\beta\in\{p,r\}} \left\{ T\left(f_{i-1}^{\beta}\right) + \phi_{c_{i-1}^{\beta}, c_i^{\alpha}} \right\}, & if\ i > 1 \end{cases}$$

$$T(f^*) = w_{n_{s_j}} + \min\left\{ T\left(f_{n_{s_j}}^{p}\right), T\left(f_{n_{s_j}}^{r}\right) \right\}$$

	i=1	i=2	i=3	i=4
$T(f_i^p)$	0	12	16	32
$T(f_i^r)$	0	11	19	29

$T(f^*) = 39$

$T(f_1^p) = 0 \qquad T(f_1^r) = 0$

$T(f_2^p) = 10 + min\{(0+3), (0+2)\} = 12$

$T(f_2^r) = 10 + min\{(0+1), (0+2)\} = 11$

$T(f_3^p) = 4 + min\{(12+2), (11+1)\} = 16$

$T(f_3^r) = 4 + min\{(12+3), (11+4)\} = 19$

$T(f_4^p) = 10 + min\{(16+6), (19+4)\} = 32$

$T(f_4^r) = 10 + min\{(16+3), (19+5)\} = 29$

$T(f^*) = 10 + min\{32,29\} = 39$

linear-time dynamic programming